# PROFIT EFFICIENCY OF SMALLHOLDER GROUNDNUT FARMERS IN EASTERN ZAMBIA

**MSc. (AGRICULTURAL AND APPLIED ECONOMICS) THESIS**

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**LILONGWE UNIVERSITY OF AGRICULTURE AND NATURAL RESOURCES**

**BUNDA CAMPUS**

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**BSc. (Agric. Econ), Zambia**

**A THESIS SUBMITTED TO THE FACULTY OF DEVELOPMENT STUDIES IN PARTIAL FULFILMENT OF REQUIREMENTS FOR AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS**

**LILONGWE UNIVERSITY OF AGRICULTURE AND NATURAL RESOURCES**

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**MARCH, 2017**

## DECLARATION

I, Musaka Mulanga Chikobola, declare that this thesis is as a result of my own original effort and work, and that to the best of my knowledge, the findings have never been previously presented to the Lilongwe University of Agriculture and Natural Resources or elsewhere for the award of any academic qualification. Where assistance was sought, it has been accordingly acknowledged.

**Musaka Mulanga Chikobola**

**Signature:** ________________________________

**Date:** ________________________________

## CERTIFICATE OF APPROVAL

We, the undersigned, certify that this thesis is as a result of the author's own work, and to our knowledge, it has not been submitted for any other qualification within the Lilongwe University of Agriculture and Natural Resources or elsewhere. The thesis is acceptable in form and content, and that satisfactory knowledge of the field covered by the thesis was demonstrated by the candidate through an oral examination held on 17th March, 2017.

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## ABSTRACT

The groundnut sector has not shown significant growth in terms of production and productivity in Zambia. One of the central problems of groundnut production is low yield per unit area. This study analysed profit efficiency and determinants of groundnut production, in the context of profit maximization, as an incentive for optimum production among smallholder groundnut farmers in Eastern Province. Data for 1,232 farm households from Central Statistical Office of Zambia was used in this analysis. The stochastic frontier approach with the application of a flexible translog profit function and an inefficiency model were used in estimating the profit efficiency.

The results showed existence of high level of inefficiency in groundnut farming because the gamma ratio was comparatively large ($\gamma = 0.6445$). Seed price and value of fixed capital were significant in the profit function. The profit efficiencies varied widely between 9.50% and 92.38%. On average, farmers realized 72.50% of their frontier profit, with an estimated 27.50% of the profit lost due to technical and allocative inefficiencies. Education level, credit access, land tenure, distance to market, availability of storage facilities and weeding duration were significant factors influencing profit efficiency.

Specific policies recommended from the study are that; technologies that enhance fixed capital, arrangements aimed at improving availability and access to improved seed varieties and credit, and land reform measures that promote titled land ownership are key to achieve positive effects on profit efficiency. In addition, policy measures that promote weed control mechanisms, reduction in transportation costs, education advancement and the ownership of proper storage facilities among the smallholder farmers are advocated.

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| | |
|---|---|
| CSO | Central Statistical Office |
| DEA | Data Envelopment Analysis |
| FAO | Food and Agriculture Organization |
| FISP | Farmer Input Support Programme |
| GDP | Gross Domestic Product |
| GRZ | Government of the Republic of Zambia |
| LP | Linear Programming |
| MAL | Ministry of Agriculture and Livestock |
| MoA | Ministry of Agriculture |
| MoAFS | Ministry of Agriculture and Food Security |
| OLS | Ordinary Least Squares |
| PE | Profit Efficiency |
| RALS12 | 2012 Rural Agricultural Livelihoods Survey |
| SAPP | Smallholder Agribusiness Promotion Programme |
| SEA | Standard Enumeration Area |
| SFA | Stochastic Frontier Analysis |
| SSA | Sub-Saharan Africa |
| UN | United Nations |
| USDA | United States Department of Agriculture |
| ZDA | Zambia Development Agency |
| ZMW | Zambian Kwacha (currency of Zambia) |

# CHAPTER ONE

# INTRODUCTION TO THE STUDY

## 1.1 Background

The agricultural sector remains key to the development of Zambia's economy, contributing 18.90% to the Gross Domestic Product (GDP) and providing livelihood for more than 60% of the population (Central Statistical Office [CSO], 2012a). Primary agriculture contributes 35% to the country's total non-traditional exports (all exports other than copper and cobalt) and 10% of the total export earnings for the country. The sector offers employment to 70% of the labour force and is the main source of income and employment for 75% of rural women who constitute 65% of the total rural population (Zambia Development Agency [ZDA], 2011; CSO, 2012a; Food and Agriculture Organization of the United Nations [FAO], 2014). While agriculture alone is not enough to massively reduce poverty, it remains a vital component of effective development strategies for most developing countries (Nkamleu, 2004; World Bank, 2008).

Groundnut constitute 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, groundnut sales have been one of the major sources of steady income for rural households. These rural farmers have limited scope to generate cash and so groundnut production offers a valuable income source (Diop *et al*., 2004; Mofya-Mukuka and Shipekesa, 2013; Zulu *et al*., 2014). Thus, the crop can substantially contribute to reducing poverty in Zambia. Groundnut is also an important raw material in the manufacturing of peanut butter, cooking oil, sweets and animal feed. Groundnut oil is also used in making soaps, cosmetics and lubricants. The seedcake after oil extraction is fed to livestock because of its residual protein value or used as manure, while leaves and stems are used as fodder (Freeman *et al*., 1999; Simtowe *et al*., 2010; CSO, 2013).

In Sub-Saharan Africa (SSA), groundnut offers 60% dietary protein requirement in cereal diets in regions where animal protein is either scarce or beyond reach for most poor households. Its seed has 26% protein content, a critical nutrient for reducing impaired growth in children (Diop *et al*., 2004; Woomer *et al*., 2014). In Zambia, groundnut is prepared for consumption in many ways and is considered a women's crop due to its importance for home consumption. The nuts 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, groundnut fixes nitrogen in the soil, which enhances soil fertility in a more environmentally friendly manner. This improves crop yield, while reducing the need for chemical fertilizers and their associated water and soil pollution effects (Zulu *et al*., 2014). These multiple uses of groundnut make it an excellent cash crop for domestic and foreign trade in several developing and developed countries. The groundnut crop is grown on a large scale in almost all the tropical and subtropical countries of the world generating an average annual production of 40 million tonnes, approximately 8% of the world‘s total oilseed production. The crop is considered the 4th most important oil seed crop in the world (United States Department of Agriculture [USDA], 2015).

## 1.2 Groundnut Production, Consumption, Export and Input Supply in Zambia

More than 660,000 households (50%) grow groundnut in Zambia, the second most widely grown crop after maize (Sitko *et al*., 2011; Ministry of Agriculture and Livestock [MAL], 2013). The crop is grown on small plots from 0.25 to 1.00 hectare throughout the country, but the Eastern, Northern, Muchinga and Central provinces account for approximately 70% share of national production. In terms of regional distribution, Eastern Province has the largest share (33%) of area planted to the groundnut crop (MAL, 2013).

The groundnut varieties grown in Zambia are adapted to different agro-ecological regions and have varying characteristics like high yielding, disease resistance, maturity, drought tolerance, oil content and peanut butter making (Ross and de Klerk, 2012; Chirwa *et al*., 2014). Varieties grown based on optimal management practices at Msekera research station of Eastern Province are in Table 1.1.

**Table 1.1** Groundnut varieties, days to maturity and yields

| Variety | Year Released | Days to Maturity | Seed Size | Oil Content (%) | Yield (Mt/Ha) |
|---|---|---|---|---|---|
| Chalimbana | 1966 | 150-160 | Large | 48-50 | 0.8-1.5 |
| Champion | 1998 | 130-140 | Large | 48-50 | 1.5-3.0 |
| Chipengo | 1995 | 100-110 | Small | 45-48 | 1.0-1.5 |
| Chishango | 2007 | 130-140 | Large | 48 | 1.5-4.0 |
| Comet | 1970 | 90-100 | Small | 45-48 | 0.5-1.5 |
| Katete | 2008 | 90-100 | Small | 43 | 1.0-2.0 |
| Luena | 1998 | 90-100 | Small | 48-50 | 1.0-2.0 |
| Makulu Red | 1964 | 130-145 | Medium | 48-50 | 2.0-2.5 |
| MGS-2 | 1988 | 130-140 | Medium | 45-48 | 1.5-2.5 |
| MGV-4 | 1992 | 120-130 | Medium | 48-50 | 2.0-3.0 |
| MGV-5 | 2008 | 130-140 | Large | 45-48 | 1.5-4.0 |
| Natal Common | 1976 | 90-100 | Small | 45-48 | 0.5-1.5 |

Source: Ross and de Klerk (2012) and Mofya-Mukuka and Shipekesa (2013).

Smallholder farmers, however, continue to realize low and declining groundnut crop yields and cultivated area (as shown in Figure 1.1). The quantity of groundnut produced significantly declined from 164,602 tonnes of shelled groundnut in 2009/10 to 106,792 tonnes in 2012/13 agricultural seasons. Similarly, the total area planted dropped from 268,803 hectares to 207,249 hectares. In 2012/13, less than 110,000 tonnes of shelled groundnut were harvested nationwide (MAL, 2013; CSO, 2014). Zambia was the 39$^{th}$ largest groundnut producer in 2011, but now it ranks 51$^{st}$ in the world (FAO, 2015).

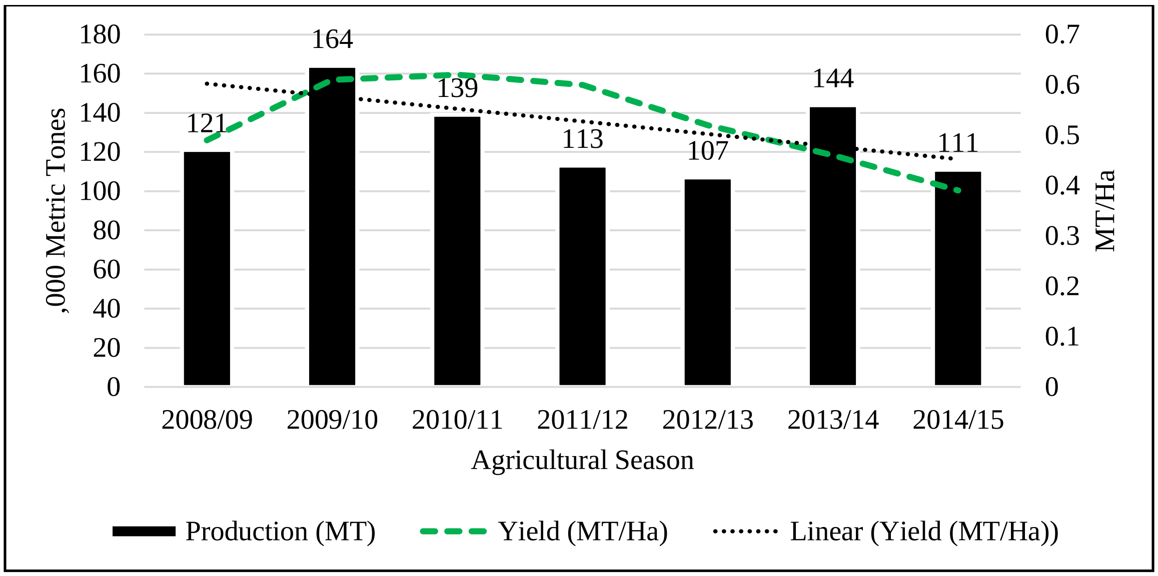



**Figure 1.1** Groundnut production and yield trends in Zambia, 2008/09 to 2014/15

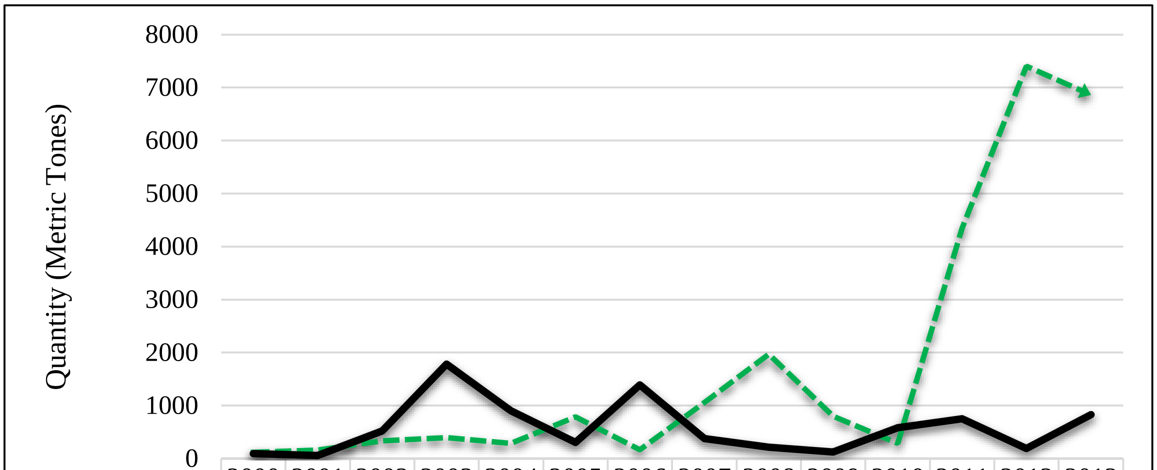
Source: CSO (2011, 2013 and 2014) and MAL (2013).

The low groundnut yields are contributing to creating a disparity between demand and supply, leading to a demand gap (Sitko *et al.*, 2011). The average national yield of 0.52 tonnes per hectare (32% of world average) is too low compared to the world average of 1.63 tonnes per hectare, and even less than Malawi's and South Africa's which average 1.05 (64% of world average) and 2.12 (130% of world average) tonnes per hectare, respectively. Northwestern Province has few smallholder farmers planting groundnut in

Zambia but their average yield per hectare is 0.81 tonnes or 36% higher than Eastern Province (MAL, 2013; USDA, 2015). This low productivity in Eastern Province prohibits farmers from earning significant returns from their groundnut enterprises and therefore reduces farm incomes. Groundnut contributed ZMW 392 or US $40 to Eastern Province's smallholder farmers' annual household income on average in 2012 (MAL, 2013).

The groundnut market in Zambia is mainly informal, but the potential for groundnut production offered by the confectionary industry locally and on the export market is substantial. Exporters estimate demand in South Africa-based food processors of 20,000 tonnes per year (Ross and de Klerk, 2012). The world market for groundnut exceeds 41 million tonnes, but in 2014 only 39 million tonnes were produced. International prices for confectionary quality groundnut are also relatively high compared with other oilseed crops (3 times the price of soybeans) (USDA, 2015). Given the urban consumption demand estimated at 30% of total production in Zambia, and taking into account the export demand, current demand for groundnut outmatches supply (Sitko *et al*., 2011; Mofya-Mukuka and Shipekesa, 2013). The meeting of part of this market demand presents a great opportunity for Zambia's producers and could have a positive impact on the economy of Eastern Province, the key producer area, and on the lives of smallholder farmers involved.

The world market demand for groundnut has been on the rise but, despite the scope for export growth, trade volumes have remained low. An average of less than 2,000 tonnes of groundnut per year were exported in the last decade in Zambia. Since 2000 Zambia has oscillated between being a net importer and net exporter of groundnut. Exports of around 188 tonnes in 2012 were too low given that exports of other countries in the region such as Malawi were around 89,847 tonnes (Figure 1.2). Statistics show that only 30% of the total groundnut quantity produced in Zambia is sold, with the remaining 66% retained for home consumption (Ross and de Klerk, 2012; CSO, 2013). These quantities are too low to even meet the local demand.




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Import | 116 | 157 | 332 | 397 | 286 | 785 | 167 | 1058 | 1969 | 799 | 286 | 4348 | 7401 | 6862 |
| Export | 91 | 57 | 523 | 1783 | 903 | 307 | 1390 | 379 | 214 | 121 | 582 | 748 | 188 | 828 |

**Figure 1.2** Imports and exports trends for groundnut in Zambia, 2000 to 2013

Source: FAO (2015).

The Government of the Republic of Zambia (GRZ), under the National Agricultural Policy, has targeted both food and cash crops for increased production and productivity. The country is divided into three agro-ecological regions (I, II and II) differentiated by rainfall pattern and soil type. Groundnut is among the major cash and high-value crops targeted in region II, and its production has been presented as a key investment and economic diversification opportunity (MAL, 2004; ZDA, 2011). Policy initiatives aimed at improving both yield and sales of groundnut include the Farmer Input Support Programme (FISP) and Smallholder Agribusiness Promotion Programme (SAPP). The government has been including groundnut seed as part of the FISP since 2012, and promoting the sale of groundnut under the SAPP project (Ministry of Agriculture [MoA], 2016). This provided the required 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.

About 60% of Zambia's population live below the international poverty line of US $1.25 per day, and poverty rates remain high at 80% in rural areas (CSO, 2012a). The government identified groundnut as a profitable cash crop with potential to significantly increase incomes and reduce poverty among rural producers. Despite this potential, the groundnut sector has not shown significant growth in production and productivity. Since farmers plant less than 30% of available plots to groundnut (CSO, 2013), its contribution to scaling up rural incomes falls far short of its potential. Consequently, there is need to determine the efficiency of groundnut production by the smallholder farmers, who are also major producers of most crops. This is because the production of both groundnut and other crops compete for productive resources like land, labour and capital.

As earlier stated, one major problem of groundnut production is low yield estimated at 32% of both world and key southern African countries' averages. This is attributed to poor production practices 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 groundnut (Sitko *et al*., 2011; CSO, 2013). The failure to meet international quality standards due to high aflatoxin levels is a key constraint to enter the export market. In Zambia a minimum aflatoxin level of 15.00 parts per billion (ppb) was set by the Zambia Bureau of Standards in 2008 for groundnut, and government seeks to invest in aflatoxin testing and detection centres. A maximum allowable level of 10.00ppb is required in line with international standards. This compounded with price instability makes it difficult for producers to plan their production, forecast their profits and eventually their income levels (Ross and de Klerk, 2012; Mofya-Mukuka and Shipekesa, 2013; Woomer *et al*., 2014).

### 1.3 Statement of the Problem

The major policy challenge is to reverse the current downward spiral of groundnut yields by improving the capacity of farmers to increase production and productivity to meet the rising local and export demand. However, to boost productivity it is not known whether the farmers are efficient both allocatively and technically. Groundnut yields do not vary a lot across the provinces yet households in Eastern Province obtain the least output per hectare, around 0.44 metric tonnes per hectare compared to the national average of about 0.52 (MAL, 2013). Mofya-Mukuka and Shipekesa (2013) showed that Eastern Province yields have consistently lagged behind the national yield averages for the past 10 years and the reason for this lag is not known. Further analysis is required to identify the reason for this variance and find out if there is room to improve performance, since the province is well suited for groundnut cultivation due to high rainfall as well as coarse textured and sandy loam soils.

The low output realized by farmers suggests that resources required in groundnut production are not at optimal levels, despite variations in yields that are normally related to changes in soil fertility, poor farming systems, moisture deficiency and pests and diseases. Limitations of studies on food crops is that they assumed technical efficiency in terms of input use and production technology (e.g. Ng'ombe and Kalinda, 2015; Musaba and Bwacha, 2014), and for groundnut production they only looked at market participation decision and choice of the marketing channel (Denison, 2011; Ross and de Klerk, 2012; Mofya-Mukuka and Shipekesa, 2013; Zulu *et al*., 2014). The problem of low yield is technical but a production function approach may not be suitable to use in evaluating efficiency because it is criticized as suffering from simultaneous equation bias since input levels are endogenously determined. Thus, the approach fails to capture inefficiencies related to different factor endowments and different input and output prices across farms (Yotopoulos *et al*., 1973; Ali and Flinn, 1989). The profit function approach avoids this problem. An advantage of a profit function model is that it is specified as a function of prices and fixed factors, which are exogenous in nature and, thus, are free from possible endogeneity problem. When input and output prices are exogenous to farm household decision making, a profit function can be used to explain input use and output supplied (Sidhu and Baanante, 1981; Abdulai and Huffman, 2000). No study has been done to find out the profit efficiency of groundnut farmers in Zambia, using the profit function model, and there is paucity of empirical literature.

## 1.4 Research Justification and Expected Contribution

Most poverty reduction strategies in Zambia focus on improving income generation. Given the benefits of groundnut as a source of income to the livelihoods of rural Zambians, this study focused on Eastern Province, the largest producer with the highest proportion (91%) of agricultural households. Despite having relatively high levels of groundnut production, the province has one of the highest rates of poverty and remains one of the poorest in the country with poverty incidence of 79% (CSO, 2012a).

The justification for the study is based on: (i) the need to accelerate smallholder agriculture growth 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 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 investment related to these issues.

This study contributes to existing literature on the link between profit efficiency of groundnut production and the major determinants in the Zambian context. Addressing profit efficiency challenges will enable smallholder farmers to do agriculture as business. This has a multiplier effect in terms of improving incomes of groundnut farmers and subsequently contributing to reducing poverty in Zambia. The results will benefit policy makers who can make or revise policies to positively impact profit efficiency and to improve agricultural productivity, with the aim of improving the welfare of groundnut farmers particularly in the study area.

### 1.5 Research Objectives

The research sought to evaluate the profit efficiency of smallholder groundnut farmers in the Eastern Province of Zambia. The specific objectives were:

i. To determine the profit efficiency levels of the smallholder groundnut farmers so as to quantify the existing opportunity for increased efficiency; and

ii. To identify the major determinants of profit efficiency in groundnut production among the smallholder farmers that could provide incentive for optimum production and help in providing solution to the declining productivity.

## 1.6 Research Hypotheses

The study tested the following hypotheses stated in null form:

i. Smallholder farmers are not profit efficient in groundnut production; and

ii. Socio-economic and institutional factors do not significantly influence profit efficiency of smallholder groundnut farmers.

## 1.7 Research Questions

The research questions were as follows:

i. What are the current levels of profit efficiency in groundnut production?

ii. What are the major socio-economic and institutional factors influencing profit efficiency in groundnut production at farm levels?

## 1.8 Structure of the Thesis

The rest of the thesis is organized as follows: Chapter Two reviews selected literature in the field of efficiency and its determinants. The chapter also highlights the research gaps in groundnut production in Zambia. Chapter Three outlines the study methodology which includes the conceptual framework, empirical model and data sources. Chapter Four explores the socio-economic characteristics of the sampled farm households. Chapter Five presents empirical results and discussions of the study; while Chapter Six focuses on conclusion, recommendations and policy implications drawn from the study.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

This chapter reviews literature on profit efficiency and determinants of profit inefficiency. Research gaps in groundnut production in Zambia were highlighted. Lastly, the chapter highlights agricultural production, constraints and the groundnut sector in SSA.

## 2.2 Theoretical Foundation

This study is based on the analysis of economic efficiency of farms derived from production frontier by Farrell (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 faced by that farm (Ali and Flinn, 1989). From Farrell's 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 2.1 traces the profit frontier for a sample of farms. Interaction between farm-specific prices ($P_i$) and levels of fixed factors ($Z_l$) 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. Given a farm operating at point F, comparative profit efficiency is defined as FP/MP and profit inefficiency as 1 - (FP/MP).

If the stochastic profit function is estimated by ordinary least squares (OLS), an average, as opposed to the best-performance frontier, is derived. The estimation shows the average profit curve which does not include the profit inefficiency (Figure 2.1). The upper bounded frontier curve in Figure 2.1 generated by maximum likelihood estimates (MLE), is estimated by postulating that the error term contains two independent components: a one-sided error term representing profit inefficiency and a random error with normal properties (Ali and Flinn, 1989; Sadoulet and de Janvry, 1995; Rachmina *et al*., 2014).

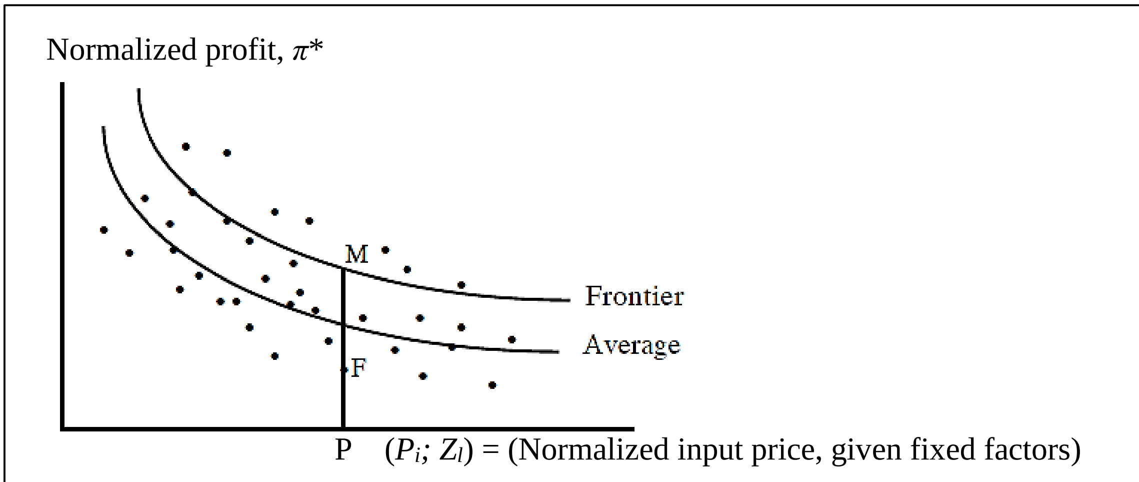



**Figure 2.1** Frontier (MLE) and average (OLS) stochastic profit functions

Source: Ali and Flinn (1989).

In smallholder farms it is not easy to isolate fixed factor costs. The practice is to use gross margin as a proxy for profit (Abdulai and Huffman, 1998; Rahman, 2003; Mohapatra, 2011). This approach was used in this study, and to be consistent with literature gross margin is called profit subsequently. Gross margin is defined as revenue per hectare planted to groundnut minus costs incurred over the growing season (Burke *et al*., 2011).

Assuming a farm that maximizes profits, then farm profit ($\pi$) from groundnut is measured in terms of gross margin (*GM*) in Zambian Kwacha (ZMW) which equals the difference between the total revenue and total variable cost given by:

$$GM = \pi = TR - TVC = p_y Q_y - \sum_i w_i X_i \quad (2.1)$$

where *TR* is total revenue from groundnut activity; *TVC* are total variable costs (seed, fertilizer and labour) of securing revenue per farm *j*; $Q_y$ is groundnut output; $X_i$ represents a vector of inputs used; $p_y$ and $w_i$ represent vectors of output and input prices, respectively. To normalize the profit function, $\pi$ is divided throughout by $p_y$ (market output price) to obtain:

$$\frac{\pi}{p_y} = \frac{p_y Q_y - \sum_i w_i X_i}{p_y} = Q_y - \frac{\sum_i w_i X_i}{p_y} = f\left(X_i, Z_l\right) - \sum_i P_i X_i \text{ ; and } X_i = g(P_i, Z_l) \quad (2.2)$$

where $Z_l$ is a vector of fixed factor inputs; $P_i = w_i/p_y$ is a vector of normalized variable input prices; and $f(X_i, Z_l)$ represents the production function. The normalized form of the profit function is more convenient to work with and has proved to be handier from theoretical and econometric point of view (Okoruwa *et al*., 2009). Under price-taking behavior of the farmers, the normalized input prices and quantities (levels) of fixed factors are considered to be the exogenous variables (Sidhu and Baanante, 1981). Following Abdulai and Huffman (2000), the implicit profit function model for the profit efficiency analysis is specified as:

$$\pi^* = \frac{\pi}{p_y} = f\left(P_i, Z_l\right)\exp\left(\varepsilon_i\right) = f\left(P_i, Z_l\right)\exp\left(V_i - U_i\right) \quad (2.3)$$

where; $\pi^*$ is the normalized profit of $j^{th}$ farm; $P_i$ is a vector of normalized variable input prices; $Z_l$ represents a vector of fixed factors; $p_y$ is output price and $\varepsilon_i$ 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 an independently 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;

$$U_i = \delta_0 + \sum_{d=0}^{1} \delta_d M_{di} + \omega_i \tag{2.4}$$

where $M_{di}$ is the $d^{\text{th}}$ explanatory variable (such as education level, credit and extension access) associated with inefficiencies on farm $j$, $\omega_i$ is the two sided random error and $\delta_0$ and $\delta_d$ are unknown parameters (Rahman, 2003; Assa *et al*., 2012).

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:

$$PE_i = \frac{\text{actual farm profit}}{\text{frontier farm profit}} = \frac{f\left(P_i, Z_l\right)\exp\left(V_i - U_i\right)}{f\left(P_i, Z_l\right)\exp\left(V_i\right)} = \frac{\exp\left(V_i - U_i\right)}{\exp\left(V_i\right)} = \exp\left(-U_i\right) \tag{2.5}$$

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 the farm is obtaining potential maximum profit given the prices 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, i.e., failure to optimize (Oladeebo and Oluwaranti, 2012; Hyuha *et al.*, 2007). The farm-specific profit efficiency is again the mean of the conditional distribution of $U_i$ given by *PE* and is defined as:

$$PE = \exp\left(-U_i\right) = E\left[\exp(-U_i) \mid \varepsilon_i\right] = E\left[\exp(-\delta_0 - \sum_{d=0}^{1} \delta_d M_{di} - \omega_i) \mid \varepsilon_i\right] \quad (2.6)$$

*PE* takes values between 0 and 1 and is inversely related to the level of profit inefficiency. *E* is the expectation operator (Kumbhakar *et al*., 1989). 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. By applying maximum likelihood estimation, the variance of the random errors and that of the profit inefficiency effect and overall variance of the model are also obtained and are related as follows:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \text{ and } \gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2} = \frac{\sigma_u^2}{\sigma^2} \quad (2.7)$$

where, $\sigma^2$ is the total variance for the combined error term $\varepsilon_i$; $\sigma^2_v$ is the constant variance for the symmetric error term $V_i$; $\sigma^2_u$ is variance for the non-negative error term $U_i$, and; $\gamma$ is ratio of farm - specific efficiency effects to the total output variance. The overall variance of the model ($\sigma^2$) measures the total variation of profit from the frontier which can be attributed to profit inefficiency. Gamma ($\gamma$) represents the share of inefficiency in the overall residual variance with values between 0 and 1 (Abu and Kirsten, 2009). If $\gamma = 1$, profit inefficiency is the dominant source of error and there is no effect of random errors in the data, denoting existence of a deterministic frontier. 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, and is evidence in favour of OLS estimation (Ali and Flinn, 1989; Battese and Coelli, 1995).

## 2.3 The Concept of Efficiency

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 factor costs (Adesina and Djato, 1996). Technical and allocative efficiencies are components of profit efficiency. The concept of efficiency is illustrated in Figure 2.2.

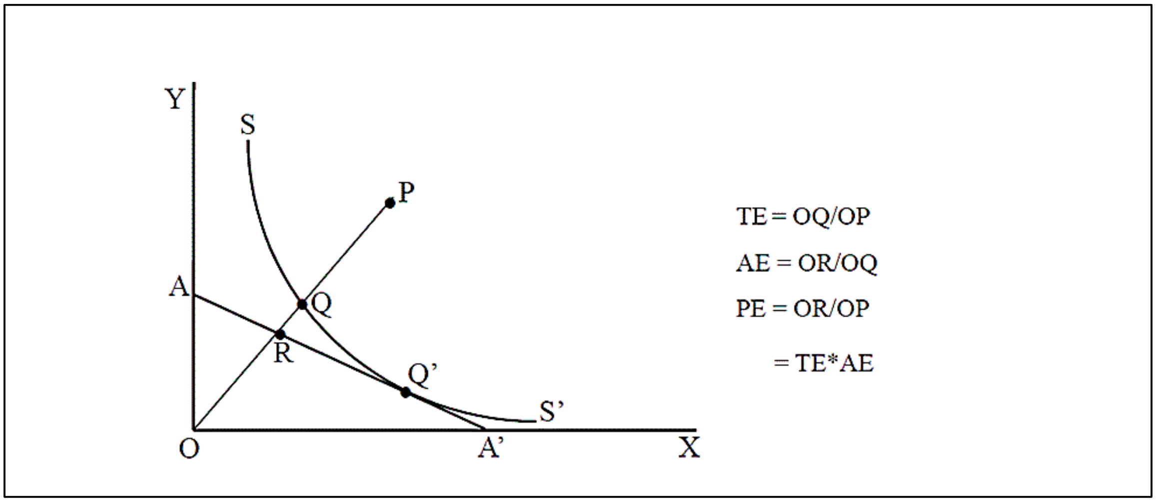



**Figure 2.2** Technical, allocative and profit efficiency measures

Source: Farrell (1957).

Suppose a firm is using two factors of production to produce a single product under conditions of constant returns to scale. The isoquant SS' shows the technological set that obtains the minimum combination of inputs required to produce a unit of output. Every combination of inputs along the unit isoquant is technically efficient and thus Q and Q' are two technically efficient points while P is an 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 is the percentage by which all inputs need to be reduced to achieve technically efficient production. Therefore, the technical efficiency (TE) of the producer under analysis (1- QP/OP) is presented by the ratio OQ/OP. For a technically efficient farmer/firm, TE = 1 but for all inefficient farmers, a value of TE < 1 is achieved (Farrel, 1957).

If information on market prices is known, it is possible to calculate the profit efficiency of the firm under deliberation. In Figure 2.2 the line AA' represents iso-cost line, thus, R and Q' have the same total cost. However, the output at point R production is outside the technology set. This 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. A producer may be technically efficient, but yet profit inefficient because he fails to choose correct input combination (allocative inefficiency) (Abdulai and Huffman, 1998). Thus, point Q' is technically efficient as well as allocatively efficient (AE). The profit efficiency (PE) is calculated by the ratio:

PE = OR/OP

Allocative efficiency and technical efficiency can also be computed 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 (overall) efficiency of a farm is equal to the product of technical efficiency and allocative efficiency (Russel and Young, 1983; Sadoulet and de Janvry, 1995).

### 2.4 Measurement of Profit Efficiency

There are two approaches mostly used for measuring profit efficiency: (i) stochastic frontier analysis (SFA) (parametric approach) and; (ii) data envelop analysis (DEA) or non-parametric approach (Ogundari, 2006; Bidzakin *et al*., 2014). Both estimate the efficiency frontier and computes the firm's efficiency relative to it. The frontier shows the best-performance observed among firms and 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 (LP) to construct a piece-wise frontier that envelops the observations of all firms (Nkamleu, 2004). 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; Ng'ombe and Kalinda, 2015). This point is important for studies of farm level data in developing economy as data generally include measurement errors (Ogundari, 2006). Nevertheless, there is no consensus among researchers as to the best method for measuring efficiency.

The SFA (or econometric frontier approach) specifies the relationship between output and input levels and decomposes the error term into two components: (i) a random error, and

(ii) 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 asymmetric distribution and may be expressed as a half-normal, truncated normal, exponential or two-parameter gamma distribution (Coelli, 1996; Ogundari, 2006). This study uses the SFA approach (widely accepted in agricultural economics literature) because of its consistency with theory, versatility and relative ease of estimation.

### 2.5 Application of Stochastic Frontier Models

Econometric models are widely applied in measuring efficiency. According to Yotopoulos *et al*. (1973), a production function approach to measure efficiency is not appropriate if farmers face different prices and have different factor endowments. This led to using stochastic profit function models to estimate farm specific efficiency directly (Ali and Flinn, 1989; Rahman, 2003; Ogundari, 2006). The profit function combines both technical and allocative efficiency concepts 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 superior to a production function because: (i) it permits straight forward derivation of own-price and cross-price elasticities and output supply and input demand functions; (ii) the indirect elasticities estimated via profit functions have a distinct advantage of statistical consistency and; (iii) it avoids simultaneity bias problems because input prices are exogenously determined. Thus, problems of endogeneity can be avoided by estimating a profit function instead of a production function (Adesina and Djato, 1997; Ogunniyi, 2011).

The Cobb-Douglas profit functional form is popular and often used to estimate farm efficiency despite its known weaknesses (Ogundari, 2006; Sunday *et al*., 2012; Bidzakin *et al*., 2014). The translog model has also been widely used (Hyuha *et al*., 2007; Abu and Kirsten, 2009; Assa *et al*., 2012) despite its susceptibility to multicollinearity and potential problems of insufficient degrees of freedom because of interaction terms. The interaction terms of the translog also do not have economic meaning (Abdulai and Huffman, 2000).

The flexible stochastic translog profit function estimation was used in this study. The choice was based on the model's suitability to estimate a single enterprise profit function and 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 and significantly reduce the reliability if the functional form was not a Cobb-Douglas function. In addition, 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. These assumptions are untenable (Christensen *et al*., 1973; Abu and Kirsten, 2009). Owing to these deficiencies, Cobb-Douglas functional forms cannot explain 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. The advantage of Battese and Coelli (1995) model is that it allows estimation of farm specific efficiency scores and the factors explaining efficiency differences among farmers in a single stage estimation procedure and it overcame some general criticism of two stage model. Following Rahman (2003), our study uses 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.

## 2.6 Empirical Literature on Profit Efficiency

Several studies show that profit efficiency is at the heart of agricultural production because the scope of agricultural production can be expanded or sustained by farmers only through efficient use of resources (Okoruwa *et al*., 2009; Mohapatra, 2011; Sunday *et al*., 2012; Bidzakin *et al*., 2014). Thus, efficiency has remained an important subject of empirical analysis mostly in developing economies where most farmers are resource-poor. These farmers must be helped to increase their production beyond subsistence levels to higher levels of profitability through more efficient use of their production resources.

In a recent contribution, Adamu and Bakari (2015) analyzed the profit efficiency of rain-fed rice farmers in Taraba state, Nigeria. Data were collected from 156 respondents using multi-stage sampling. The Cobb-Douglas stochastic profit frontier and inefficiency model were used for analysis. The results revealed an average profit efficiency level of 59%, showing that 41% of profit was lost due to a combination of both technical and allocative inefficiencies in rice production. Age, education, farming experience, household size and access to credit facilities increased the profit efficiency of the respondents. The implication of the results was that; learning opportunities, farm inputs and credit facilities should be made available to farmers at the appropriate time.

A study by Ajijola *et al*. (2014) estimated economic efficiency of yam enterprises in Oyo State of Nigeria. Ninety yam farmers were purposely selected in three agricultural zones of the state. The Cobb-Douglas functional form was applied to estimate economic efficiency levels. From the results, cost of weeding, hired labour, farm size, and production per hectare determined profit levels in the enterprises, while level of education, farming experience, age and gender were the major factors influencing economic efficiency.

Results showed the need to assist farmers in securing loans from agricultural banks to acquire necessary tools, implements and equipment to enhance their productivity.

Another study of interest on profit efficiency was carried out by Bidzakin *et al*. (2014) on small scale maize production in northern Ghana using the Cobb-Douglas stochastic frontier model. A multistage random sampling method was used to obtain 144 small scale maize farmers. The average profit efficiency of 61% was recorded in the area with a minimum and a maximum of 11% and 100%, respectively. This showed that farmers had opportunity to increase profit by 40% through improvements in their technical and allocative efficiency. The inefficiency model showed that an increase in educational level, farming experience, or household size increased profit efficiency of the farmers; whereas sex of farmer and age reduced profit efficiency. The female farmers were more efficient than their male counterparts.

Ani *et al*. (2013) applied the Cobb-Douglas stochastic frontier to measure the profitability and economic efficiency of groundnut production in Benue State, Nigeria. A multi-stage sampling technique was applied in collecting cross-sectional data from 270 groundnut farmers using questionnaires and oral interviews. The key variables that influenced profitability were costs of hired labour, seed, agrochemicals and fertilizer. The mean technical efficiency estimate of the groundnut farmers was as low as 4% and this was attributed to high demand for labour, land and agrochemicals which are critical factors in groundnut production. The socio-economic factors that affected groundnut production in the study area were; farmers' age, household size and annual income. An average farmer spent about 28% above the minimum frontier cost. The elasticities of cost of production with respect to hired labour (0.59) or seed (0.41) were relatively high, showing their importance in groundnut production in the stochastic cost frontier model. The study recommended that more land should be put to groundnut production and farmers given essential agricultural inputs to enhance productivity of the groundnut cash crop. The study further recommended the development and dissemination of simple machines that could help in groundnut production.

Sunday *et al*. (2013) estimated a translog stochastic profit function and an economic efficiency model for cassava farmers in Cross River State, Nigeria. A two-stage random sampling method was used to select 120 farmers in the study area. Maximum likelihood estimates of the specified models revealed an average economic efficiency of 0.58. The results further showed that; level of involvement in farming, farmer's education, ability to predict rainfall, farming experience, household size, soil management technique adopted, extension agent visits and farm size were significant determinants of profit efficiency. To increase farmer's economic efficiency, farm-level policies aimed at improving farmer's education, reduction in production constraints and increase in extension agent visits in addition to increased private investment in the sub-sector, were recommended.

In Malawi, Assa *et al*. (2012) measured profit efficiency and determinants of profit inefficiency of a sample of Irish potato farms in Dedza district. The translog model of the stochastic profit frontier analysis was used to measure efficiency. Two hundred randomly selected farmers were interviewed for plot level data. The results revealed that the average profit of Irish potato farmers could increase by 26% under prevailing technology. The profit efficiency of the farms ranged from 0.31 to 0.99 (0.74 average). Non-farm employment, education, extension visits, credit status, farm experience, degree of specialization, and frequency of weeding (number of times per year) negatively affected profit inefficiency; whereas age positively affected profit inefficiency.

Oladeebo and Oluwaranti (2012) used a Cobb-Douglas stochastic frontier profit function to estimate profit efficiency of cassava producers in Southwestern Nigeria. Cross sectional data were obtained from 109 cassava producers with structured questionnaires, supplemented by oral interviews. Results showed that the profit efficiencies of the farmers ranged between 20% and 91% with an average profit efficiency of 79%, and an estimated 21% loss in profit due to a combination of both technical and allocative inefficiencies. Household size and farm size were the major significant factors that positively influenced profit efficiency.

Ogunniyi (2011) employed the translog frontier profit function to measure profit efficiency among maize farmers in Oyo State in Nigeria. A multistage random sampling technique was used to select 240 maize producers. The results showed that profit efficiencies of the farmers varied widely between 1% and 99.90% with a mean of 41.40% showing that 58.60% of the profit was lost due to a combination of both technical and allocative inefficiencies. Education level, farming experience, extension services and non-farm employment were significant factors that positively influenced profit efficiency. Improvement in the level of education of sampled farmers could reduce profit inefficiency in maize production.

In measuring profit efficiency of small scale cowpea farmers in Niger State of Nigeria, Ojo *et al*. (2009) used the Cobb-Douglas stochastic profit frontier. Data were obtained using a structured questionnaire administered to 100 randomly selected cowpea farmers. The results showed that levels of profit efficiency ranged from 11.62% to 91.90% with mean of 77.75%, suggesting that an estimated 22.25% of the profit was lost due to technical and allocative inefficiency in cowpea production. Cowpea farmers were expected to increase profit efficiency in their farming activities by about 23%. Farmers' age, educational level, and years of farming experience significantly influenced their efficiency. Investments in rural education through extension delivery were recommended.

In a study by Taru *et al*. (2008) on economic efficiency of resource use in groundnut production in Adamawa State of Nigeria, the Cobb-Douglas profit frontier model was used. Data used were collected with the aid of structured questionnaires administered to 143 farmers using a simple random technique. The regression analysis revealed that the Cobb-Douglas function gave the best fit. The $R^2$ was highly significant at 1% level with a value of 0.784. Significant explanatory variables were farm size, quantity of seed used and labour input. The economic efficiency of resource use showed that seed and labour were underutilized, while fertilizer and agrochemicals were over used.

Hyuha *et al*. (2007) determined profit efficiency among rice producers in Eastern and Northern Uganda using the normalized translog functional form. A stochastic profit function and inefficiency function were estimated using cross-sectional data of 253 households from three districts of the study area. The results showed that all farmers were not operating on the profit frontier and scored a mean profit efficiency of 66% with about 70% of the farmers scoring at least 61%. The efficiency levels at district level were 75%, 70% and 65% for Pallisa, Lira and Tororo, respectively. The area under rice and capital had a positive influence on profit levels while cost of family labor had a negative effect. The main causes of inefficiency were low education and limited access to extension services. Improvement in profit efficiency required increased access to education and extension services.

In Bangladesh, Rahman (2003) estimated a translog stochastic profit function for rice farmers. A total of 406 farm households from 21 villages were selected following a multistage stratified random sampling procedure. Results showed that a high level of inefficiency existed in rice farming. The mean level of profit efficiency was 77% suggesting that an estimated 23% of the profit was lost due to a combination of both technical and allocative inefficiency in modern rice production. The efficiency differences were explained largely by infrastructure, soil fertility, experience, extension services, tenancy and share of non-agricultural income.

### 2.7 Research Gaps based on Literature Review

Reviewed literature shows that whether a farmer is producing for home consumption or for the market, the cost of production and the returns accruable to the farmer's effort are an important measure of performance to obtain the optimum profit from the effort. In Zambia, few studies were done in groundnut production and marketing (Denison, 2011; Ross and de Klerk, 2012; Mofya-Mukuka and Shipekesa, 2013; Zulu *et al*., 2014).

In a recent contribution, Zulu *et al*. (2014) applied the Cragg's model for corner-solution problems to determine the effect of FISP maize subsidy on groundnut production in Zambia. A panel dataset from the 2001, 2004 and 2008 nationally representative surveys by CSO, which employed a two-stage sampling method, were used. A panel of 4,286 agricultural households successfully interviewed in all the three waves was used for analysis. The results showed that the FISP did not significantly affect smallholder farmers' decision to participate in production, but significantly influenced the proportion of cultivated land area allocated to groundnut. High subsidies targeted at maize caused farmers to relocate their productive resources, mostly land, from other crop enterprises towards maize production. Land allocation to groundnut was also influenced by the household's labour endowment, level of the Food Reserve Agency (FRA) activity, access to market information, and the price of groundnut relative to prices of related commodities like maize, mixed beans, cowpeas and soya beans. This study, however, did not look at the causes of low yields in groundnut production.

Ross and de Klerk (2012) assessed constraints faced by groundnut farmers in Eastern Province of Zambia to identify those which substantially limited area planted to groundnut. The study used several data collection methods which included literature review and direct observation. Thirteen farmers were interviewed individually; 7 focused group meetings held with 96 farmers; and production, consumption and sales data collected from 57 farmers. In addition 13 buyer and 23 key informant interviews were conducted. Results showed low yields, averaging 612kg unshelled nuts per hectare nationally. Lack of reliable organized markets and low prices were reported as deterrents to expanding groundnut area. The study did not take account of efficiency measures, a vital factor for productivity growth.

Denison (2011) determined the allocation of land to produce maize, groundnut and cotton by farmers when constrained by labor and capital resources to generate the highest potential for food security and financial gains. The study was done on smallholder farmers who grow maize and groundnut for food security in Chipata District of Zambia. Data from 53 households for the 2008/09 agricultural season obtained through participant observation, informal interviews, and structured interviews using a questionnaire was analyzed using LP. The results showed that farmers made most profit by first allocating their resources to ensure that the minimum maize and groundnut requirements were met, and then allocated additional available resources to cotton. Although the LP model is an effective tool in optimization, Bidzakin *et al*. (2014) and Ogundari (2006) argue that its major limitation is the assumption that any deviation from the frontier function is due to inefficiency, therefore it is very sensitive to outliers. Observations with noise may end up as technically efficient firms.

Mofya-Mukuka and Shipekesa (2013) employed a value chain analysis approach to examine the primary stages in the groundnut value chain and constraints limiting the full functioning of the chain in Eastern Province. The study was based on a qualitative survey conducted among key actors in the value chain supported by nationally representative data. Key findings showed: (i) persistently low yields due to the low use of hybrid seed and extensive recycling of open pollinated varieties; (ii) approximately 80% groundnut grown is for home consumption leaving very little for the market; (iii) low and unpredictable prices; and (iv) high levels of aflatoxin contamination caused by poor drying and storage methods of groundnut. Our study builds on Mofya-Mukuka and Shipekesa's (2013) work by estimating the levels of profit efficiency using a stochastic frontier profit function approach to establish the gap between actual and potential profits. Our study will also identify factors that influence groundnut profit efficiency by testing for statistical significance. Since the estimation procedures are stochastic, some white noise and measurement errors are accommodated.

The existing studies on efficiency (Kabwe, 2012; Chiona *et al*., 2014; Musaba and Bwacha, 2014; Ng'ombe and Kalinda, 2015), did not focus on groundnut. There is limited application of the profit frontier function in the study of efficiency in Zambia as none of the existing studies combined both technical and allocative efficiency measures into a single estimation procedure. This shows that the existing knowledge on efficiency in crop production, especially groundnut, is inadequate. The profit function approach enables more consistent and efficient estimates to be obtained as profits and variable inputs are determined at the same time through simultaneous estimation of the system (Sidhu and Baanante, 1981; Wang *et al*., 1996).

Measuring profit efficiency level of farmers helps to determine the extent to which it is possible to raise profitability by improving the neglected sources of efficiency under the existing prices, resource base and available technology. According to Russel and Young (1983), efficiency measurements that show possibility for improved performance are useful in the formulation and analysis of agricultural policy. So far no study was done using the profit function method to evaluate efficiency of smallholder groundnut farmers in Eastern Province of Zambia. Studies done in other countries on groundnut (e.g., Taru *et al*., 2008 and Ani *et al*., 2013) may not be applicable in all aspects to the local context due to differences in institutional arrangements governing different markets in the economy as well as the economic environments. Moreover, our study introduces land tenure as an explanatory variable based on the premise that access to titled land, a proxy for tenure security, would result to increasing the profit efficiency.

## 2.8 Agricultural Production and Constraints in SSA

Agriculture is key in economic development in developing countries but, despite its importance yields remains low (World Bank, 2008; Kabwe, 2012). FAO projections show that, even with decreasing consumption, agricultural production still needs to increase by 60% (and nearly 80% in developing countries) in the next four decades to cope with a 39% increase in world population. Much of the increase in global crop production from 2000 to 2009 is attributed to improvements in yield, followed by an expansion in arable land, while a small part is due to crop intensification. However, increase in yields and more intensive use of land accounts for overall growth in crop production in developed countries (FAO, 2014).

The SSA has rapid population growth of 2.55% against a comparatively slow expansion in cultivated area of 0.90%, mostly because uncultivated land is scarce (Otsuka and Kalirajan, 2005; Alexandratos and Bruinsma, 2012; United Nations [UN], 2015). In addition, the yield of food grain per unit of land has been constant or declined in some cases. If these trends persist there is a likelihood of severe food shortages. This problem of stagnation in food production is reflected in rising poverty, reliance on food imports and food aid, as well as in increasing degradation of the natural resource base (Nkamleu, 2004). The United Nations estimated that human population in Africa is expected to double to 2.4 billion between 2015 and 2050, which will further increase demand for food (UN, 2015). This shows that Africa's food production gap demands fresh thinking and urgent attention by scientists and policy makers.

## 2.9 Overview of the Groundnut Sector

Groundnut (*Arachis hypogaea*) is an important legume and oilseed crop for most parts of the world to both smallholder and large commercial producers. Although groundnut originated in South America, it is now widely grown the in tropical, subtropical and warm temperate areas in Asia, Africa, North and South America and Oceania (Freeman *et al*., 1999). China is the largest groundnut producer in the world accounting for more than 40% share, followed by India with 15% and Nigeria at 8%. Groundnut production remained at 35 million tonnes until 2000, and then steadily rose to reach approximately 40 million tonnes in 2012. Productivity of groundnut is highest in the United States of America, China and Argentina. Although India is the largest cultivator of the crop in terms of acreage, low yields kept her in second place in terms of output, and production has been declining since 2000. SSA comprises 40% of the world's groundnut harvested area, but only contributes 26% to global groundnut production (USDA, 2015). Lower groundnut productivity in Africa and India is due to limited use of modern varieties and high dependence on rain-fed preproduction (Diop *et al*., 2004). In addition, severe drought due to inadequate and highly variable rainfall and high levels of pests and diseases are significant factors contributing to the low productivity in developing countries (Freeman *et al*., 1999; Simtowe *et al*., 2010).

The world demand for groundnut is strong and rising by 2% per year. Globally, the producer prices also increased at an average growth rate of 7.20%. China is not only the largest producer but also the largest consumer in the word. Following the increase in consumption, exports from China declined steadily from 2008 onwards. As a result, Argentina became the largest exporter of groundnut. However for two years (2010/11 and 2011/12), India became the top exporter. Major importers have been the European Union, Vietnam, Indonesia, Mexico and Russia. The increasing trend in shelled groundnut exports by 6% from 2004 to 2013 globally shows a positive future outlook (USDA, 2015). Moreover, increasing producer and export prices for both shelled groundnut and groundnut oil are expected to offer incentives for increased groundnut production. According to Woomer *et al*. (2014), two major limitations to large-scale development of groundnut as an export commodity in Southern Africa include; (i) overcoming yield gaps and (ii) the management of aflatoxins to industry standards.

The transformation of agriculture from low productive traditional inputs to high productivity modern inputs is a major problem facing agricultural development in SSA. In Zambia, production of groundnut has not significantly increased. Yields of shelled nuts average as low as 500kg per hectare. The major objective is to increase yield per unit area and expand areas under groundnut cultivation (Freeman *et al*., 1999; MAL, 2004; USDA, 2015). The adoption of and/or investments in new technologies designed to enhance farm output and income has received attention as a means of accelerating economic development (Nkamleu, 2004; Simtowe *et al*., 2010). However, output growth is not only achieved through technological innovation but also through the efficient use of such technologies. Understanding production efficiency and factors affecting it are a prerequisite to raising agricultural production, through improved farm level efficiency with the existing resource base and technology.

## CHAPTER THREE

## METHODOLOGY OF THE STUDY

### 3.1 Introduction

This chapter deals with the study methodology. It discusses the conceptual framework, data sources and sample design. The chapter also looks at the study area and the empirical model used in data analysis. Finally, limitations of the study are specified.

### 3.2 Conceptual Framework

The conceptual framework illustrated in Figure 3.1 below shows how various sets of factors interrelate to determine crop management and production decisions to influence groundnut profit efficiency within a farming system.

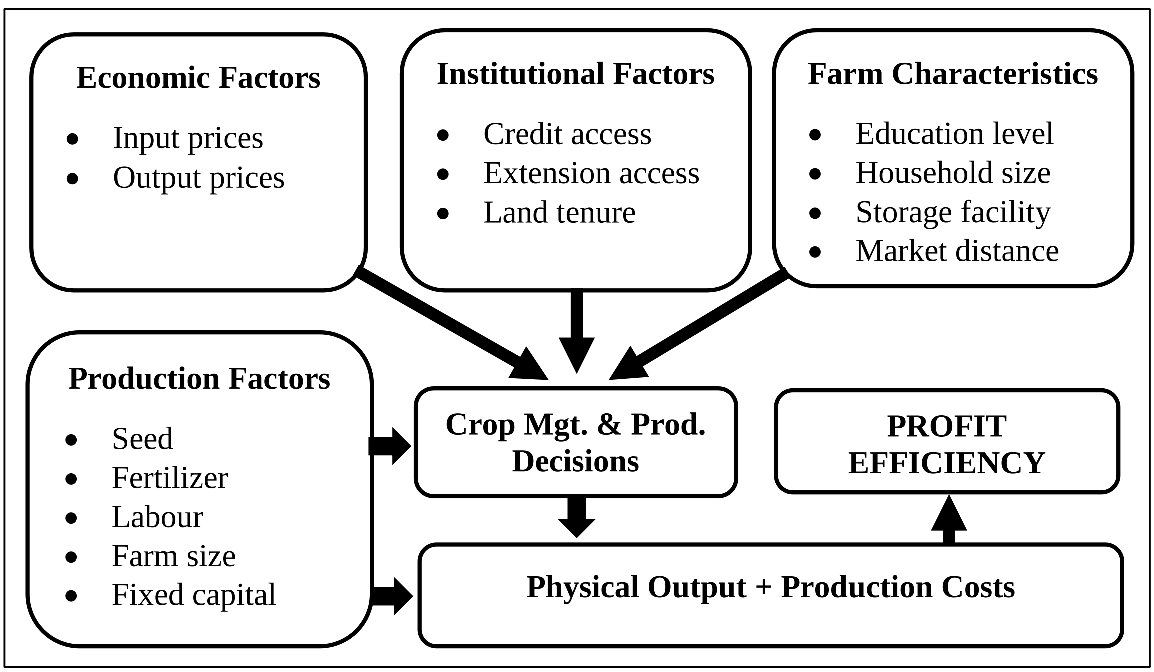



**Figure 3.1** Conceptual framework of factors influencing profit efficiency

Economic factors include input and output prices, which limit the scale of the groundnut enterprise (Taru *et al*., 2008; Ani *et al*., 2013; Ajijola *et al*., 2014). Institutional factors such as land tenure, access to credit and extension enhance the capacity of the groundnut farmer to use improved technologies on the farm. Production factors such as labour, fertilizers, farm size and capital determine resource allocation decisions on the production mix that a farmer chooses and also determine physical output (Ali *et al*., 1994; Rahman, 2003; Hyuha *et al*., 2007; Donkor and Owusu, 2014; Adamu and Bakari, 2015). Additionally, farmer and farm level characteristics including education level and household size play a key role in influencing decisions on the farm (Duraisamy, 1990; Ali *et al*., 1994).

For a production process to be effective, the manner in which available farm resources are used is important. Attainment of technical and allocative efficiency depends on these decisions, which leads to achieving profit efficiency. A farm that is profit efficient in groundnut production is expected to get higher groundnut output per hectare compared to one that is less profit efficient. Such a profit efficient farm is assumed to experience less production costs leading to higher profits.

### 3.3 Empirical Model

This study estimated a flexible translog profit function equation (3.1) and inefficiency function equation (3.2). This function has both linear and quadratic terms with possibility of using more than two factor inputs and can be approximated by second-order Taylor series[1] (Christensen *et al*., 1973; Sadoulet and de Janvry, 1995). The model is adopted from

[1] The first and second-order conditions when taken together are the necessary and sufficient conditions for profit maximization (Christensen *et al*., 1973; Sadoulet and de Janvry, 1995).

Rahman (2003) with some modifications. Thus, the explicit normalized translog stochastic profit frontier (equation 2.3) for the farm is defined as:

$$\ln \pi^* = \alpha_0 + \sum_{i=1}^{3} \alpha_i \ln P_i + \frac{1}{2} \sum_{i=1}^{3} \sum_{k=1}^{3} \tau_{ik} \ln P_i \ln P_k + \sum_{i=1}^{3} \sum_{l=1}^{2} \phi_{il} \ln P_i \ln Z_l + \sum_{l=1}^{2} \beta_l \ln Z_l$$
$$+ \frac{1}{2} \sum_{l=1}^{2} \sum_{q=1}^{2} \varphi_{lq} \ln Z_l \ln Z_q + V_i - U_i \qquad (3.1)$$

where;

$$U_i = \delta_0 + \sum_{d=1}^{8} \delta_d M_{di} + \omega_i \qquad (3.2)$$

$\pi^*$ is profit normalized by price of output ($p_y$); $P_i$ is price of the *i*th input normalized by the output price ($p_y$); $i$ = 1, 2 and 3 for seed, fertilizer and labour prices respectively; $Z_l$ is quantity of fixed input, $l$; $l$ = 1 for farm sizes and 2 for fixed capital; $V_i$ = two sided random error and can affect profit both favorably and unfavorably; $U_i$ = 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 level, household size, credit access, land tenure, extension access, market distance, storage facility and weeding duration respectively; $\omega_i$ = two sided random error; $\alpha_0$, $\alpha_i$, $\tau_{jk}$, $\beta_l$, $\phi_{lq}$, $\varphi_{il}$, $\delta_0$ and $\delta_d$ are the unknown parameters. Symmetry is imposed by constraining (3.1) according to $\tau_{ik} = \tau_{ki}$ for all $i$, $k$, and the function is homogenous[2] of degree one in prices of all variable inputs and output. The assumption is that any change in prices does not affect

[2] Homogeneity was automatically imposed in equation **(3.1)** because the normalized specification of the translog profit function was used (Rahman, 2003; Abu and Kirsten, 2009).

the optimal choices but only scales up the amount of the resulting profit by the magnitude of the price change.

The determination of elasticities is necessary to estimate the responsiveness of profit to inputs because the first-order coefficients of the translog profit function are not very informative. Rather, the profit elasticities for each of the inputs calculated at the variable means are of interest (Kibaara, 2005). The profit elasticities ($\eta$), from equation (3.1), are defined as:

$$\eta_{\pi i} = \frac{\partial \ln \pi *}{\partial \ln P_i} \tag{3.3}$$

for the elasticity of profit with respect to changes in variable input prices ($P_i$) and;

$$\eta_{\pi l} = \frac{\partial \ln \pi *}{\partial \ln Z_l} \tag{3.4}$$

for the profit elasticity with respect to changes in fixed factor inputs ($Z_l$).

The following hypotheses required testing with the likelihood ratio (LR) test;

i. $H_0$: $\tau_{ik} = \phi_{il} = \varphi_{lq} = 0$. The coefficients of the cross terms in the translog model are equivalent to zero. This null hypothesis identifies an appropriate functional form between the restrictive Cobb-Douglas and the translog profit function. 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. This means that the inefficiency term $U_i$ is absent and that the model is an ordinary average response model with $V_i$ as the only error term. This null hypothesis specifies that each farm is operating on the profit efficient frontier and that the asymmetric and random profit efficiency in the inefficiency effects are zero. This hypothesis implies that 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. If the coefficients of the inefficiency variables sum up to zero then it means even though the model might contain $U_i$, it is not significantly determined by the socio-economic and institutional variables.

The generalized likelihood ratio statistic ($LR_\lambda$) is defined with the following equation;

$$LR_\lambda = -2\{\ln[L(H_0)/(L(H_1)]\} = -2\{\ln[L(H_0)] - \ln[(L(H_1)]\} \tag{3.5}$$

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 $LR_\lambda$ has approximately a chi-square ($\chi^2$) distribution with the number of degrees of freedom equal to the number of parameters (restrictions), assumed to be zero in the null hypothesis. When $LR_\lambda$ is lower than the correspondent critical value (for a given significance level) we fail to reject the null hypothesis (Ali and Flinn, 1989; Abu and Kirsten, 2009; Chiona *et al*., 2014).

### 3.4 The Study Area

The study was done in Eastern Province since it is a top producer of groundnut. The province's population is 1,592,661 or 12% of the total population of Zambia. More than other provinces 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 farmers (27% at national level). They produce over 30,000 tonnes of groundnut per year and this equates to approximately 30% of Zambia's total output. The top four groundnut growing districts of Chipata, Petauke, Lundazi and Katete Districts account for approximately 75% of provincial output (CSO, 2013, MAL, 2013). Figure 3.2 shows a map of the Eastern Province of Zambia and the districts it contains.

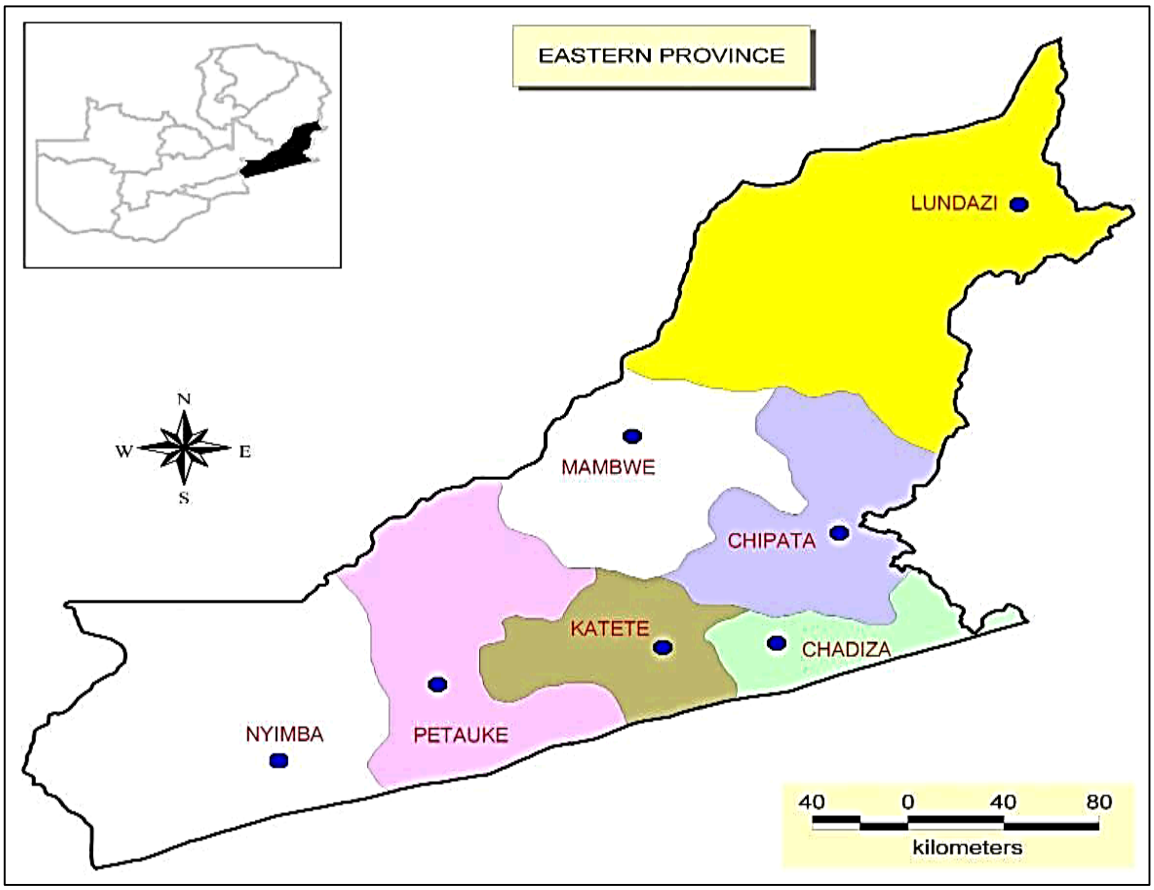



**Figure 3.2** The Eastern Province of Zambia

Source: Mofya-Mukuka and Shipekesa (2013).

The province's economy depends on agriculture with potential for smallholder-led agricultural growth. Smallholder farmers produce groundnut, 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). As poverty remains deeper and wider in the province, targeted poverty reduction programmes are required. The government has been promoting crop diversification to offer farmers alternative ways of generating income, to reduce poverty and improve food security. This is done by encouraging them to grow other crops like groundnut (under FISP and SAPP) in addition to maize.

## 3.5 Sources of Data

The study used 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 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.

### 3.5.1 Survey coverage

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 divided into 10 provinces, 74 districts, 150 constituencies and 1,430 wards, with the ward being the lowest administrative unit. The CSO further divided wards into Census Supervisory Areas (CSA), which are further 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.

### 3.5.2 Sample design and size

The sample was designed to represent rural farm households with 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 covered 8,839 households in Zambia. Each sample SEA had all households listed and a random sample of 20 was selected. During the enumeration if a household could not be visited another was selected to ensure that 20 households were interviewed in each SEA. Cross sectional data for 1,232 farm households was used in this analysis.

## 3.6 Definition of Study Variables

The choice of explanatory variables in this study was based on theory, empirical literature, data availability, and researchers' knowledge of the contextual setting.

### 3.6.1 Farm and farmer characteristics

**Education level:** Household head's highest education level was measured as number of years of formal education successfully completed, a proxy for managerial input. Farmers with more years of schooling achieve significantly higher profit efficiency than farmers with less years of schooling (Duraisamy, 1990; Ogundari, 2006; Sunday *et al.*, 2013) for they are able to perceive, interpret and respond to new information and adopt improved technologies. Education level was hypothesized have a positive impact on efficiency.

**Household size:** In all farming activities, human physical energy is required. The household size was measured as number of persons in a household. If household size increases, more needed family labour force for groundnut production is provided. Groundnut production is labour intensive, thus, there are improvements in profits with more available labour (Oladeebo and Oluwaranti, 2012; Bidzakin *et al*., 2014). A positive relationship was postulated between household size and profit efficiency.

**Market distance:** Distance (km) to nearest established main market place with many buyers and sellers of locally-produced agricultural products, was included to capture the effects of transaction costs for purchasing farm inputs and selling farm outputs. If a groundnut farm is located relatively far from the market, more time is used to obtain inputs and the transport cost is higher. This negatively affects the profit efficiency of groundnut production (Abdulai and Huffman, 2000; Musa *et al*., 2014).

**Weeding duration:** This referred to the number of weeks after planting when the household finished the first weeding. This was posited to negatively affect profit efficiency of groundnut production. Weed control is important to increase yields of the groundnut crop. Agronomists recommend that weeding is done at least twice during the growth period, within 2 to 7 weeks after sowing (N'zala *et al*., 2002; Ministry of Agriculture and Food Security [MoAFS], 2012). Weeds positively affect profit inefficiency (Assa *et al*., 2012; Musa *et al*., 2014).

**Storage facility:** This referred to availability of a groundnut storage facility, a structure used for long-term storage after drying for future home consumption or for sale. A storage facility referred to a crib with sides made of wood, bricks or mud and/ or a cement plastered structure with a roof. It can be inferred that availability of a storage facility reduces profit inefficiency (Mohammed *et al*., 2013). The variable was dichotomous, 1 if the household had a storage facility and 0 otherwise.

### 3.6.2 Institutional factors

**Credit access:** Credit enables adoption of improved technology, which in turn should cause a reduction in profit inefficiency (Abdulai and Huffman, 1998; Hyuha *et al*., 2007). This was measured as a binary variable, 1 if household accessed credit to support agricultural production and 0 otherwise.

**Land tenure:** Land title was used as a proxy for tenure security. Titles increase farmers' access to formal credit which leads to a higher likelihood of land improvements, more intensive use of variable inputs, and higher yield per unit of land (Place and Otsuka, 2002). It is thus assumed that titled land is positively related to profit efficiency (Donkor and Owusu, 2014). This was measured as a dummy variable, 1 if titled state or customary land and 0 otherwise.

**Extension access:** Extension advice affords the farmer opportunity to acquire skills and adopt new innovations (Ali *et al*., 1994; Hyuha *et al*., 2007). This was measured as a dichotomous variable, 1 if the household accessed extension and 0 otherwise.

### 3.6.3 Production and economic factors

**Seed price:** Price of seed was computed as total seed expenditure (including transport cost) per kilogram and was postulated to have a negative relationship with profit (Rahman, 2003; Ani *et al*., 2013).

**Fertilizer price:** This was measured as the total expenditure on fertilizer per kilogram. The variable was postulated to have a negative relationship with profit (Wang *et al*., 1996).

**Labour wage:** Wage rate was measured as the total cost of human labour for family members and hired labourers per labor-day. Labor was valued at the agricultural wage rates prevailing in the local area. Labor-days were computed according to the rule that one adult male, one adult female and one child (< 18 years) working for one day (8 hours) equals 1 labor day; 0.75 labor days; and 0.50 labor days, respectively. This variable is expected to have a negative relationship with profit (Duraisamy, 1990; Ajijola *et al*., 2014).

**Farm size:** Land is one of the major factors used in agricultural production. This continuous variable referred to the total arable farmland that a farmer owned measured in hectares. Larger farms in addition to good management practices translates into increased outputs and income (Wang *et al*., 1996; Okoruwa *et al*., 2009; Ajijola *et al*., 2014). Farm size was thus hypothesized to affect profit efficiency positively.

**Fixed capital:** Among fixed inputs included in the profit frontier was the value of fixed farm capital, a continuous variable measured in ZMW. This was computed as the total value of capital assets or implements owned by the household including motorized or hand-operated groundnut sheller, ox-drawn plough, rippers, knapsack sprayer, weeder and oil expellers used in groundnut production. Fixed capital affects productivity and was hypothesized to have a positive relationship with profit (Rahman, 2003; Hyuha *et al*., 2007; Kabwe, 2012).

The potential explanatory variables hypothesized to influence smallholder groundnut farmers' profit efficiency in the study area are summarized and presented in Table 3.1.

**Table 3.1** Variable descriptions, measurement and hypothesized relationships

| Variable | Description | Expected Sign | References |
|---|---|---|---|
| ***Inefficient Factors*** | | | |
| Education level | Completed highest level of formal education of household head (years). | + | Ali *et al*., 1994; Ogundari, 2006; Sunday *et al*., 2013. |
| Household size | Number of people in household (proxy for labour). | + | Oladeebo & Oluwaranti, 2012; Bidzakin *et al*., 2014. |
| Market distance | Distance to nearest established market place (kilometers). | - | Abdulai & Huffman, 2000; Mohammed *et al*., 2013. |
| Weeding duration | Duration after planting when the household finished the first weeding (weeks). | - | N'zala *et al*., 2002; MoAFS, 2012; Musa *et al*., 2014. |
| Storage facility | Availability of a groundnut storage facility (available=1, not available=0). | + | MAL, 2004; Mohammed *et al*., 2013. |
| Credit access | Access to credit by household to support agricultural production (yes=1, no=0). | + | Abdulai & Huffman, 1998; Hyuha *et al*., 2007. |
| Land tenure | Land title as a proxy for tenure security (titled land=1, no title=0). | + | Place & Otsuka, 2002; Donkor & Owusu, 2014 |
| Extension access | Access to advice on problems associated with aflatoxins in g/nuts (yes=1, no=0). | + | Ali *et al*., 1994; Hyuha *et al*., 2007. |
| ***General Model*** | | | |
| Seed price | Normalized price of seed per kilogram (ZMW). | - | Rahman, 2003; Ani *et al*., 2013. |
| Fertilizer price | Normalized price of fertilizer per kilogram (ZMW). | - | Wang *et al*., 1996; Taru *et al*., 2008. |
| Labour wage | Normalized wage of hired and family labour per day (ZMW). | - | Duraisamy, 1990; Ani *et al*., 2013; Ajijola *et al*., 2014. |
| Farm size | All land operated for agricultural purposes owned by the farmer (hectares). | + | Wang *et al*., 1996; Okoruwa *et al*., 2009. |
| Fixed capital | Value of fixed capital assets owned by the farm household (ZMW). | + | Rahman, 2003; Hyuha *et al*., 2007; Rachmina *et al*., 2014. |

### 3.7 Limitations of the Study

This study was restricted to measuring profit efficiency, determinants and efficiency levels. In addition, the study used only one approach to evaluate profit efficiency. Frontier functions assume that all inputs are taken into consideration. However, in this study, it is possible to raise questions about whether all inputs have actually been accounted for, since farms that are apparently inefficient may just use less of certain unmeasured inputs. Models relying on panel data are likely to yield more accurate efficiency estimates given that there are repeated observations on each unit. However, this study used cross-sectional data since the preference is on the SFA approach of estimation which does not necessarily require panel data to accomplish. It was also assumed that profit maximization dominated groundnut production decisions against utility maximization or risk minimization as the production objective. Only information for smallholder farmers and the groundnut crop was used, but the results can be generalized to the performance of farmers in Eastern Province.

# CHAPTER FOUR

# CHARACTERISTICS OF HOUSEHOLDS

## 4.1 Introduction

This chapter gives descriptive statistics of an important set of explanatory variables used in the empirical model for the sample farm households. These take account of; (i) farm and farmer characteristics, (ii) institutional factors and, (iii) production and economic factors. The purpose is to offer a general understanding about the farmers and their situation. This is necessary to understand how socio-economic situations influence farming decisions.

## 4.2 Farm and Farmer Characteristics

The results in Table 4.1 show farm characteristics (distance to market, household size, weeding duration and availability of a storage facility) and farmer characteristics (education level, age and gender of household head) of the selected households.

**Table 4.1** Summary statistics of farm and farmer characteristics

| Variables | Mean | Std. deviation |
|---|---:|---:|
| Education level (years) | 5.09 | 3.99 |
| Gender (% female=0) | 19.97% | |
| Age (years) | 46.08 | 14.84 |
| Household size (number) | 5.81 | 2.59 |
| Market distance (kilometers [km]) | 21.06 | 8.99 |
| Weeding duration (weeks) | 3.16 | 1.15 |
| Storage facility (% available=1) | 48.94% | |
| Sample size | 1,232 | |

Source: 2012 Rural Agricultural Livelihoods Survey data.

### 4.2.1 Education level of household head

A look at education levels shows that on average household heads had about 5 years of formal education (Table 4.1). Eastern Province lags behind in terms of general educational attainment in Zambia because the average years of formal education for household members is less than the national average of 6.7 years. Education is important in improving efficiency as it affects the allocative ability of a farmer (Ogunniyi, 2011; Kabwe, 2012).

### 4.2.2 Gender of household head

The results in Table 4.1 reveal that out of 1,232 smallholder farm households selected for analysis, female headed households comprise 19.97% compared to 22.80% at national level (CSO, 2013). This means that most groundnut growing households (80.03%) are headed by males. This agrees with Zulu *et al*. (2014) who reported that 77.85% of households that grew groundnut were male headed in Zambia.

### 4.2.3 Age of household head

The overall average age of farmers in the province is 46 years (Table 4.1). This is consistent with national statistics, which estimate that 67.50% of the household heads are of ages 25 to 59 years with very few being 60 years or older (CSO, 2012a). This shows that the groundnut farmers are economically active, with capacity to adopt new farming practices. Musaba and Bwacha (2013) also reported an average age of 46 years for small scale maize farmers in Masaiti District of Zambia.

### 4.2.4 Household size

While nationally an average household has 5.3 persons, results in Table 4.1 show that an average household had 6 members. This agrees with Chiona *et al*. (2014) who revealed that farming households in Central Province of Zambia had an average household size of 6 members. Household size determines the amount of family labour available for farm activities and larger households implicitly mean increased labour force for agricultural production. In Eastern Province, larger households had more family labour needed for groundnut production.

### 4.2.5 Distance to market

The respondents reported on average 21 kilometers of distance to the nearest established market place (Table 4.1). The results also show a substantial variation of distances from the average, with a standard deviation of 9 kilometers. Distance to the market is an indicator of access to markets, organized trade and proximity to economic resources. The results agree with national statistics which show that more than 50% of the households in rural areas are at a distance of over 16 kilometers from a market in Zambia (CSO, 2012a).

### 4.2.6 Weeding duration

The results in Table 4.1 show that, on average, duration of 3.16 weeks was the earliest time after planting a household completed first weeding. Thorough weed control is very important before pegging. During pegging, only hand weeding must be done to avoid damage to developing pods (MoAFS, 2012; Ross and de Klerk, 2012). Instead of using herbicides, most smallholder farmers use manual labor to control weeds in the fields and weed management is the most time consuming and labor intensive activity during the growing season.

Our study established that few farmers (1.26%) applied herbicides to their groundnut fields. This corroborates with Burke *et al*., (2011) who pointed out that only 3% of maize fields had herbicides applied among smallholder farmers in Zambia. Soil fertility programs and timing of completion of first weeding after crop emergence are critical to achieving good yields (CSO, 2012b). Timely weeding improves technical efficiency (Musa *et al*., 2014).

### 4.2.7 Storage facility

Nearly 48.94% of sampled farmers had groundnut granary (storage) facilities (Table 4.1). This means that more than half of the farmers were unable to store groundnut for a longtime due to lack of storage facilities. Storage has an advantage of minimizing post-harvest losses and increasing market flexibility as farmers with storage facilities do not need to market their produce at once and immediately after harvest (MAL, 2004). In Zambia, national statistics show that 68% of the households use some rooms in main house to store their groundnut and only 21% use cribs. Only less than 2% of the households use other types of groundnut storage facilities (CSO, 2013).

## 4.3 Institutional Factors

Institutional factors are important determinants of profit efficiency in crop production. Table 4.2 presents a summary of the institutional factors.

**Table 4.2** Summary statistics of institutional factors

| Variables | Frequency | Percentage (%) |
|---|---|---|
| Extension access (yes=1) | 542 | 43.99 |
| Land tenure (titled land=1) | 96 | 7.79 |
| Credit access (yes=1) | 622 | 50.49 |
| Cooperative membership (yes=1) | 700 | 56.82 |
| Sample size | 1,232 | |

Source: 2012 Rural Agricultural Livelihoods Survey data.

### 4.3.1 Extension access

On average, 43.99% of the farmers had access to extension service (Table 4.2). The results show that there is less than 50% coverage of extension services in the study area. In Zambia, agricultural extension services are provided through extension workers of MAL, complemented by Non-Governmental Organizations and private seed companies. Extension exposes farmers to better techniques and contributes to greater efficiency (Ali *et al*., 1994).

### 4.3.2 Land tenure

The results in Table 4.2 show that on average only 7.79% of the households had titled state or customary land, with title deeds renewable after 99 years. Most households (92.21%) had land that was owned without title. This implies that titled land ownership is limited among smallholder farmers in Eastern Province and in the rest of Zambia. Although the decline in crop yields is related to several factors, it may also be a result of insecure land tenure systems (Kariuki *et al*., 2008). Out of the estimated 1.5 million smallholder farmers in Zambia, only 3% have title deeds. The lack of title deeds discourages farmers from adopting sustainable and long-term land management practices (Jayne *et al*., 2008; Sitko *et al*., 2014).

### 4.3.3 Credit access

The proportion of farmers that had access to credit to support agricultural production was approximately 50% (Table 4.2). This credit was mainly accessed through out-grower scheme loans and informal money lenders. On average, the value of ZMW 329.44 credit obtained was inadequate for farmers to obtain appropriate inputs, machinery and equipment to increase production in the study area. Access to credit from commercial banks and the private sector was less than 1% because they are reluctant to give long term agricultural loans to smallholder farmers who have low collateral and poor loan repayment reputation. Further, the loans were also expensive as interest rates of 20% to 30% are too high (MAL, 2004).

### 4.3.4 Cooperative membership

The majority (56.82%) of the farmers were members of cooperatives (Table 4.2). Cooperative membership is a requirement for a farmer to receive subsidized improved seed and fertilizer under the FISP in Zambia (MoA, 2016). The use of such inputs in groundnut production increased profit efficiency.

## 4.4 Production and Economic Factors

The summary statistics for production and economic factors are reported in Table 4.3.

**Table 4.3** Summary statistics of production and economic factors

| **Variables** | **Mean** | **Std. deviation** |
|---|---:|---:|
| Gross margin (ZMW/ha) | 2,374.60 | 45.56 |
| Yield (kilogram [kg]/ha) | 500.94 | 421.78 |
| Output price (ZMW/kg) | 3.61 | 0.83 |
| Seed price (ZMW/kg) | 3.50 | 1.42 |
| Fertilizer price (ZMW/kg) | 3.83 | 0.41 |
| Labour wage (ZMW/day) | 14.13 | 6.91 |
| Farm size (hectares [ha]) | 0.92 | 0.70 |
| Fixed capital (ZMW/household) | 7,061.05 | 2,470.00 |
| Sample size | 1,232 | |

Note; 1 US $ = 5.239 ZMW (approximately) as of April, 2012 currency exchange rate.
Source: 2012 Rural Agricultural Livelihoods Survey data.

### 4.4.1 Gross margin

Table 4.3 shows that households obtained varied gross margins with an average of ZMW 2,374.60 per hectare from groundnut sales after deducting the costs of labor, fertilizer and seed, for which data were available. This means that groundnut production provides positive returns and is therefore attractive to farmers in the study area. Tembo and Sitko (2013) showed that, on average, a hectare of groundnut in 2012 provided a mean gross margin of ZMW 1,502.49 per hectare for in Eastern Province, slightly lower than the national average of ZMW 1,864.43. The value was also lower compared to the gross margin for maize (ZMW 2,297.30) in Zambia. The gross margins estimated in this study were not net profits. This is because some fixed costs such as capital and land were not considered due to lack of reliable data. However, as stated earlier, gross margin over the growing season was used as a proxy for profit.

### 4.4.2 Groundnut yield

An average shelled groundnut yield of 500.94 kg (0.50 tonnes) per hectare was recorded for the sampled area (Table 4.3). This is close to 0.52 tonnes per hectare national average and 69% lower than 1.63 tonnes per hectare world average (Alexandratos and Bruinsma, 2012; MAL, 2013). Yield varied widely with a standard deviation of 421 kg per hectare about the mean, reflecting the existence of differences in input and factor endowments among farm households. Such differences are expected to bring differences in profit efficiency. Expected yield of 2.3 tonnes per hectare of groundnut can be produced in the study area (Ross and de Klerk, 2012). Therefore, the potential to realize substantial higher yields exists.

### 4.4.3 Output price

An average groundnut output price of ZMW 3.61 per kg was recorded (Table 4.3). Prices in Zambia vary from ZMW 1.80 to ZMW 6.00 per kg within one season, depending on when the selling is done, whether it is a cash or credit transaction and distance to markets. The fact that groundnut sold early in the marketing season contain more moisture slightly compensates for the low per kg prices at this time (Denison, 2011; Mofya-Mukuka and Shipekesa, 2013).

### 4.4.4 Seed price

Seeds are an important input determining productivity of a farm activity. The demand for seed does not only concern quantity, but more importantly the quality (Rachmina *et al*., 2014). The results in Table 4.3 show that the average seed price was 3.50 ZMW per kg. This is lower than the subsidized price of maize and rice seed of ZMW 4.00 per kg. With the subsidized price of groundnut at ZMW 6.00 per kg under FISP, 65% of farmers opt use recycled seed from own harvest or get maize seed which is relatively cheaper (MoA, 2016). Variations in seed prices were attributed in part to differences in transport costs. Purchased improved seed inputs can be profitable compared to recycled seed which hinder increased productivity. In a study by Chirwa *et al*. (2014) in Chisamba District of Zambia, the price of a 10 kg bag of MGV5 and MGV4 at ZMW 188.00 was too expensive for smallholder farmers.

### 4.4.5 Fertilizer price

The average price of fertilizer reported among the sampled farm households was 3.83 ZMW per kg (Table 4.3). During the period under study, groundnut farmers bought fertilizer through the subsidy scheme. Fertilizers under FISP were distributed at ZMW 1.80 per kg, 64% lower than commercial prices of ZMW 4.50 per kg (MoA, 2016). Though a fertilizer subsidy was in effect during the survey period, there was a variation in observed fertilizer prices.

### 4.4.6 Labour wage

The estimated average cost of labour in Table 4.3 was ZMW 14.13 per day. Farming activities were conducted using mostly family labor and, in some cases, hired labor was used especially during peak periods such as field preparation and weeding. In a study by Denison (2011) the cost of hired labour for farm work was ZMW 10.00 per half day and ZMK 20.00 per day in the study area. Their study also found ZMW 300.00 as labour cost for groundnut per hectare, higher than for maize (ZMW 192.50) but lower than for cotton (ZMW 1,920.00).

### 4.4.7 Farm size

The average farm size was 0.92 hectares (Table 4.3). The farm size confirms that the farmers were small-scale operators who could hardly generate enough farm income for their families.  Ng’ombe and Kalinda (2015) estimated a higher average farm size of 1.61 hectares for smallholder farmers who produce maize under minimum tillage in Zambia. A study by Smale and Mason (2014) found that farm size had a significant effect on the quantity of hybrid seed planted among smallholder maize farmers in Zambia.

### 4.4.8 Fixed capital

The average value of fixed capital among the households was ZMW 7,061 (Table 4.3). Smale and Mason (2014) estimated that the average value of total productive assets for smallholder maize-growing households in Zambian was ZMW 4,900.02 in 2006. The average total value of productive assets for maize growers who do not plant hybrid seed was less than half that of hybrid seed users (ZMW 8,610.57 vs. 2,144.12). This implied that farmers that did not plant purchased hybrid seed were economically disadvantaged relative to those that did. Ng'ombe and Kalinda (2015) reported that maximum capital owned by smallholder farm households in Zambia was ZMW 16,700. Beside infrastructure, fixed assets determine profit and farming efficiency (Farrell, 1957; Rachmina *et al*., 2014).

### 4.5 Concluding Remarks

The Eastern Province is lagging behind in educational attainment because households live far (about 6km) from the nearest school in rural areas. The lower levels of formal education among the smallholder farmers makes it difficult for them to take full advantage of good farm practices and market opportunities. The overall average age of 46 years shows that the farmers are within an active age group and are likely to adopt new technologies. Only half of the farm households in the study area had access to loans/credit to support agricultural production during the growing season. The lack of access to credit by some farmers translates into inadequate working capital, and so, they were unable to purchase productivity-enhancing inputs such as seed, fertilizer, labour, machinery and equipment to increase production.

The average gross margin revealed that groundnut production is profitable in the study area. Furthermore, titled land ownership is very limited among the smallholder farmers. As a result, they are unable to access loans using the land as security. The finding implies that, on average, only less than 8% of the fields are owned with title. The results further reveal that the potential to achieve substantially higher yields per hectare exists in the Eastern Province of Zambia. However, it can be inferred that lower market prices at the time of harvest decrease interest to engage in production among farmers who were unable to store their groundnut for a longtime. This implies that prices received by individual farmers for groundnut produce also depended on how long they can delay the sale.

# CHAPTER FIVE

# EMPIRICAL RESULTS AND DISCUSSIONS

## 5.1 Introduction

This chapter is devoted to the results of the profit frontier model. The major determinants of profit efficiency in groundnut production among the farmers were later discussed. The research hypotheses tested were: (i) smallholder farmers are not profit efficient in groundnut production and; (ii) socio-economic and institutional factors do not significantly influence profit efficiency of smallholder groundnut farmers.

## 5.2 Hypothesis Tests for Model Specification

The likelihood ratio test was used to verify consistency of specific hypotheses related to the profit frontier function adopted in the empirical model, as stated in section 3.3 of chapter three. Table 5.1 presents the statistical tests that were applied and the results.

**Table 5.1** 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 | 0.000 | Reject $H_0$; Translog is appropriate |
| $H_0$: $\gamma = 0$ | 8.36 | 1 | 0.002 | Reject $H_0$; Inefficiency effects are present in the model |
| $H_0$; $\gamma = \delta_0 = \delta_1 = \ldots \delta_8 = 0$ | 6.96 | 8 | 0.000 | Reject $H_0$; Explanatory variables determine the *Ui* |

Note: The parameters for the null hypotheses are as defined in section 3.3.

The first statistical test in Table 5.1 was carried out to test for the Cobb-Douglas hypothesis. The null hypothesis identifies an appropriate functional form that fits the data between the restrictive Cobb-Douglas and the translog production function. According to Sidhu and Baanante (1981), for the profit function to be Cobb-Douglas, coefficients of all second order terms ($\tau_{ik}$, $\phi_{il}$ and $\varphi_{lq}$) in equation (3.1) should be zero. The null hypothesis was rejected in favour of translog frontier function since the generalized likelihood-test statistic of 45.36 is significantly different from zero at the 1% level, p = 000. The implication is that the translog does not reduce to the Cobb-Douglas profit function in this case. Therefore, results from the translog model are more accurate and an adequate representation of the data, given the assumptions of the frontier model (Kibaara, 2005; Abu and Kirsten, 2009).

The second null hypothesis ($\gamma = 0$) specifies that the inefficiency effects are absent in the model. The profit function without inefficiency component is tested against the profit function with the inefficiency components as specified in equation (3.1). The system of log likelihood ratio test used to find out the presence of inefficiency rejected the null hypothesis at the 1% level of significance ($LR_{\lambda}$ statistic 8.36, $p = 0.002 < 0.01$) 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. This result showed that the stochastic frontier profit function was more appropriate to fit the data than the average response profit function estimated by OLS (Ali and Flinn, 1989; Adamu and Bakari, 2015).

The last test in Table 5.1, ($H_0$; $\gamma = \delta_0 = \delta_1 = \ldots \delta_8 = 0$), specifies that inefficiencies are absent from the model at every level. The null hypothesis is rejected at the 1% level ($LR_{\lambda}$ statistic 6.96, $p = 0.000 < 0.01$). These results confirm that the joint effect of socio-economic and institutional indicators of profit inefficiency is statistically significant. Therefore, some variables included in the inefficiency effects model can explain the inefficiency term $U_i$ (Battese and Coelli, 1995; Chiona *et al*., 2014). As a result the decision to exclude them was discarded.

### 5.3 Analysis of Groundnut Farmers' Profit Efficiency

The maximum likelihood estimates of the parameters of the stochastic profit frontier model are presented in Table 5.2. The model gave a Wald chi-square statistic of 140.69 which was significant at 1%, implying that all covariates in the model are jointly significant. The variables included were tested for multicollinearity using Variance Inflation Factor (VIF). The mean VIF was 1.41. Since the mean VIF is less than 10, we conclude that there was virtually no multicollinearity in the model. 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 ($p = 0.168 > 0.05$). In addition, a sigma square ($\sigma^2$) 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 (Rachmina *et al*., 2014). 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 ($\gamma$) is statistically greater than zero at the 1% level and comparatively large (0.6445) given the (0, 1) interval within which $\gamma$ lies. The value of $\gamma$ shows that 64.45% the 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 which makes the profit frontier stochastic (Rahman, 2003).

**Table 5.2** Results of the translog stochastic profit frontier analysis

| Variables | Parameters | Coefficients | Std. error | p-values |
|---|---|---|---|---|
| **General model** | | | | |
| Constant | $\alpha_0$ | 8.3753*** | 1.7199 | 0.000 |
| $\ln P_1$ (Seed) | $\alpha_1$ | 1.0097** | 0.4628 | 0.029 |
| $\ln P_2$ (Fertilizer) | $\alpha_2$ | -1.3225 | 0.8707 | 0.129 |
| $\ln P_3$ (Labour) | $\alpha_3$ | -0.5549 | 0.4724 | 0.240 |
| $½\ln P_1 \times \ln P_1$ | $\tau_{11}$ | 0.0674 | 0.0522 | 0.196 |
| $½\ln P_2 \times \ln P_2$ | $\tau_{22}$ | -0.3051 | 0.3413 | 0.371 |
| $½\ln P_3 \times \ln P_3$ | $\tau_{33}$ | -0.0085 | 0.1259 | 0.946 |
| $\ln P_1 \times \ln P_2$ | $\tau_{12}$ | 0.3919** | 0.1845 | 0.034 |
| $\ln P_1 \times \ln P_3$ | $\tau_{13}$ | -0.1230 | 0.1085 | 0.257 |
| $\ln P_2 \times \ln P_3$ | $\tau_{23}$ | 0.1694 | 0.1646 | 0.303 |
| $\ln P_1 \times \ln Z_1$ | $\phi_{11}$ | 0.1654* | 0.0915 | 0.070 |
| $\ln P_1 \times \ln Z_2$ | $\phi_{12}$ | -0.0517* | 0.0270 | 0.056 |
| $\ln P_2 \times \ln Z_1$ | $\phi_{21}$ | 0.1614 | 0.1574 | 0.305 |
| $\ln P_2 \times \ln Z_2$ | $\phi_{22}$ | 0.1340** | 0.0498 | 0.007 |
| $\ln P_3 \times \ln Z_1$ | $\phi_{31}$ | 0.0861 | 0.0754 | 0.254 |
| $\ln P_3 \times \ln Z_2$ | $\phi_{32}$ | 0.0209 | 0.0260 | 0.422 |
| $\ln Z_1$ (Farm size) | $\beta_1$ | 0.4338 | 0.4096 | 0.290 |
| $\ln Z_2$ (Fixed capital) | $\beta_2$ | 0.3537* | 0.1916 | 0.065 |
| $½\ln Z_1 \times \ln Z_1$ | $\varphi_{11}$ | -0.0576 | 0.0807 | 0.476 |
| $½\ln Z_2 \times \ln Z_2$ | $\varphi_{22}$ | 0.0151 | 0.0127 | 0.232 |
| $\ln Z_1 \mathrm{x} \ln Z_2$ | $\varphi_{12}$ | 0.0005 | 0.0221 | 0.982 |
| **Diagnostic statistics** | | | | |
| Sigma-square | $\sigma^2 = \sigma^2_v+\sigma^2_u$ | 0.7105*** | 0.0596 | 0.000 |
| Gamma | $\gamma = \sigma^2_u/\sigma^2_v + \sigma^2_u$ | 0.6445*** | | 0.000 |
| Log likelihood function | (llf) | -1316.5914 | | |
| Wald chi$^2$ (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. The dependent variable is normalized groundnut gross margin (proxy for profit) from an output of the 2010/2011 agricultural season measured in ZMW.

Source: 2012 Rural Agricultural Livelihoods Survey data.

The result of $\gamma$ 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 farmer's control, confirming that a high level of inefficiency exists in groundnut farming and is indeed stochastic (Kumbhakar *et al*., 1989; Abdulai and Huffman, 1998; Kibaara, 2005; Adamu and Bakari, 2015). We, thus, accept the null hypothesis that smallholder farmers are not profit efficient in groundnut production.

Except for seed price, all the estimated parameters of the normalized profit function, based on the assumption of competitive markets, carry the theoretically expected signs in the model. The estimated function reveals that the price of seed and the value of fixed capital significantly affected the farm level profit and have important implications on the profit efficiency of groundnut farmers in the study area. The results further show that fertilizer price, labour wage and farm size had the expected signs but were not significant. The interaction parameters are not explained because they have no economic meaning (Abdullai and Huffman, 2000; Okoruwa *et al*., 2009; Ogunniyi, 2011).

The reason for the insignificance of the fertilizer cost might be because the government provides the fertilizers to most farmers at subsidized prices through FISP (MoA, 2016). Some farmers are able to obtain an adequate supply of fertilizer at the GRZ distribution price, applied mostly to maize. 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. The farm size coefficient (0.4338) in Table 5.2 shows that although farm size has a positive relation with normalized profit, the effect is not significant. This outcome does not mean that farm size is not important in increasing farm profit, but there are other variables that have more influence than farm size (Battese and Coelli, 1995).

**Seed price**

The sign on the coefficient on seed price was positive (contrary to the expected negative sign) and significant at the 5% level (Table 5.2). Price of improved seed varieties shows a positive effect on profit and the effect is very large since the coefficient (1.0097) is greater than one. Most seed sold in agro dealer shops is in fact recycled seed that is acquired from local farmers and then repackaged (Mofya-Mukuka and Shipekesa, 2013). Thus farmers believe that the more expensive the seed, the better it is for groundnut production. This shows that the marginal value productivity of improved seed was greater than its price, making it rational to obtain a higher profit with increased price and quality. This result shares the opposite version of the law of profits in production but it agrees with Mohammed *et al*. (2013). Adamu and Bakari (2015) also reported that using high quality seed, which was relatively expensive than local variety seed, increased farm profits of rain-fed rice farmers in Nigeria.

**Fixed capital**

The coefficient on fixed capital (0.3537) in Table 5.2 has a significant positive relationship with farm profit at the 10% level. This shows that capital is an important factor in explaining changes in profit. The implication is that an increase in the value of fixed capital assets owned by a farmer will bring about an increase in farm profit. Thus, expansion in farm capital, in the form of necessary tools, implements and equipment contributes positively to groundnut supply and significantly increases farm profit. Increased capital facilitates increased output, which in turn leads to increased profit (Abu and Kirsten, 2009). This is in line with Hyuha *et al*. (2007) who observed a positive relationship between capital and gross profit among rice producers in Uganda. Rachmina *et al*. (2014) also reported that capital asset accumulation increased profit in vegetable farming in Indonesia.

### 5.4 Profit Elasticities

The profit elasticities ($\eta$) with respect to changes in variable input prices and fixed factors, computed at mean values, are shown in Table 5.3. The profit elasticities associated with all the variables were less than one, except for capital. Estimates of the profit elasticities 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).

**Table 5.3** Estimated profit elasticities of input prices and fixed factors

| Prices and fixed factors | Profit elasticity |
|---|---|
| With respect to: | |
| $P_1$ (Seed) | 0.44 |
| $P_2$ (Fertilizer) | -0.03 |
| $P_3$ (Labour) | -0.08 |
| $Z_1$ (Farm size) | 0.02 |
| $Z_2$ (Fixed capital) | 1.25 |

Source: 2012 Rural Agricultural Livelihoods Survey data.

**Price of seed:** The price of seed (0.44) dominates profit share followed by labour wages and price of fertilizer among the variable production costs that affect profits (Table 5.3). A 10% increase in price of seed would increase profitability by 4.40%, ceteris paribus. The reason is that a higher price of seed means that farmers use higher qualities of improved seed varieties as opposed to recycled seed and yield will be indirectly increased (Adamu and Bakari, 2015). However, a unit increase in price would still result in less than a unit increase in profits.

**Price of fertilizer:** The profit elasticity with respect to fertilizer price (-0.03) implies that a 10% rise in fertilizer price will reduce profitability by 0.30%. Similarly, a unit increase in fertilizer price would result in less than a unit decrease in profits among the groundnut farmers. The elasticity of profit in terms of the price of fertilizer was among the lowest. The reason for its lesser contribution to profit is that most farmers do not use fertilizer in groundnut production (Denison, 2011; Ross and de Klerk, 2012).

**Labour wage:** If labour wage increases by 10%, profitability is reduced by 0.80%. The elasticity of -0.08 shows that holding all other factors constant, a unit increase in labour wage is associated with a less than unit reduction in groundnut profits in the study area. An increase in labour wage has a relatively small effect on reducing the profit for the reason that groundnut labour is largely provided by household members (Mofya-Mukuka and Shipekesa, 2013).

**Farm size:** Profit response to size of land operated for agriculture purposes is very low. The elasticity estimate reveals that a 10% increase in farm size will raise profits by 0.20%. Thus, a rise in farm size has a small contribution to smallholder farm income in the short-run. The highly inelastic response to farm size may reflect the presence of other institutional constraints that limit groundnut profitability. As shown by Sitko *et al*. (2014), obtaining land title in Zambia is not very easy. A few people who are relatively better-off, more educated, and have access to wage income are able to go through the long and expensive process, regardless of whether it is state or customary land.

**Fixed capital:** The incremental contribution of capital to profit (1.25) is very elastic, showing that a 10% increase in value of fixed capital will increase profits by 12.50% (Table 5.3). The implication is that even small increments in the value of fixed capital can have relatively large impact on profit. The results also show that capital is the most limiting factor in groundnut profitability (Adesina and Djato, 1997), suggesting that technologies that enhance the value of fixed capital are likely to achieve significant positive effects on groundnut profits.

### 5.5 Levels of Profit Efficiency

The distribution of profit efficiency in groundnut production is presented in Table 5.4. The farmers exhibit a wide range of profit efficiency from 9.50% to 92.38% for the worst and best farmers, respectively. The result 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 most efficient groundnut farmer did not achieve the optimal resource allocation and needed improvements to attain the frontier profit. This improvement can be achieved if the determinants of inefficiency are minimized. Similar results were reported by Ojo *et al*. (2009) who obtained a minimum of 11.62% and a maximum of 91.90% efficiency scores for cowpea farmers in Niger State of Nigeria. Wang *et al*. (1996) documented similar findings, where profit efficiency estimates ranged from 13% to 93% for Chinese farm households.

**Table 5.4** Distribution of profit efficiency scores among farmers

| 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: 2012 Rural Agricultural Livelihoods Survey data.

The average profit efficiency score of 0.725 (Table 5.4) show that groundnut farmers achieved, on average, 72.50% level of efficiency. This implies that considerable or significant amount of profit (about 27.50%) is lost from groundnut production in 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 groundnut in the area is not produced due to profit inefficiency in resource use among the groundnut farmers. The producers can increase their profits by 27.50%, on average, to strengthen their competitiveness in the short run through the adoption of best farm practices that reduce inefficiencies (e.g. timely weeding) to attain the frontier. The result agree with Rahman (2003) who reported mean profit efficiency levels of 0.77 for Bangladeshi rice farmers and also Oladeebo and Oluwaranti (2012) who recorded a mean profit efficiency level of 79% for cassava producers in Southwestern Nigeria.

Despite the variation in efficiency, Figure 5.1 shows that about 68.90% 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 a 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 show that individual differences in profit efficiency levels at farms partly contributed to variation in their total groundnut profits.

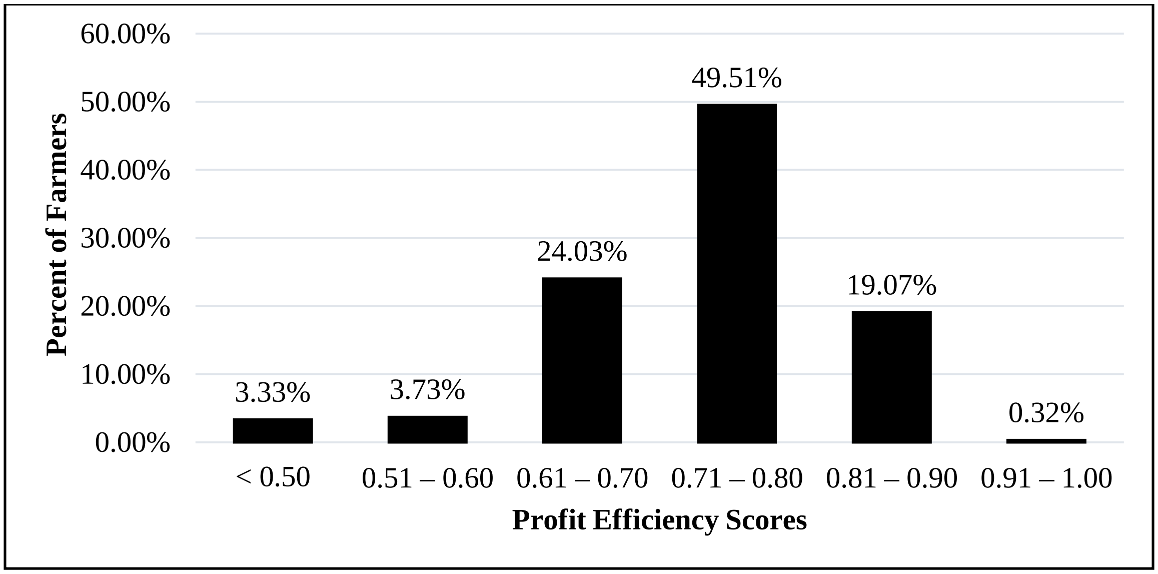



**Figure 5.1** Percentage distribution of farmers by profit efficiency score

Source: 2012 Rural Agricultural Livelihoods Survey data.

### 5.6 Determinants of Profit Inefficiency

The estimated coefficients (δ) of socio-economic and institutional factors accounting for inefficiency in groundnut production are listed in Table 5.5. The purpose was to determine factors that explain profit inefficiency. The variables included in the model were in line with theory and had consistent expected signs. The negative signs show 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 (Abu and Kirsten, 2009). This is because the value of $U_i$ would be higher when the farm is further away and below the profit frontier. Moreover, inefficiencies are assumed to always decrease profits (Ali and Flinn, 1989).

**Table 5.5** Determinants of profit inefficiency for groundnut farmers

| Variables | Parameters | Coefficients | Std. error | p-values |
|---|---|---|---|---|
| **Inefficiency effects** | | | | |
| Constant | $\delta_0$ | -1.1268** | 0.5474 | 0.040 |
| Education level | $\delta_1$ | -0.0494* | 0.0289 | 0.088 |
| Household size | $\delta_2$ | -0.0989 | 0.0667 | 0.138 |
| Credit access | $\delta_3$ | -0.5011* | 0.2634 | 0.057 |
| Land tenure | $\delta_4$ | -1.0289* | 0.6033 | 0.088 |
| Extension access | $\delta_5$ | -0.0815 | 0.2033 | 0.689 |
| Market distance | $\delta_6$ | 0.0115** | 0.0058 | 0.048 |
| Storage facility | $\delta_7$ | -0.5137* | 0.2946 | 0.081 |
| Weeding duration | $\delta_8$ | 0.2146** | 0.0960 | 0.025 |

Note: * and ** signify levels of significance at 10% ($p<0.10$) and 5% ($p<0.05$) respectively.
Source: 2012 Rural Agricultural Livelihoods Survey data.

The maximum likelihood estimates showed that coefficients on six of the eight variables significantly affected the level of profit inefficiency among the farmers. We therefore, reject the null hypothesis that the socio-economic and institutional factors do not significantly influence profit efficiency of smallholder groundnut farmers.

The results in Table 5.5 show that household size and extension coefficients are negative and do not exert a statistically significant influence on profit inefficiency. Therefore, following Battese and Coelli (1995), the implication is that the inefficiency effects in the stochastic frontier are clearly stochastic, but are unrelated to household size and extension access. There was no significant statistical difference between the district dummy variables in this study. A joint test was also done on district variables, testing whether the coefficients were simultaneously zero. The test was not significant shown by an $F$ value of 2.38 ($p = 0.123 > 0.05$) and we accepted the hypothesis of no difference between districts. The results implied similar climatic conditions, and thus the district variables were excluded from the inefficient model.

**Education level**

The results in Table 5.5 show that the coefficient on education was negative and statistically significant ($p < 0.10$). This implies that greater education of the household head brings about a decrease in inefficiency (increase in profit efficiency) in groundnut production. More educated farmers are more likely to adopt best farm practices to move toward producing the frontier output using the least cost combination of productive inputs available than farmers with less education (Ali and Flinn, 1989; Duraisamy, 1990; Ogunniyi, 2011). An increase in the highest level of formal education of the household head results in a decrease in profit inefficiency. These results are consistent with Ali *et al*.

(1994) who showed that giving education to farmers was very beneficial in reducing profit inefficiency of farmers in Pakistan. A similar study by Mohapatra (2011) on sugarcane farm households in India showed that a higher level of education minimizes inefficiency.

**Credit access**

The results in Table 5.5 also show 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 inputs that they otherwise could not provide from their own sources (Abdulai and Huffman, 1998). This finally translates into increased profit efficiency. Farmers who face a credit constraint on purchased inputs experience higher profit inefficiency. This is consistent with Hyuha *et al*. (2007) who noted that in Uganda access to credit reduces inefficiency in rice profits. In examining efficiency differentials among rice producers in Punjab Province of Pakistan, Ali and Flinn (1989) observed significant effects of farmers' access to credit on profit.

**Land tenure**

With respect to land tenure, titled land was significant and negatively related to profit inefficiency at the 10% level (Table 5.5). This implies that titled land increases farmers' likelihood of improving production and productivity. Key channels through which this occurs are: (i) facilitating the use of land as collateral for accessing credit markets; (ii) enhancing tenure security thereby incentivizing long term land investments and more intensive use of variable inputs; and (iii) enabling the development of formal land markets which facilitate the transfer of land to the most productive producers (Place and Otsuka, 2002; Abdulai *et al*., 2011; Sitko *et al*., 2014).

Smallholder farmers may be less efficient if collateral requirements affect their ability to raise working capital. Similar results were reported by 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 inefficiency in rice production.

**Distance to market**

Distance to market showed a positive effect on profit inefficiency as expected and it was significant at the 5% level (Table 5.5). An increase in the distance to the nearest established market leads to an increase in the farm's profit inefficiency. The positive effect of distance to nearest established market place on profit inefficiency was as expected. This result is related to higher transaction and transport costs from the farm to the market place. This is because as farmers are located far from markets there is limited access to input and output markets and market information. Moreover, longer distance to markets leads to reduced benefits that accrue to farmers. More importantly, longer distance to markets discourages farmers from participating in market-oriented production (Musa *et al*., 2014). This result is consistent with Abdullai and Huffman (2000) who established a positive relationship between distance to market and profit inefficiency for rice farmers in Ghana. Likewise, Mohammed *et al*. (2013) noted that profit inefficiency decreases with nearness to market.

**Storage facility**

Coefficient on storage facility was negative and statistically significant at the 10% level (Table 5.5). This means that availability of groundnut storage facilities reduce profit inefficiency among the groundnut farmers. This is consistent with expectation. Farmers with storage facilities can hold on to their harvest until such a time when favorable producer prices are offered on the market (MAL, 2004). Mohammed *et al*. (2013) also reported a negative relationship between farmers having storage facilities and profit inefficiency of castor seed producers in Nigeria. This study, however, only sought to know whether farmers had storage facilities without being specific on whether such facilities were used for castor storage.

**Weeding duration**

The number of weeks after planting that elapsed before a household completed the first weeding was significant in determining profit inefficiency. This variable positively affected profit inefficiency in groundnut production and was significant at the 5% level (Table 5.5). The results show that groundnut farmers become inefficient as the duration of weeding increases.

The results show that, following planting, the key groundnut agronomic practice is weeding. Weeds cause losses in groundnut yield by competing for water, sunlight, nutrients and space (N'zala *et al*., 2002). Weeds may also harbour pests and diseases causing reduction in yields. To reduce competition, it is important that famers weed their crops timely (MoAFS, 2012). Thus, there is a possibility to increase profit efficiency level through timely weeding. The result is in line with the findings of N'zala *et al*. (2002). Their study on weed population and the groundnut crop cycle in Congo established that lack of weeding and the weeding done 9 weeks after emergence resulted in a mean yield loss of 46%. A related study by Musa *et al*. (2014) on maize farmers in Ethiopia observed that timely weeding is positively related to efficiency.

### 5.7 Chapter Summary

The objective of this chapter was to estimate profit efficiency, efficiency levels and identify the major determinants of profit inefficiency among groundnut farmers in the Eastern Province of Zambia. The null hypothesis that smallholder farmers are not profit efficient in groundnut production was accepted, whereas the null hypothesis that the socio-economic and institutional factors do not significantly influence profit efficiency of smallholder groundnut farmers was rejected. Both statistical noise and inefficiency were important in explaining deviations of the realized profits from the frontier profit. Since the estimated variance parameter ($\gamma$) was close to 1 and significant, inefficiency was an important cause of reduced profitability.

The profit response to increase in capital was positive and elastic, showing that capital is the most limiting factor in groundnut profitability. There is low responsiveness of profit to increases in farm size. An average farm household in Eastern Province has the potential of obtaining 27.50% more profit given the same set of inputs and fixed factors if it was on the efficient frontier. The lowest profit efficiency score shows two things: (i) a relatively high profit loss, and (ii) higher opportunities to increase profit efficiency are still possible from the analysis of the source of inefficiency. Sources of variation in the profit inefficiencies included education level, credit access, land tenure, market distance, availability of storage facilities and weeding duration. The results imply that a considerable amount of profit, that is lost due to inefficiency, can be realized through improvements in technical and allocative efficiencies in groundnut production in the study area.

# CHAPTER SIX

# CONCLUSION AND RECOMMENDATIONS

## 6.1 Introduction

This chapter begins with the study summary and conclusion where the objectives, postulated hypotheses, method of analysis and results are summarized. Based on empirical results, recommendations and implications are then made for policy makers and stakeholders in the groundnut sector. The chapter ends with suggestions on areas of focus for future research.

## 6.2 Summary and Conclusion

This study set out to determine profit efficiency in groundnut production and the determinants of profit efficiency among the smallholder groundnut farmers in Eastern Province of Zambia. The study made two null hypotheses: (i) smallholder farmers are not profit efficient in groundnut production; and (ii) socio-economic and institutional factors do not significantly influence profit efficiency of smallholder groundnut farmers. The translog stochastic profit frontier and an inefficient model were employed to evaluate profit efficiency using farm level data obtained from 1,232 farm households of Eastern Province of Zambia.

The results showed that there is a high level of inefficiency in groundnut farming because the gamma ratio was closer to one ($\gamma = 0.6445$), meaning profit inefficiency at the given level of inputs and prices is more pronounced than the pure noise effect. This result led to the acceptance of the first hypothesis that smallholder farmers are not profit efficient in groundnut production. The presence of inefficiency supports the proposition that models that assume absolute efficiency could lead to misleading conclusions. This was shown by the log likelihood test which rejected the model without inefficiency in favour of the one that incorporated inefficiency. Seed price and value of fixed capital were significant at the 5% and 10% levels, respectively in the profit function. This estimation revealed that changes in seed input prices and level of fixed capital factors affect the farmer's profit. In addition, the elasticity of groundnut profit was highest with respect to capital at 12.50% given a 10% rise in value of fixed capital in the study area.

With respect to profit efficiency levels, the variation in actual profit from maximum profit (profit frontier) between households, ranged from 9.50% to 92.38%. This mainly arose from differences in farmers' practices rather than from random variation. The least profit efficient farmer needs an efficiency gain of 89.71% to attain the profit efficiency of the best farmer in the province. An average efficient groundnut farmer needs an efficiency gain of 21.52% to attain the level of the most profit efficient groundnut farmer, while the most profit efficient groundnut farmer needs only 7.62% gains in profit efficiency to be on the frontier. These findings entail that farmers were not using production resources efficiently to achieve higher profits in Eastern Province.

The study estimated an average efficiency value of 0.725 among the sample farmers. This implies that, on average, production is 27.50% below the efficiency frontier. The estimated average profit efficiency was correspondingly high (> 0.70), but showed that there existed an opportunity to increase efficiency given the present state of technology. Profit realized from groundnut production can increase by 27.50% if producers adopted the best farm practices and used the least cost combination of inputs. The study identified efficiency drivers, including education level, credit access, land tenure, market distance, storage facility and weeding duration. These were the major determinants of profit efficiency in groundnut production, which led to the rejection of the second hypothesis that socio-economic and institutional factors do not significantly influence profit efficiency of smallholder groundnut farmers.

### 6.3 Recommendations and Policy Implications

The study provides information with important policy implication in promoting profit efficiency and improving farm incomes among groundnut farmers in Eastern Province and in Zambia in general. The presence of inefficiency established in groundnut production entails that, trying to introduce new technologies without addressing the causes of inefficiency may not yield the anticipated impact. The study therefore makes the following recommendations:

i. The study shows that capital and seed are important resources in groundnut production. Thus stakeholders should formulate programs that encourage farmers to invest their farm profits into more farming equipment and income generating assets. The use of hybrid seed is profitable (or associated with a higher profit efficiency) and over time can contribute to the accumulation of productive assets and improve productivity.

ii. It is recommended that hybrid seed be made available to farmers at affordable prices and appropriate time by the stakeholders. This can be done through set up of community seed banks and/or seed loans for farmers to secure the required quantity of seed for increased production. Out-grower schemes provide successful models for increasing access to inputs. The seed system should also be strengthened through testing, registration and protection in addition to monitoring private seed suppliers and backstopping agro-dealers to avoid non-certified or recycled seed sold through local markets.

iii. The significance of the education level variable implies that perceiving and responding efficiently to changes in market prices require allocative ability that is acquired by investing in education and in useful and timely information. Therefore, promotion of rural education and training of less educated farmers through extension advice is required. This will enable the adoption of best management practices in groundnut farming to reduce inefficiency.

iv. This study has shown that use of agricultural credit is important and may raise allocative efficiency in groundnut production as it allows farmers to use inputs in a cost minimizing combination. This finding imply that institutional arrangements targeted at improving availability and access to credit could positively improving profit efficiency. It is therefore recommended that policy makers develop a sustainable rural credit institution or introduce appropriate legislation that encourages financial institutions to accommodate smallholder farmers to access loans at affordable interest rates. One option is group lending because the willingness to apply peer pressure reduces default in loan repayments within borrowing groups. The use of a compliance reward by stakeholders can lessen the problem of default among smallholder farmers.

v. Distance to market and availability of storage facilities are essential efficiency factors. The significance of distance to market underscores the need for stakeholders to develop better roads and market infrastructure in the rural areas to attract private investors as a way to reduce transport costs and the distance farmers have to cover to access markets. Since infrastructure development is expensive, encouraging well managed cooperatives or farmer organizations to pool their procurement of inputs and marketing of products could help to reduce per unit transport costs. This in turn would encourage optimal application of farm inputs and lead to increased profit efficiency. It is recommended that strategies to improve groundnut productivity should also focus on promoting improved storage facilities. This would compel the farmers to produce larger quantities for sale at profitable times.

vi. The results provide evidence that the type of land tenure followed in a country is an important determinant of profit efficiency. This implies that land tenure services need to be refocused to address the needs of smallholder farmers if land is to be used to its potential. Untitled land ownership is a constraint to increasing average profitability and productivity. Therefore, land reform measures aimed at promoting titled land ownership would yield positive results in increasing profit efficiency of groundnut producers. The Agricultural Lands Act of 1994 requires strengthening to shorten the land allocation and title deed processing period to increase access to land ownership. As a second best, allocating property rights to farmers may enhance security of tenure. This is necessary if farmers are to allocate more of the available farm land to groundnut production.

vii. The significance of weeding duration shows the importance of good management practices regarding the economics of weeding to improve yields per unit area. This result shows that policy measures should be considered to educate smallholder farmers about the benefits weeding their groundnut crop on time and its contribution to improve their profit efficiency. Plant protection measures such as the use of herbicides should be promoted through agricultural extension services to help the farmers to suppress weeds on time.

## 6.4 Future Research

Since this study used cross-sectional data, it would be interesting to estimate profit efficiency using panel data to assess changes in efficiency over time. In future studies, variables showing the effects of soil conditions on efficiency could be considered. Further research is required to empirically show how groundnut productivity is affected by the farmers' risk preferences. This would help to judge the rationality of popular cropping patterns that exist in the study area.

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