

**The Impact of Farm Input Subsidies on Economic Efficiency of  
Maize Production in Malawi**

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Master of Commerce in Development Finance Degree

by

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## DECLARATION

‘I declare that the thesis *‘The Impact of Farm Input Subsidies on Economic Efficiency of Maize Production in Malawi’* is my own work which has not been submitted to any other institution for similar purposes. However, where other people's works have been used, acknowledgement has been duly given. I am solely responsible for all errors contained herein’.

John Chiromo (CHRJOH007)

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**Legal Name**

Signed by candidate

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**Signature**

August, 2017

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**Date**

## DEDICATIONN

To my wife and children as well as my mother for her moral support, guidance and love since the death of my father in 1994.

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## ABSTRACT

The study analyzed the impact of the farm input subsidy programme (FISP) on the technical, allocative and economic efficiency and determining factors associated with these efficiencies of 12, 271 smallholder maize farmers from 2010 IHS3 dataset in Malawi. Descriptive statistics, stochastic frontier approach as and a Cobb-Douglas production function were applied. Yield responsiveness to production inputs was estimated by computing input elasticities.

The findings indicate that technical efficiency of smallholder maize farmers ranged from 15.7 to 78.9 with a mean of 61.3 percent reflecting a substantial level of inefficiency. The allocative efficiency scores were between 23.5 and 86.2 with a mean of 66.9 percent reflecting a substantial level of allocative inefficiency. The economic efficiency scores were between 14.1 and 74.6 with a mean of 59.2 percent reflecting a substantial economical inefficiency. An estimated return to scale was 0.87 indicating that during the period under review, smallholder maize farming decreased by about 13 percent. The results of second stage Tobit regression estimations indicates that the FISP programme improved the efficiencies of maize farmers in Malawi. In addition, farmers' age, farming experience, education years, having an income generating activity and receiving remittance were also identified as significant drivers of production capacity of smallholder farmers maize. However, farmers' marital status, family size and distance to the market had a negative impact on smallholder farmers' capacity in maize production. Smallholder farmers in Malawi were experiencing a decreased return to scale meaning that they were technical, allocative and economically inefficient in maize production.

From the findings, among other issues to be considered for the improvement of technical, allocative and economic efficiencies of maize production among smallholders farmers, the government should support only energetic farmers, make farm inputs available and accessible to farmers, continued advocacy on

adoption of family planning to reduce population growth to cater for scarcity of resources, increase and enhance extension services to help in educating these smallholder farmers in handling new technologies associated with modern agriculture, encourage them to engage in IGAs to complement FISP in purchasing farm inputs, increased and extended cash transfer program to economically empower these smallholder farmers.

**Keywords:** Maize, smallholder farmers, technical, allocative and economic efficiencies, stochastic production frontier, FISP, Malawi

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## LIST OF ABBREVIATIONS AND ACRONYMS

AE	Allocative Efficiency
BBC	Bankers, Charnes and Cooper
CCR	Charnes, Cooper and Rhodes
DEA	Data Enveloping Analysis
DFA	Distribution-Free Approach
DMU	Decision Making Unit
EE	Economic Efficiency
FDH	Free Disposal Hull
FISP	Farm Inputs Subsidy Programme
FRM	Fractional Regression Model
GDP	Gross Domestic Product
GNP	Gross National Product
IHS3	Integrated Household Survey – Phase 3
IGA	Income Generating Activity
MDGs	Millennium Development Goals
MGDS	Malawi Growth and Development Strategy
MoAFS	Ministry of Agriculture and Food Security
MoF	Ministry of Finance
MWK	Malawi Kwacha
NGO	Non-Governmental Organizations
NSO	National Statistical Office
RBM	Reserve Bank of Malawi
R and D	Research and Development
RTS	Return to Scale
SAP	Structural Adjustment Program
SFA	Stochastic Frontier Approach
SFF	Stochastic Frontier Function
SSA	Sub-Saharan Africa
SPS	Starter Pack Scheme
TE	Technical Efficiency
TFA	Thick Frontier Approach
TFP	Total Factor Productivity
TIP	Target Inputs Program
USA	United States of America
WB	World Bank
WDI	World Development Indicator#

# Chapter 1

## INTRODUCTION

### 1.1 Study Background and Motivation

In sub-Saharan Africa (SSA), smallholder farmers are the primary producers of agricultural outputs. According to World Bank, (2008), these farmers account for about 80 percent of all the farm produce and they directly employ about 175 million people. Smallholder farmers are those that are in subsistence farming having less than 2 hectares of farms, with insufficient labour, no access to irrigation, affordable inputs and financial credits and do not participate in commercial markets for their produce. Most of them practice low-input/low yield with an average yield that falls well short of global averages irrespective of crops being grown. In general, these farmers are sometimes classified as “resource-poor”. Despite these factors, policy makers and development practitioners still see smallholder farmers as the driving force of economic growth and poverty reduction. Gross domestic product (GDP) growth originating from agriculture is 2 to 4 times more effective in raising the incomes of extremely poor people than the GDP from outside the sector (World Bank, 2008).

According to Dorward et al. (2008), smallholder agriculture in Malawi is characterized by large numbers of very poor farmers heavily dependent on low input maize production and small land holdings, which are very short of nitrogen. Their maize production is normally not sufficient to meet annual consumption needs, and they depend upon casual labour and other income-earning opportunities to finance the purchase of the balance of their needs. This means that many farmers are vulnerable to impoverished livelihoods based on low productivity maize cultivation and casual labouring. Food insecurity problems of these farmers worsen with national food shortages due to poor production seasons. In trying to mitigate these problems, the Government of Malawi (GoM) started implementing the Farm Input Subsidy Programme (FISP) in the 2005/06 season with the objectives of improving smallholder productivity that will reduce vulnerability to food insecurity and hunger. Other

objectives were to promote food self-sufficiency, development of the private sector input markets, and wider growth and development.

## **1.2 Agriculture in Malawi**

Agriculture is the single most important sector of Malawi's economy. It employs about 80 percent of the workforce, accounts for 39 percent of GDP, contributes more than 80 percent of foreign exchange earnings, supplies more than 65 percent of manufacturing sector's raw materials and provides 64 percent of the total income of the rural people (MoAFSm (2011), Mucavele, 2010).

The agricultural sector is divided into a smallholder sub-sector and an estate sub-sector, which contribute about 70 and 30 percent to agricultural output, respectively (MoAFSm(2011)). The smallholder sub-sector is primarily subsistence-oriented. Farmers in this sector mostly grow staple food crops, such as maize, cassava, and sweet potatoes. Estates focus on exportable, high-value cash crops, such as tobacco, tea, sugar, coffee, and macadamia nuts. Smallholder agriculture is characterized by small, highly fragmented land holdings under customary land tenure, and by lower yields than the estate sector, in which most of the land is under freehold and leasehold tenures. Due to the importance of agriculture, Malawi's development strategies and policies have been heavily oriented towards this sector and one such strategy/policy is the FISP.

FISP provides inorganic fertilizer to smallholder farmers at below-market rates and is currently receiving a great deal of attention as a sustainable strategy to foster an African Green Revolution (Denning et al. 2009). Due to FISP, maize production increased from 26 to 60 percent during the first four years, which occurred during years of good rainfall (Dorward et al. 2010). Despite the potential benefits, the cost of implementing large scale FISP are high, and increase substantially when fertilizer and fuel prices rise. For example, in 2008 GoM spent about 70 percent of the Ministry of Agriculture and Food Security (MoAFS) budget or just over 16 percent of government's total budget on FISP (Dorward et al. 2011). The high cost of FISP warrants a thorough evaluation of the benefits.

The stated goals of FISP were to reduce poverty and boost production of staple crops such as maize (Kelly *et al.* 2011). In practice, achieving both goals is difficult because evidence from elsewhere in Africa suggests that returns to technologies such as hybrid seed and inorganic fertilizer vary across a population of smallholders (Duflo *et al.* (2008); Suri, 2011). Furthermore, Marenya and Barrett (2009) demonstrated that poorer households with low soil organic matter obtain little to no response when they apply inorganic fertilizer to maize in their fields. The findings call for some questions about the rationale for relying on FISP for households with poor soil as they may be unlikely to use fertilizer effectively.

### **1.3 Farm Input Subsidies in Malawi**

The use of input subsidies in Malawi dates to the early seventies. Not only was the use of agricultural subsidies perceived as successful in stimulating food crop production, subsidies enabled the country to achieve a high degree of self-reliance in maize, Malawi's main staple. The use of subsidies was eliminated in the early 1990's as part of a Structural Adjustment Program (SAP) that was adopted to deregulate Malawi's markets.

Agricultural subsidies were reintroduced in 1998 under a program called the Starter Pack Scheme (SPS). The SPS provided small quantities of seed and fertilizer to nearly all farmers in the country. The SPS eventually evolved into a Targeted Inputs Program (TIP). Under TIP program, all households were entitled to a package containing sufficient fertilizer and seed to plant about 0.1 hectare of maize. Although this was not a large subsidy, for food insecure households it was a substantial intervention.

Bad weather in the 2004/05 agricultural season led to very low national production and a severe food crisis in 2005. In response, government reoriented its food security program and scaled down the TIP. The ongoing food crisis prompted the government to re-introduce large-scale input subsidies for maize and tobacco under a program called the Farm Input Subsidy Program (FISP).

The FISP was first implemented in 2005. During the first two years of the program, guidelines for identifying beneficiaries were not clear. Targeting was decentralized, and village leaders and village distribution committees had wide latitude in deciding who was

eligible to receive the voucher. At the start of the 2007/08 agricultural season, clearer guidelines and criteria were established both for eligibility and selection. Priority was placed on emphasizing vulnerable households as program beneficiaries. Additional changes were made for the 2008/09 growing season. Pesticides for postharvest grain storage were introduced and vouchers were made more secure to prevent fraud, and voucher resale, two commonly recognized and ongoing problems during previous seasons. For the 2009 subsidy program each targeted household was entitled to 100kg of maize fertilizer at nearly a 90% subsidized price and either 2kg of free hybrid maize seed or 4kg of open pollinated maize. Some households were also entitled to coupons for tobacco fertilizer allowing access to 50kg of chemical fertilizer and some subsidies were also provided for cotton growers.

FISP was implemented with the objective to increase smallholder farmers' access to improved agricultural inputs as a way of achieving food self-sufficiency and increasing farm income levels. The program transfers paper vouchers to selected households, which enables them to purchase fertilizer, hybrid seed and/or pesticides at greatly reduced prices.

Starting from the 2005/06 agricultural season, the GoM implemented a large scale input subsidy program at national level to subsidize the cost of agricultural inputs for poor smallholder farmers. Program beneficiaries were intended to comply with three main criteria. They must be *(i)* fulltime "resource poor" smallholder farmers, *(ii)* residents in the village, and *(iii)* own land that will be cultivated in the agricultural season they enter the program. According to FISP implementation guidelines, varying categories of household heads were to be targeted. This includes household heads that are elderly, HIV positive, female, children, orphans, physically challenged household member with only one farmer per household. The program targeted over 50 percent of smallholder farmers and it was a coupon based where eligible households received a number of coupons that could be used to redeem fertilizer and improved seeds at heavily subsidized prices at participating retailers.

Despite the program's acclaim for contributing harvests, the program required large investments of government resources and this raised concerns over its fiscal sustainability and opportunity costs. The initial cost of the program in 2005/06 was US \$48 million and continued to increase thereafter until 2008 (Ricker-Gilbert, 2012). Between 2006/07 and 2008/09 agricultural seasons, the GoM spent over US \$73 million Ricker-Gilbert, *et al.* (2011) and US \$200 million Chibwana *et al.* (2012) for the program. In the four years since the implementation of FISP, the program's costs accounted for between 5 and 15 percent of the national budget Dorward *et al.* (2011). In 2008, the program accounted for 70 percent of the agricultural budget and 16 percent of the government budget (Mason and Ricker-Gilbert, 2012). The government paid between 70 and 90 percent of the cost of the program, while external donors supplemented the remained balance (Chibwana and Fisher, 2011; Dorward *et al.* (2008)

There is strong evidence to suggest that agricultural inputs raise productivity substantially and that they are essential for sustaining intensive agriculture in the long run without depleting soil fertility Crawford *et al.* (2006). Therefore, assessing the effects of a program such as FISP is important especially in a context where household resource endowments vary. The goals of FISP in Malawi were to increase household income, reduce food insecurity and hence reduce poverty. Therefore, assessing the direct impacts of such a program on household income or expenditures on the targeted beneficiaries and reduction of food insecurity would be ideal for policy makers. By investigating the impact of FISP on the incomes of smallholder farmers, this study shall add an important dimension to the emerging literature on the impacts of FISP in Malawi.

#### **1.4 Problem Statement**

In Malawi, the national budgetary expenditure on agriculture has been increasing on a yearly basis in the past decade. The overriding aim of this increase in budgetary support has been the achievement of poverty reduction and food security (MGDS I and II – GoM, 2002, 2006). The farm input subsidy programme benefits the poor and can be part of a viable national development strategy. Implementing the programme has prompted large cuts to

other agricultural programmes, such as irrigation, research and extension, as well as to other sectors, including roads, industry and the environment. Its budget accounts for 3-6% of Malawi's GDP and represents around 9-18% of government spending.

The rising budgetary expenditure does not seem to have transformed into meaningful economic growth through poverty reduction and food security, since Malawi still ranks among the poorest countries in the world (World Development Report – World Bank, 2012). Most Malawians continue to wallow in abject poverty and more than 50 percent live on less than a dollar per day (Human Development Index – World Bank, 2012). Even though Malawi has so far satisfied the commitments made by African Heads of State and Government in the 2003 Maputo Declaration of allocating at least 10 percent of national budgetary resources to agricultural sectors, there is an information gap on the contribution of FISP on economic growth and poverty reduction through increased agricultural production in Malawi. In spite of huge government expenditure that has been devoted to enhance poverty reduction and food security, no noticeable success has been achieved as poverty levels remain high and majority of Malawians still depend on food handouts and cash transfers through government “Money for Work” programmes. Given the scale of the programme, there is, correctly, strong interest in its effectiveness towards increasing maize production in Malawi. It is against this background that this research is set out to empirically investigate the actual impact of FISP on economic efficiency of smallholder farmers' food security through maize production in Malawi.

### **1.5 Objectives of the study**

As there is lack of improved output per hectare in maize production, this study was set out to empirically investigate how smallholder farmers use available resources to maximize their efficiency and thereby increase output in maize production. Using the 2009/10 Integrated Household Survey Phase 3 (IHS3) dataset, the study sought to examine the economic efficiency of maize production by smallholder farmers in Malawi. Specifically, the study seeks to:

- a. Analyze technical allocative efficiency levels of smallholder farmers in Malawi.
- b. Examine the effect of FISP on the efficiency of smallholder farmers in Malawi.

### **1.6 Justification and significance of the study**

Food security in Malawi is generally equated with adequate maize production, the country's main staple crop, which accounts for more than 60 percent of total food production. Malawi has been implementing a targeted agricultural input subsidy programme through the provision of fertilizers and maize seeds to smallholder farmers at subsidized prices. In concept, the FISP programme aim at making input prices affordable to poor smallholder farmers.

Though agricultural subsidies are used in many countries to support farmers and promote specific agricultural practices, they are costly and for this reason they justify close scrutiny, especially in developing countries like Malawi, where there are numerous competing demands for scarce public resources. There are several outlined justifications for continued FISP despite several calls for its abolishment. There is also a heated debate over the relative merits of farm input subsidy programs among policy makers and politicians in Malawi.

Since there is a direct relationship between agricultural productivity growth and poverty reduction, any decrease in maize total factor productivity may lead to a decrease in earnings of farmers that could potentially increase rural poverty. This study therefore, examines the impact of farm input subsidies on economic efficiency of maize production in Malawi.

### **1.7 Structure of the dissertation**

This thesis consists of five chapters, the order of which follows. Chapter One gives the study background and motivation, the problems statement, and justification of the study and objectives of the study. Chapter Two, a comprehensive literature survey, explores inefficiency theories, how to measure it and studies done elsewhere. Chapter Three gives the study methodology that includes the study design, data collection, model formulation and analyses done. Chapter Four gives the study results, findings, discussions

and limitations of the findings. Finally, Chapter Five wraps up the discussion by drawing conclusions from the findings of the previous chapters, conclusions drawn and policy implication.

## **Chapter 2**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

The characterization of Malawian agriculture, maize production and farm input subsidies presented above points to the fact that the concept in this thesis is based on the economic principles of efficiency, equity and sustainability. In this research, therefore, we will discuss these principles and relate them to effect of subsidies on maize production. In this Chapter, therefore, we would briefly discuss each principle in relation to the effect of input subsidies by referring to studies that are directly related to this study and the theory upon which they are based.

#### **2.2 Maize production in Malawi**

Malawian economy mainly depends on rain-fed agriculture that is characterized by low productivity, low technology and high labor intensity. The low productivity is attributed to the loss of soil fertility, low application of inorganic fertilizers and traditional, low technology, rain-fed farming systems (Chibwana, Fisher, & Shively, 2012). The agricultural sector is also characterized by the dominance of maize-producing farmers who own small plots of land.

Maize is one of the most important cereal crops in the world including Malawi, both as food for human beings, feed for animals and other industrial raw materials. According to Minot (2010), it is one of the world's leading crops cultivated over an area of about 142 million hectares with a production of 637 million tons of grain. It is by far the most important food staple in Malawi. It is for this reason that it is the focus of food security policy in Malawi.

Maize cultivation occupies roughly 60 percent of the cultivated area in the smallholder farm sector (GoM, 2008a, p.44). It is variously estimated that maize contributes 55 percent Ricker Gibert et al. (2008) and 72.8 percent (MoAFS, 2008) of all calories consumed by the population of Malawi. Some 97 percent of smallholder farmers are thought to grow

maize (MoAFS, 2011).

Throughout the nineteen seventies and eighties the country was able to produce a maize surplus and agricultural productivity grew in general terms, under-girded by a pervasive reliance on input subsidies to support the adoption of hybrid maize and fertilizer Katengeza et al. (2012). But in the mid-nineties the credit and subsidy programs, upon which the country had been relying, were abandoned in response to conditions imposed by the structural adjustment programs (SAP) of the World Bank and IMF (Denning et al. (1995); Harrigan (2003). Liberalization had severe negative effects for smallholders in Malawi, as the purchase price of maize skyrocketed and key inputs like fertilizer became prohibitively expensive (Blackie & Mann, 2005). Severe productivity shortfalls were forecast and, despite donor reticence, government-led interventions were resumed, first, from 1998 to 2000 in the form of the Starter Pack Program, then up to 2005 as the Targeted Input Program, and finally, to date, as the Agricultural Input Subsidy Program (Chinsinga, 2011).

#

### **2.2.1 Subsidized maize inputs in Malawi**

The crop yields of most common crops have stagnated at less than 50% of the actual attainable yields, leading to declining per-capita food production as the population grows. For example, while the attainable yields for maize varieties that are used are 6 to 10 t/ha, on average smallholder farmers produce only about 2 t/ha Mutegi et al. (2015). The large yield gaps warrant further investigation.

Successful maize production depends on the correct application of production inputs that will sustain the environment as well as agricultural production. These inputs are, among others, adapted cultivars, plant population, soil tillage, fertilisation, weed, insect and disease control, harvesting, marketing and financial resources (du Plessis, 2003). An important share of total agricultural productivity growth in Malawi has been attributed to increased use of fertilizers and hybrid seeds. Studies indicate that receiving subsidized fertilizer in a given year may have positive effect on household level of maize production and income. For example, Dorward et al. (2011) found that, receipt of subsidized fertilizer over the prior three seasons in production of maize had a significant positive effect on current years'

maize output and household income.

The strong incentive provided by FISP has created an important market for quality maize seed. FISP is one of the preconditions which supported the shift from a public seed delivery system, fueled by one public company, to a sector in which a number of national and international companies are operating. These private companies are providing farmers with seed of improved varieties of maize, largely hybrids. The country has seen a great surge in the use of hybrids, because hybrids are widely promoted by the government through the FISP program (Audet-Bélanger, Gildemacher and Hoogendoorn, 2018).

Chibwana et al. (2012) found a positive correlation between participation in the input subsidy program and the amount of land planted with maize in Malawi using cross-section data from two districts, suggesting that households with access to subsidies allocated less land to other crops. Contrary to Chibwana et al. A Noradic report on the impacts of the fertiliser subsidy programme in Malawi found that the input subsidy program was associated with land use intensification in the period when the subsidy program was scaled up such that maize yields increased and the area share under maize declined significantly after controlling for selection associated with unobservable household and farm characteristics using household fixed effects. Furthermore, the report found that intercropping of maize with other crops was more common on plots that received fertilizer than plots that did not receive fertilizer and that the probability of intercropping increased with increasing land scarcity (Holden and Lunduka, 2010).

### **2.3 Theoretical framework of the concept of efficiency**

This study wants to determine the impact of farm input subsidies on economic efficiency of maize production in Malawi. We therefore need a mathematical production functions that consist of classical inputs and outputs as well as stochastic elements beyond the maize producers control. The idea that production functions may consist of not only classical inputs and outputs, but also can incorporate stochastic elements beyond the produce's control was developed by Just and Pope (1978). Further work was completed by DiFalco and Chavas (2006), who provided an analysis of the associations between crop genetic

diversity, risk management and farm productivity. DiFalco and Chavas also made an assessment of the impact of crop genetic diversity on the mean, variance and skewness of yield. Recently, Antle (2010) proposed methods to estimate asymmetric effects of inputs on potato yield distributions.

Production function that is often used as analytical tool in research using econometric approach is Cobb-Douglas production function. Mathematical formula of Cobb-Douglas production function is:

$Y = f$  (hectarage, seed type, fertilizer, labour, water application, weeding, credit assistance, slope of land and other inputs for maize production)

$$Y = f(x, v, e)$$

This model is used to find out the responsiveness of dependent variable (yield) to independent variables (hectarage, seed type, fertilizer, labour, water application, weeding, credit assistance, slope of land and other inputs for maize production).

A maize producer faces a given production function represented by  $y = f(x, v, e)$ , where  $y$  is yield or output,  $x$  is a vector of inputs, and  $v$  is a vector of stochastic inputs, and  $e$  is a random production error. In this case,  $f(x, v, e)$  represents the greatest possible output a maize producer can obtain with inputs  $x$  and  $v$ . In the analysis,  $v$  is considered to be a random vector, with a given probability distribution that is subject to change and represents production uncertainty or risk.

Production function as defined in microeconomic theory, is the maximum output that can be produced from a given set of inputs, using a particular technology available to that firm at that point in time (Farrell, 1957). When firms (such as farms as in this study) operate under uncertainty that might cause fluctuations in output (maize productivity as in this study). These fluctuations might be mainly due to inputs used (all inputs involved in the production of maize in a farm), the technical inefficiency of a producer (farmer in this case) and random shocks. Before the pioneering work of Farrell (1957), most of the empirical studies used the least squares methods to estimate the production function. As

reported by Battese in 1991, this resulted in an average function. Functions based on the least squares methods assumed that producers were operating on their production function that maximized the output as a result of inputs used. In this model formulation, fluctuations in the outputs were thought to be due to statistical noise. Kumbhakar and Lovell (2000) argued that fluctuation can be captured through a production function specification while variation in output due to technical inefficiency and random shocks can be captured and decomposed through the stochastic production frontier approach (parametric approach). They argued that the existence of inefficiency in production comes from the inefficient use of scarce resources.

Efficiency is an important concept in economics due to the scarcity of resources. For this reason, improvements in efficient use of resources are important to an economic agent such as farmers. It is usually concerned with the relative performance of the various processes used in transforming given inputs into outputs. The conceptualization and its measurement rely on the specification of the production which represents the maximum outputs attainable from the use of a given level of inputs. In agriculture production, the efficiency with which farmers use available resources with improved technology is very vital. This implies that increased efficiency is associated with the quality of resources used as well as their quantity and increased resource mobilization and efficient use help to account for productivity increase. Given the nature of Malawian smallholder farmers, most of which are rural based and resource constrained, it is important to investigate the extent of the realization of maximum outputs from their highest level of farm activities.

According to Charnes *et al.* (1978), efficiency is the degree to which the observed use of resources to produce outputs of a given quantity matches the optimal use of resources to produce output of a given quantity. It is measured by comparing the observed output against the feasible (frontier) output Fried *et al.* (2008). Algebraically, productivity is defined as the ratio of the amount of output produced to the amount of resources used. However, efficiency is a ratio of the value output produced to the cost of inputs used. The term efficiency as used here refer to economic efficiency, which is a combination of both technical and allocative efficiencies.

It was Leibenstein (1966) through the concept of X-efficiency that the non-systematic

optimal behavior of producers (such as farmers) was considered. The economic literature identifies three components of efficiency: technical efficiency (TE), allocative efficiency (AE) and economic efficiency (EE). According to Koopmans (1951), a producer is technically efficient if the increase in any output requires a decrease of at least one other output or an increase of at least one input, and when a decline of any input requires increase of at least one other input or a reduction of at least one output. In other words, a technically efficient firm must be at the frontier of a production set.

In developing agricultural economies where resources are meager and opportunities for developing and adopting better technologies are dwindling, efficiency is a very important factor of productivity growth, (Ali and Chaudhry, 1990). Determining the extent to which it is possible to raise productivity or increase efficiency, at the existing resource base or technology can benefit greatly such economies. Non-physical inputs, such as experience, information and supervision, might influence the ability of a producer to use the available technology efficiently. Each type of efficiency is costly to a firm or production unit (e.g. a farm) in the sense that each inefficiency causes a reduction in profit below the minimum value attainable under full efficiency. According to Charnes (1978), TE measures how the firm combines inputs when their proportions of use are given. In production function, there is TE when we could get the same level of output with less inputs. The price-efficiency measures how the producer sets the proportions of the various inputs used in the production function, based on their respective prices. This measure provides an assessment of how firms allocate their productive resources relative to a production target. Hence the name of AE often used instead of the price-efficiency used by Farrell (1957). The ability of producers to choose the inputs in optimal proportions is what is defined as AE.

The simultaneous achievement of both TE and AE is a necessary and sufficient condition to talk about EE. However, it is possible for a firm to achieve both TE and AE without being achieving EE. As summarized by Adegbola, *et al.*, (2005), EE is a multiple of TE and AE, (i.e.  $EE = TE * EA$ ). It is achieved when the producer combines resources in the least possible combination to generate maximum output (technical) as well as ensuring least

possible cost to obtain maximum revenue (allocative) (Chukwuji, *et al.*, 2006). This study was set to estimate both TE and AE of smallholder farmers in Malawi.

There are so many procedures for assessing efficiency in Economic theory and two techniques are commonly used to estimate the frontier - the Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) approaches. DEA is a non-parametric method, while the SFA is parametric. Coelli (1995) compared the two methods and concluded that the main strengths of the SFA are its ability to deal with stochastic noise and the incorporation of statistical hypothesis tests pertaining to production structure and the degree of efficiency.

### **2.3.1 Production Efficiency**

Oyewa *et al.* (2009) defined production as the transformation of goods and services into finished products (that is input-output relationship) and this applied to every production process. The production technology can be represented in a form of a cost function that represents the dual approach in the technology, which is seen as a constant towards the optimizing behaviour of firms (Chambers, 1983). In the context of the cost function, any error of optimization is taken to translate into higher cost for producers. However, the stochastic nature of the production frontier would still imply that the theoretical minimum cost frontier would be stochastic.

Referring to the theoretical details of efficiency given in the previous section, it suffices to state that if a farmer is efficient both technically and allocatively, then s/he is said to be cost-effective Chukwuji *et al.* (2006). For the improvement in Agriculture, production farmers have therefore to be both technically and allocatively efficient. The ultimate goal of FISP was for the smallholder farmers to be both allocatively and technically efficiency to boost food security and their income levels by maximizing profits especially in poverty pressed countries such as Malawi Lunduka *et al.* (2014). Thus, this study aimed to determine the impact of FISP based on its major objective of transforming agriculture especially maize production so as to promote food security and increase their income levels, which one of the major priorities of Malawi Growth and Development Strategy II (MGDS II).

### 2.3.2 Efficiency Measurement

In production, the true frontier is always not known, efficiency measurement involves a comparison of actual performance with optimal performance located on the relevant frontier through approximation, which is commonly called a “*best practice*” frontier. The *best practice* frontier can be done either using parametric or non-parametric techniques and both techniques emphasize on optimizing behavior subject to constraints. In 1992, Berger and Humphrey identified at least four different optimization approaches (data envelopment analysis, free disposal hull, stochastic frontier approach, and thick frontier approach) that have been employed for determining the best-practice frontier against which relative efficiency scores are measured. The differences in these methods lies in the differences on the assumptions made on: (i) the functional form of the frontier, be it a parametric or a nonparametric functional form; (ii) whether a random error is included; and (iii) if there is random error, what probability distribution is assumed for the efficiency scores.

Data Envelopment Analysis (DEA) is a Non-parametric technique that builds a linear piece-wise function from empirical observations of inputs and outputs, without assuming any a priori functional relationship between the inputs and outputs. Efficiency ratios are then calculated relative to this surface. According to Coelli *et al.* (2005) testing of hypothesis is not possible however, this method does not suffer multicollinearity and heteroscedasticity. Deprins *et al.* (1984) developed another non-parametric method of estimation is the Free Disposal Hull (FDH), which is a special case of the DEA model, because it includes only the DEA vertices and the free disposal hull points, interior to these vertices. Thus, the FDH usually generates larger estimates of average efficiency than the DEA. Both approaches allow the variation of efficiency over time and do not impose any a priori functional form to the distribution of inefficiency scores. Though they do not suffer multicollinearity and heteroscedasticity but testing of hypothesis is not possible.

Another measurement of efficiency is the Stochastic Frontier Approach (SFA), also referred to as the econometric frontier approach, specifies a functional form for the cost, profit, or production relationship among inputs, outputs, and environmental

factors, and it allows for random errors Aigner *et al.* (1977). Another parametric approach pioneered by Muessen, W and Van Den Broeck, J. (1997) is the Distribution- Free Approach (DFA), which also designates a functional form for the frontier, except that it assumes that the efficiency of each firm is stable over time, whereas the random error tends to average out to zero over time.

Thick Frontier Approach (TFA) is another efficiency measure proposed by Berger and Humphrey (1992) that specifies a functional form and it assumes that deviations from the predicted performance values from the highest and lowest performance quartiles of the observations (stratified by size class) represent random error, while deviations in predicted performance between the highest and lowest quartiles represent inefficiency. It should be noted that parametric methods are susceptible to misspecification errors. However, their advantage is that it is possible to test hypotheses. In recent years both parametric and non-parametric methods have become more robust than they were years ago. The exploration of the efficiency of smallholder farmers using the most recent techniques is left for future research, as for this study; time, data and resource constraints favored convenience and therefore, we used the DEA.

It was Farrell (1957) that pioneered the non-parametric method of measuring efficiency and many improvements have since been made to his works. He considered a firm that employs two factors of production  $X$  and  $Y$  to produce a single product  $P$ , under conditions of constant returns to scale. These assumptions make it possible to illustrate the production function by a simple isoquant diagram, designated by  $SS$  in Figure 1. Farrell (1957) also assumed that the efficient production function is known; otherwise, it would have to be estimated from sample data by using any of the various methods available.

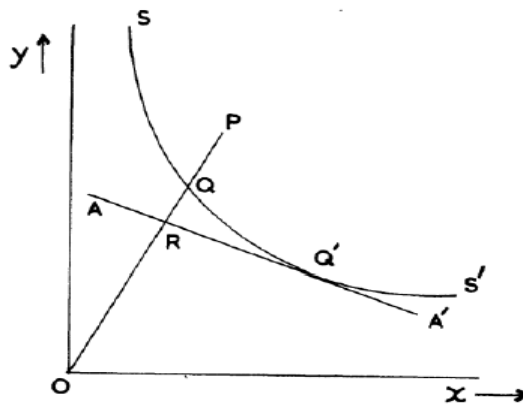


Figure 1: Technical and Allocative Efficiency from an output orientation

Source: Ajibefun (2008)

Units of two factors are represented in Figure 1, per unit of output that the firm is observed to use. As seen in Figure 1, the isoquant  $SS'$  represents various combinations of the two factors that a perfectly efficient firm might use to produce a unit output. It is also important to note that  $SS'$  presents a lower bound of a scatter indicating the same level of output and as such  $Q$  and  $P$  are on the same isoquant. The point  $Q$  represents an efficient firm using the two factors in the same ratio as  $P$ . It can be seen that it produces the same output as  $P$  using only a fraction  $OQ/OP$  as much of each factor. It is producing  $OP/OQ$  times as much output from the same inputs. Therefore,  $OQ/OP$  is defined as the technical efficiency of Firm  $P$ . The TE of that firm is presented by the distance  $QP$  which is the amount by which all inputs could be proportionally reduced without a reduction in outputs. If the ratio is equal to 1 then the firm is technically efficient and if it is less than 1 the firm is inefficient. Another factor that can be measured from Figure 1 is the price or AE of the firm. Considering the budget line represented by  $AA'$ , its slope is equal to the ratio of the prices of the two factors of production. Therefore, the optimal point is obtained where the isoquant curve is tangential to the budget line and that is point  $Q$ . It is only at this point that the firm is both technically and allocatively efficient. The AE is, therefore, the fraction represented by  $OR/OQ$ .

Charnes, *et al.*, (1978), based on Farrell's work developed the fractional linear programming method of DEA, known as "the Charnes, Cooper and Rhodes (CCR)

DEA model”, which compares inefficient firms with the best practice within the same group. It assumes constant returns to scale. However, Bankers, *et al.*, (1984) added another constraint to the CCR model to reflect variable returns to scale and formed the Banker, Charnes, and Cooper (BBC) DEA model. In agricultural economics, DEA has gained ground with a lot of studies being done and has been widely applied.

## **2.4 Influencing Factors of efficiency**

Literature suggests that there are many factors that affect the efficiency of farmers that can be classified as either conventional or non-conventional. Non-conventional factors (land quality, irrigation, agricultural research, calorie availability, agricultural export and instability) that capture the impacts of macroeconomic variables such as public investment and agro-ecological variables while conventional factors (labor intensity, fertilizer usage, tractor use intensity and stock of livestock) that are traditional choice variables in the farmers’ production decision process. Deininger and Olinto (2000) and Pender *et al.* (2004) also identified fertilizer, cattle ownership, access to credit, the supply of extension, human capital (education, age, and gender of house head), family size and proportions of dependents as explanatory variables to efficiency. The plot level factors such as the size of the farm, tenure, distance of the field from the residence in one way or another affect productivity Xu *et al.* (2009).

Dzimadzi *et al.* (2001) in a study of a targeted input safety net programme found that problems of literacy and numeracy led farmers to use the inputs inappropriately. In some cases, inputs were used on larger areas than the technical specifications that were contained in the leaflets and in other cases the instructions conflicted with the traditional farming systems. Sibale *et al.*(2001) found that only 50 percent of the targeted inputs recipients followed the targeted inputs programme instructions for planting maize.

Livestock ownership especially oxen is likely to help framers prepare their fields early and also allows them to increase the area of land cultivated. Furthermore livestock acts as a buffer zone and improves farmers’ access to credit and fertilizer markets. In an effort to identify strategies to increase agricultural productivity and reduce land degradation, Pender

*et al.*(2004) used econometric analysis on cross-sectional data in Uganda. The study findings showed that ownership of livestock (especially oxen), agro-climatic zones, primary sources of income, age of house head, ownership of land and participation in agricultural extension activities positively affected productivity. This study also showed that investments such as irrigation facilities are more likely to improve productivity. Population density has a bearing on the way farmers employ their inputs. Studies showed that farmers in high density populated areas tend to use intensive methods of crop production. For example Frisvold and Ingram (1994) and Pender *et al.* (2004) showed that households in more densely populated areas were found to adopt some labor intensive land management practices which enabled them to increase crop production per hectare. Farm size also affects the productivity. Pender *et al.*(2004) showed that farm size was negatively related to productivity in Uganda.

In Zambia, Brambilla *et al.*(2009) used cross-sectional post-harvest survey data to investigate the dynamic impacts of cotton marketing reforms on farm output. This study showed that small farms are more efficient. Frisvold and Ingram (1994) also agreed that for small fields the production is normally small but in terms of productivity or production per hectare, they perform better than larger plots. Trade performance has some impact on the agricultural productivity. If farmers can access local and export markets, the literature shows that productivity can go up because whatever is produced would be bought on the market. Using cross-section time series data for 28 sub Saharan African countries, Frisvold and Ingram (1994) estimated an aggregate agricultural production function in an attempt to examine sources of agricultural productivity growth and stagnation. The results showed that the coefficient on agricultural export was positive and statistically significant. However, Pender *et al.*(2004) found little evidence on the impact of access to markets on agricultural intensification and crop productivity. The explanation to this could be that Pender *et al.*(2004) used sectional data while Frisvold and Ingram (1994) used panel data. Although education as human capital is important for increasing household income, it was not found to be a solution to the problem of low productivity in Uganda Pender *et al.*(2004) . Similar results were reported by Deininger and Olinto (2000) using panel data from the post-harvest survey. However, the study which aimed at examining the relatively lackluster performance of the country's agricultural sector following

liberalization concluded that education enables farmers to overcome market imperfections as reflected in the fact that more educated farmers demand higher amounts of fertilizer and credit per hectare.

#### **2.4.1 Studies in Production Efficiency**

There are very few efficiency studies in agriculture that used DEA method. For example, using the production function of the stochastic frontier to estimate the agricultural efficiency index in rural Ethiopia and regressing the efficiency index on the probability of being ill, under the control of household characteristics and other exogenous variables, Ulimwengu (2009) showed the negative impact of the health status of farmers on both agricultural efficiency and poverty reduction. He concluded that improving agricultural efficiency consecutive to an investment in the farmers' health may not lead to poverty reduction because additional measures were needed to achieve simultaneously increasing agricultural productivity and reducing poverty rates.

Similar results were obtained by Venkataramani *et al.*(2006) in a study of TE of inputs specific to each district in India using a C-D production function. They found that better health is associated with a significant increase in TE. Also, Loureiro (2009) found that the differences in the health of farmers explain the variance in the efficiency of agricultural production in Norway. Furthermore, in a comparative study between the poor and non-poor farmers, Ahmad (2003) showed that the production elasticity of land is significantly higher in the rich farms compared to farms owned by poor farmers. In addition, the average cost of the existence of technical inefficiencies is about 43% in terms of production losses, with large variations between farms ranging from 17 to 62 percent. He also concluded that the worst performing group works not only below the frontier but also at the lower part of the production frontier. Therefore, increasing access to inputs might increase productivity and reduce poverty.

In addition, Costa *et al.*(2013) studied the relationship between agricultural productivity and household food security in Brazilian metropolitan areas, taking into account other individual factors. They found that productivity gains were associated with greater household food security in low proportions due to the strong influence of specific characteristics such as education and income. In order to identify the determinants of

technical efficiency, Koirala *et al.* (2013) used the C-D functional form for rice producers in the Philippines. The results showed that fuel, fertilizer, land rent, planting season and land area were factors that affect the production and technical efficiency of rice production. They found an average technical efficiency score of 0.54. A similar study was made by Mohammed & Saghaian (2014) on rice production in South Korea. It was apparent from their study that it was possible to increase the production efficiency and the effect of the location on the production yield was significant.

In their study Benin, Adegbola *et al.* (2005) and Adegbola *et al.* (2008) analyzed the technical, allocative and economic efficiency levels respectively in Central and Northeast rice production systems that are competitive and in cashew nuts units' production and processing using the stochastic production function. These studies showed that rice farmers were largely inefficient; 62 percent of the variation in the yield of rice was mainly due to TE. On the other hand, the distribution of the efficiency index showed that for TE, 77 percent of rice farmers had an efficiency index greater than 50 percent, 97 percent of rice growers regarding AE and 50% for the EE. The most efficient rice farmers were characterized by the use of weed-killers, animal traction and improved varieties in small areas. Also, there are in the various classes of producers, technically and economically inefficient production units and that large farms are not more efficient than small ones. Thus, any action to promote the cashew sector must also be well oriented to large and small units.

Studies reviewed above suggest that TE varies by household characteristics and the impact of these characteristics vary by region. In addition, most studies do not take econometrically account the AE consistently and have not explored the sources of allocative inefficiency. Also, they use the Tobit model, in a second step to identify the determinants of inefficiency. This is econometrically biased because the Tobit model assumes a double censorship in efficiency scores. This is not the case since the scores are proportions which are naturally between 0 and 1 (Baum, 2008; Ramalho *et al.* (2010). Thus, there is need to include both the technical, allocative and economic efficiency and also the fractional regression model (FRM) as developed by Papke & Wooldridge (1996) for the estimation of the second stage of SFA method.

DEA and SFA are different techniques used to estimate efficiency measures and both have their merits and disadvantages. Some studies such as those of Wadud and White, 2000; Puig-Junoy and Argiles, 2000 have done the comparison of the two and have shown that their estimates differ quantitatively, with those of DEA being smaller than SFA estimates. However, the ordering or ranking of the decision making units (DMUs) according to their estimated efficiency scores has been shown to be similar in both methods (Wadud and White, 2000; Puig-Junoy and Argiles, 2000). Although the efficiency scores for each DMU did not coincide in all cases for both methods, the ranking of DMUs in terms of efficiency was highly correlated. In this study, SFA was the main analytical tool used in the analysis to come up with the results.

Kibaara (2005) in a study on the technical efficiency in Kenyan's maize production using stochastic frontier approach revealed that input elasticities are inelastic. A one percent increase in quantity of fertilizer and seed rate resulted in increase in maize output by 0.17 percent and 0.63 percent, respectively.

## Chapter 3

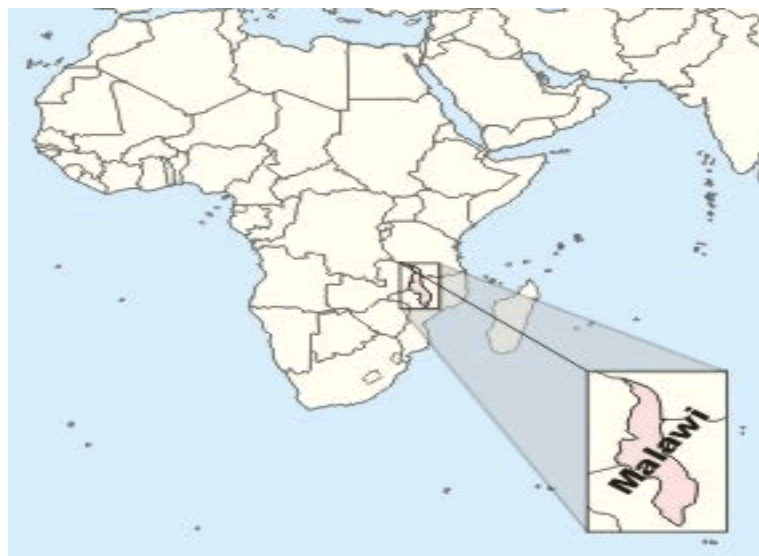
# METHODOLOGY

### 3.1 Introduction

This chapter presents an overview of the research data and its sources as well as the empirical approach employed in this thesis. This chapter gives a detailed exposition of the data and methodological approach that has been followed to answer the primary and secondary research questions.

### 3.2 Study Area

The methodological research approach is a framework that binds research together so that the research questions can be analyzed effectively (Edmunson and McManus, 2007). Identification of a suitable research method is paramount as it makes the collection of data easier and gives a clear idea about the required information (Trochim and Donnelly, 2006). Hence, this chapter gives a detailed exposition of the data and methodological approach that has been followed to answer the primary and secondary research questions. This study was done in Malawi, which is one of the poorest countries in the world where the majority of the poor people live in rural areas and agricultural sector is the most significant source of livelihoods.



*Figure 2: Map of Africa showing the Republic of Malawi - the Study Area*

### **3.3 Data Gathering Process and Analysis Approach**

The three common approaches to conducting research are quantitative, qualitative, and mixed methods. This study operated from a common belief among many researchers that research questions determine the research design. Accordingly, the study's research questions influenced what was to be investigated (Henning, Van Rensburg & Smit, 2004). Research design indicates the structure and procedure followed to answer research questions. Based on this premise, this study was conducted using quantitative research methodology. The main characteristic of quantitative research is the emphasis on objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques. Quantitative research focuses on gathering numerical data and generalizing it across groups of people or to explain a particular phenomenon (Babbie, 2016).

This study did not make use of either a qualitative or mixed methodology because the research question did not call for an understanding of meanings, experience, ideas, beliefs and values or any other intangibles such as these. It is a retrospective study that takes a quantitative approach in observing the direction of the relationship between FISP and agricultural productivity. Punch (2005) stated that quantitative research is typically directed at theory verification and related to numerical data. It uses times series data which is best for a country specific research and this can avoid some of the econometric and sampling problems (Kweka and Morrissey, 2000). A time series study of a country is potentially more informative, though the findings cannot be generalized to other countries. This study uses this approach as it involves an empirical exploration of quantitative aspects of FISP on agricultural productivity in Malawi.

The study therefore, used secondary data from 2010 Third Integrated Household Survey Phase 3 (2013 IHS3) conducted by the National Statistics Offices (NSO). The nationally representative surveys cover the period from 2010 to 2011. The survey is a Living Standards Measurement Survey – Integrated Surveys on Agriculture (LSMS-ISA) that incorporates extensive agricultural content in addition to the standard LSMS components

of a household survey. This multi-topic survey contains a large, nationally representative data consisting of 12, 271 households in 768 enumeration areas, of which over 80 percent are agricultural households. It contains both types of households; those which benefited (recipients) from FISP to be categorized as FISPB in this study and those who did not benefit to be categorized as FISPNB. Using these reference groups, within group and between group analyses was done to comprehensively analyze the impacts of FISP. From this data set, the following categorized variables were considered: demographic (age, gender, marital status, etc.), social (access to social amenities such as roads, markets, etc.) and economic (remittance, sales of farm related outputs, etc). Table 1 presents variables used in the analysis.

**Table 1: Description of variables**

<b>Variable</b>	<b>Description</b>
AGE	Age of the household head in years
SEX	Gender of the household head: 1 if the household head is male and 0 if the household head is female
MSTATUS	Marital Status of respondents: 1 if the respondent is married and 0 otherwise
LABOUR	Number of adult members in a household
HHSIZE	Family Size of the household
EDUCS	Education Status of the respondents: 1 = None, 2 = Primary, 3 = Secondary, 4 = Tertiary and 5 = Others
FSIZE	Land holding size in hectares
FISP	1 if the household is a beneficiary and 0 if the household did not benefit from FISP
IGA	Income Generation Activity: 1 if the household has an IGA and 0 otherwise
R	Remittance: 1 if the household get some form of money transfer from outside the family and 0 if the household does not get some form of money transfers
DM	Distance to Market; 1 if the market is less than 1 KM, 0 Otherwise
QH (Output)	Quantity Harvested; 1 if more than 10 bags and 0 otherwise

*a key determinant for selling produce; average smallholder farmer harvests 10 or less bags per hectare; most smallholder farmers store 10 bags or less for sale as well as for consumption*

### **3.4 Sample Size and Sample Design**

This is a retrospective study that aimed at evaluating the impact of FISP on smallholder farmers' income in Malawi. The study used panel data collected under 2010 IHS3 by NSO. The survey collected information from a sample of 12,271 households statistically designed to be representative at both national, district, urban and rural levels enabling the provision of reliable estimates for these levels. Data from IHS have among other insights, provided benchmark poverty and vulnerability indicators to foster evidence-based policy formulation and monitor the progress of meeting the Millennium Development Goals (MDGs) as well as the goals of the Malawi Growth and Development Strategy (MGDS). The data contained in this survey is ideal for this study as it contains information on key welfare and socio-economic indicators and meets special data needs for the review of the MGDS II and at international level, MDGs

### **3.5 Data Analysis and Modelling**

The data analysis involved the use of both descriptive and inferential statistics (C-D and Tobit regression analyses) in R application package (version 3.2.1). EE was calculated as a product of TE and AE while Tobit regression model was used to determine factors associated with TE, AE and EE. Descriptive statistics were used to summarize the data. This involved the use of percentages, means, frequency distributions and standard deviations to describe socio-economic characteristics parameters and institutional factors but also compare within and between impacts of FISP on those who benefited and those who did not benefit.

Income is a transitory character through the process of earning and consumption. After harvests, households receive large amount of cash, but smaller or no amount during the rest of the year. Comparing to income, expenditure is a more stable indicator through the inclusion of consumption and thus, a measure of welfare over time with constantly income spending and consumption Benson *et al.* (2004:4). However, both are accepted indicators for welfare analysis of households: "Consumption and expenditure can be viewed as realized welfare, whereas income is more a measure of potential welfare" Benson *et al.* (2001:14). Another reason for the consideration of agricultural income is that it is rarely explained in spatial analysis.

### 3.6 Analytical Framework and Model Specification

Both descriptive and quantitative methods were used in the analysis of the study data. C-D production function model using an SPF approach was used to analyze the variables that affect maize production, and this analytical technique helps to determine the technical efficiency level of smallholder maize farmers in Malawi. The SPF was chosen instead of DEA due to the fact that SPF embraces both technical inefficiencies of the production process and the probabilistic, random effects leading to productive inefficiency (Burhan *et al.* (2009). In this sense, there appears a composite error term involving technical inefficiency and random effects. Therefore, SPF allows the researcher to measure both the technical efficiency source and impact of measurement errors or factors that are not directly related to production process itself (Burhan *et al.*(2009). The estimation appears as a frontier or benchmark with the parameter estimates indicating whether the production unit (a farm as in this study) is producing at the production or profit frontier.

The estimation of a SPF function and efficiency was done in two stages. In the first stage, a C-D SPF was estimated where the total output per hectare was modelled in terms of independent variables as listed in Table 2. In the second stage, the analysis of TE were regressed on various farm farmer specific variables, which were considered appropriate in explaining the variation in EE for the sampled farmers. The production function in this study was presented as:

$$Y = F(X\beta)exp^E \quad (1)$$

Where Y = maize outputs (kg/ha)

X = Vector of input quantities

$\beta$  = a vector of parameters

E = stochastic disturbance term consisting of elements U and V, E = V-U

The V is distributed randomly and a symmetrical two-sided error term as  $V \sim N(0, s_v^2)$ , which captures the effects of random shocks outside the farmers control, i.e. observation and measurement error and other statistical noise. Thus, V allows the frontier to vary across farms, or over time for the same farm and therefore the frontier is stochastic.

The  $U$  is a distributed half-normal one-sided error term as  $U \sim N(0, s_u^2)$  that captures deviation from the frontier due to inequality. Both  $U$  and  $V$  are independent of each other. The TE of an individual farm is defined as a ratio of the observed output to the corresponding frontier output, conditional on the levels of inputs used on the farm.

The Cobb-Douglas production function has been used in many empirical studies, particularly those relating to development agriculture (Battese and Coelli, 1995) as it meets the requirement of being self-dual, allowing an examination of EE. In this study, the following functional form was adopted and used to model maize production technology:

$$Y = \beta_0 * X_1^{\beta_1} * X_2^{\beta_2} * X_3^{\beta_3} * X_4^{\beta_4} * X_5^{\beta_5} * e^{v_1 - u_1} \quad (2)$$

Which, when linearized, becomes:

$$\text{Log}Y_i = \text{log}\beta_0 + \beta_1 \text{log}X_{1i} + \beta_2 \text{log}X_{2i} + \beta_3 \text{log}X_{3i} + \beta_4 \text{log}X_{4i} + \beta_5 \text{log}X_{5i} + (v_1 - u_1) \quad (3)$$

Where  $i = 1, 2, \dots, n^{\text{th}} \text{ farmer}$ ,  $\ln$  = logarithm to base e,  $Y_i$  = Yield of maize in the  $i^{\text{th}}$  farmer (kg/ha),  $X_1$  = Farm size,  $X_2$  = Quantity of Fertilizer,  $X_3$  = Amount of seeds used (kg/ha),  $X_4$  = Amount of pesticides (litres),  $X_5$  = Total labour used (man-hour/ha),  $u_i$  = specific TE factor for farm  $i$  and  $v_i$  = random variable for farm  $i$ . TE indices generated by model (3) were regressed on farm and farmers characteristics to determine factors affecting TE using the following two-limit Tobit regression model. The two-limit Tobit model was adopted because TE of an individual vegetable farmer is the ratio of the observed input to the corresponding frontier output conditional on the level of input used.

$$Y^* = X\beta_i + \varepsilon_i \quad (4)$$

$$Y_i^* = \alpha_0 + \alpha_1 P_{1i} + \alpha_2 P_{2i} + \dots + \alpha_k P_{nk} \quad (5)$$

Where  $Y^*$  = TE ratio,  $P_1$  = Farmers age in years,  $P_2$  = Years in farming,  $P_3$  = Gender,  $P_4$  = Household size,  $P_5$  = FISP status,  $P_6$  = IGA,  $P_7$  = Occupation,  $P_8$  = Education status,  $P_9$  = Marital status.  $\alpha_0$  is a constant,  $\alpha_1, \alpha_2, \dots, \alpha_k$  are elasticities to be measured.

AE in the analysis was obtained using the cost function on the assumption that total cost was dependent on cost of inputs. The total cost of inputs was regressed on each of the independent variables to determine the extent of the relationship that exist between the dependent and independent variables. The AE model was given as:

$$Y = \alpha_0 * X_1^{\alpha_1} * X_2^{\alpha_2} * X_3^{\alpha_3} * X_4^{\alpha_4} * X_5^{\alpha_5} * v \quad (6)$$

$$\text{Log}Y_i^* = \text{log}\alpha_0 + \alpha_1 \text{log}X_{1i} + \alpha_2 \text{log}X_{2i} + \alpha_3 \text{log}X_{3i} + \alpha_4 \text{log}X_{4i} + \alpha_5 \text{log}X_{5i} + v \quad (7)$$

Where Y = total cost (E/ha),  $X_1$  = Yield (kg/ha),  $X_2$  = Cost of human labour used (E/ha),  $X_3$  = Cost of fertilizer used (E/ha),  $X_4$  = Cost of pesticide (litres),  $X_5$  = Cost of seeds (E/ha),  $\alpha_0$  = constant and  $v$  = Random error term (U+V).

Efficient scores obtained from model (6) were regressed on farmer and farm characteristics using a two-limit Tobit regression model (7). It was assumed that AE effects were independently distributed and  $Y_i^*$  arise by truncation at zero of the normal distribution.

$$Y = A * Z_1^{\alpha_1} Z_2^{\alpha_2} * \dots * Z_n^{\alpha_n} * v \quad (9)$$

$$Y_i^* = \alpha_0 + \alpha_1 P_{1i} + \alpha_2 P_{2i} + \dots + \alpha_k P_{nk} \quad (10)$$

Where  $Y_i^*$  = AE ratio,  $P_1$  = Farmers age in years,  $P_2$  = Years in farming,  $P_3$  = Gender,  $P_4$  = Household size,  $P_5$  = FISP status,  $P_6$  = IGA,  $P_7$  = Occupation,  $P_8$  = Education status,  $P_9$  = Marital status.

According to Bravo-Ureta and Pinheiro (1997), EE is a product of TE and AE. Therefore, EE of each farmer was calculated using the following equation:

$$EE_i = TE_i * AE_i; \text{ for } i = 1, 2, \dots, n^{\text{th}} \text{ farmer} \quad (11)$$

In measuring the factors affecting EE levels, a two-limit Tobit regression model was used as a second step analysis to establish the relationship between the socio-economic characteristics, production characteristics and market characteristics of smallholder farmers and the computed indices of TE. The estimated efficiency sores were regressed on a set of socio-economic factors that were considered more appropriate since the values of the

dependent variable (efficient scores) lied within a certain interval (0 – 1), which are the two acknowledged restrictions of the model (Wilson, *et al.*, 1998). It was assumed that efficiency effects were independently distributed and  $U_{ij}$  arises by truncation (at zero) of the normal distribution with mean  $U_{ij}$  and variance  $\sigma^2$ , such that:

$$U_i^* = \alpha_0 + \alpha_1 X_{1i} + \alpha_2 X_{2i} + \dots + \alpha_k X_{nk} \quad (12)$$

$$i = 1, 2, \dots, k^{th} \text{ farmer}$$

Where  $U_i^*$  = AE ratio,  $X_1$  = Farmers age in years,  $X_2$  = Years in farming,  $X_3$  = Gender,  $X_4$  = Household size,  $X_5$  = FISP status,  $X_6$  = IGA,  $X_7$  = Occupation,  $X_8$  = Education status,  $X_9$  = Marital status. Note that  $U_i^*$  was calculated as the product of TE and AE.

Regression model diagnostics was done to ensure that the available data meets the assumption of Ordinary Least Squares (OLS) regression. Firstly, the linearity assumption was checked to see if the relationship between the variables and the outcome variable were linear. The data were also tested for multicollinearity.

### 3.3 Output Elasticities and Return to Scale

The first order coefficients of Equation (3) are not considered as they are not very informative, instead the determination of elasticities becomes necessary for the estimation of responsiveness of yield to inputs. Output elasticities for each of the inputs calculated at variable means are of great importance in this case (Awudu & Eberlin, 2001). The elasticity output with respect to the  $i^{th}$  input,  $e_i$ , evaluated at the mean values of the relevant data points can be derived as:

$$e_i = \frac{\partial \ln Y}{\partial \ln X_i} = \beta_i + 2\beta_{ii} \ln \bar{X}_i + \sum_{j \neq i} \beta_{ij} \ln \bar{X}_j \quad (14)$$

Using Equation (3), output elasticity with respect to input,  $X_i$  evaluated at the sample mean. The elasticity of output with respect to the  $i^{th}$  input measures the responsiveness of output to a 1 percent change in the  $i^{th}$  input. The measure of return to scale (RTS) representing the percentage change in output due to a proportional change in the use of all inputs, is

estimated as the sum of output elasticities for all inputs. If this estimate is greater than, equal to or less than 1, we have increasing, constant or decreasing return to scale respectively.

### **3.0 CHAPTER**

**4**

## **DATA ANALYSIS, RESULTS AND DISCUSSIONS**

#### **4.04.1 INTRODUCTION**

In this chapter, the data analysis, empirical findings and results and discussion of the results are presented. The chapter is structured according to the empirical procedures followed. It starts with a descriptive statistical analysis of all variables used in the modelling, distribution of all variables, technical and allocative efficiencies and finished with factors that affect the inefficiencies of smallholder maize farmers both technically and allocatively.

## 5.04.2 DESCRIPTIVE STATISTICAL ANALYSIS OF STUDY POPULATION

The dataset comprised of 12, 271 households covering both FISP beneficiaries and non-beneficiaries. This dataset contains many variables, however, those that were used in this study are described and presented in Table 2.

*Table 2: Profile of Smallholder farmers covered in the study*

<b>Variable</b>	<b>Units</b>	<b>Min</b>	<b>Mean</b>	<b>Max</b>	<b>Std. Dev</b>
Age of Household Head	Years	20	36	55	8.3
Formal Education of Household Head	Years	0	2	12	6.2
Farming Experience of Household Head	Years	2	21	35	7.8
Household Size	Persons	1	4	9	3.1
Labour	Persons	1	2	7	1.8
Fertilizer Amount	Kg	5	20	50	9.1
Amount of Labour	Man-hours	26	340	1800	15.6
Output (Quantity Harvested)	Kg/Ha	50	150	500	7.3
Farm Size	Ha	0.1	2	5	7.8
Income Generating Activity (IGA)	MWK	0	3 000	10000	11.6
Distance to the Market (DM)	KM	0	2	5	9.8
Amount of Seeds	Kg	5	11	20	0.7

*Source: Authors estimate from Research data*

The age distribution of these smallholder farmers as presented in Table 2, shows that on average, they were 36 years old with a minimum of 20 and a maximum of 55 years. Education is an essential personal characteristic that influences one's capability to adapt. In this study, the average educational years of these smallholder farmers was 2, with a minimum of 0 and a maximum of 12 years. Farming experience is one of the strong points of smallholder maize farmers. The average farming experience was 21 years and the minimum and maximum experience was 2 and 35 years respectively. The average household size, which was the provider of labour force in farming was 4 persons, the minimum was 1 person and the maximum was 9 persons. Man-hours, which was a proxy for labour in the study had an average of 2 persons, with a minimum of 1 person and a maximum of 7 persons.

On average, farmers used 20 kgs of fertilizer, with a minimum of 5 kgs and a maximum of 50 kgs. On amount of seeds, these smallholder farmers used on average 11 kgs, with a minimum of 5 kgs and a maximum of 50 kgs. Amount of seeds used during the study farming year was also another input used. On average, these smallholder farmers used 11 kgs of hybrid maize seeds, with a minimum of 5 kgs of seeds and a maximum of 11kgs. The farm size distribution of these smallholder farmers had an average of 2 ha, with a minimum of 0.1 and a maximum of 5 ha. The distance to the market was also taken into account. Most of the farmers were living within an average of 2 km, with a minimum of 0 km and a maximum of 5 km distance from the nearest market.

As presented in Table 1, these farmers got 3, 000 Malawi Kwacha (an equivalent of 2 United States Dollars) from other income generating activities. This additional income was also used to provide supplementary funds for purchasing farm inputs. The overall output – quantity of maize produced in kgs was evaluated and presented in Table 1. On average, these smallholder farmers harvested 500 kgs with a minimum of 50 kgs and a maximum of 5 000 kgs per season. Further description of variables are presented in Table 3.

Table 3: Distribution of study population variable characteristics

<b>Variable</b>	<b>Category</b>	<b>Frequency</b>	<b>Percent</b>
Gender	Male	9 210	75.1
	Female	3 061	24.9
	<i>Total</i>	<i>12 271</i>	<i>100</i>
Age	0 - 18 Years	78	0.6
	18 - 50 Years	8 898	72.5
	Over 50 Years	3 295	26.9
	<i>Total</i>	<i>12 271</i>	<i>100</i>
Marital Status	Never Married	438	3.6
	Married	8 767	71.4
	Divorced	1 439	11.7
	Widowed	1 627	13.3
	<i>Total</i>	<i>12 271</i>	<i>100</i>
Education	None	8 556	69.7
	Primary	1 197	9.8
	Secondary	2 101	17.1
	Tertiary	417	3.4
	<i>Total</i>	<i>12 271</i>	<i>100</i>
FISP Beneficiary	Yes	8 465	69
	No	3 806	31
	<i>Total</i>	<i>12 271</i>	<i>100</i>
Household Size	0 - 5 People	8 637	70.4
	Over 5 People	3 634	29.6
	<i>Total</i>	<i>12 271</i>	<i>100</i>
Household Labour Force	0 - 5 People	9 977	81.3
	Over 5 People	2 294	18.7
	<i>Total</i>	<i>12 271</i>	<i>100</i>

Source: Authors estimate from Research data

*Table 3 continues: Distribution of study population variable characteristics*

Variable	Category	Frequency	Percent
Land Holding Size (Hectares)	Less than 1	8 379	68.3
	0 - 5	3 873	31.6
	5 – 10	9	0.1
	Over 10	10	0.1
	<i>Total</i>	<i>12271</i>	<i>100</i>
Harvested Quantity (Maize) (50 Kg Bags)	Less than 1	454	3.7
	0 - 5	6 285	51.2
	5 – 10	1 355	11
	Over 10	4 177	34
	<i>Total</i>	<i>12 271</i>	<i>100</i>
Sold Quantity (50 KG Bags)	Less than 1	157	1.3
	0 - 5	574	4.7
	5 – 10	254	2.1
	Over 10	11 286	92
	<i>Total</i>	<i>12 271</i>	<i>100</i>
Value for Sales (MK '000)	0 – 5	10 873	88.6
	5 – 10	331	2.7
	10 – 50	633	5.2
	Over 50	434	3.5
	<i>Total</i>	<i>12 271</i>	<i>100</i>
Quantity Stored (50 KG Bags)	Less than 1	12 123	98.8
	0 - 5	75	0.6
	5 – 10	28	0.2
	Over 10	45	0.4
	<i>Total</i>	<i>12 271</i>	<i>100</i>
Distance to Market	Less than 1KM	11 852	96.6
	1 - 2KM	192	1.6
	Over 2KM	227	1.8
	<i>Total</i>	<i>12 271</i>	<i>100</i>

*Source: Authors estimate from Research data*

*Table 3 continues: Distribution of study population variable characteristics*

Variable	Category	Frequency	Percent
Income Generating Activities	Yes	2 592	21.1
	No	9 679	78.9
	<i>Total</i>	<i>12 271</i>	<i>100</i>
Remittance	Yes	127	1
	No	12 144	99
	<i>Total</i>	<i>12 271</i>	<i>100</i>
Geographic Area	Urban	2 233	18.2
	Rural	10 038	81.8
	<i>Total</i>	<i>12 271</i>	<i>100</i>

*Source: Authors estimate from Research data*

Table 3 shows that of the 12, 271 households interviewed in the survey, 9, 210 (representing 75.1 percent) were male-headed while 3, 061 households (about 24.9 percent) were female-headed. This shows the dominance of male heads in the study. The other issue of importance to be described is the marital status of these households. Table 3 shows that of the interviewed households, 438 of them (about 3.6 percent) were unmarried, 8, 767 of them (about 71.4 percent) were married, 1, 439 (about 11.7 percent) had divorced while 1, 627 (about 13.3 percent) were widowed.

Table 3 shows the distribution of ages of the interviewed households mainly in three categories taking into account the main demographic divisions of young (0 – 18), young adults (18 – 50) and adults (above 50). From the table, only 78 households (about 0.6 percent) were in the age range of 0 to 18, while the majority (8, 898) of the households representing about 72.5 percent were in the young adults category (18 to 50) with 3, 295 households (about 26.9 percent) being in the adult category of above 50 years of age.

Education is another supplement of agricultural activities as far as following instructions is concerned. Worldwide campaign of migrating from traditional to modernized farming relies mainly in educational background of those involved in agricultural activities. To understand educational background of the interviewed households, Table 3 unfortunately shows that majority (8, 556) of the interviewed households (representing about 69.7 percent) were uneducated, 1, 197 of the households (about 9.8 percent) had primary education, 2, 101 households had secondary education while only 417 households (about 3.4 percent) went beyond secondary education.

Land is an important factor of production. Modern farming methods can do very little on limited resources such as land, and when lack of this important element is combined with other limiting factors such as poor education, this can be a potentially huge obstacle to crop production. Land in hectares was therefore, another variable that was described in this study and Table 1 gives the description of land holding sizes (LHS) of the interviewed households. The table reveals that majority of the households (8, 379) representing about 68.3 percent had LHS of less than 1 Hectare, 3, 873 households (about 31.6 percent) had LHS of between 1 and 5 Hectares, 9 households (about 0.1 percent) had LHS in the range of 5 to 10 Hectares while only 10 households had LHS of above 10 Hectares.

Labour is another important factor of production. Adult household members were used as proxy to labour in this study. Labour was described by categorizing in two groups (0 – 5 and above 5). Traditional farming as mainly practiced in Malawi is labour intensive and this is crucial to maximizing agricultural production. As summarized in Table 4.1, 9, 977 households (about 81.3 percent) comprised of members in the range of 0 to 5 people while 2, 294 households (about 18.7 percent) comprised of more than 5 members.

Number of people in a family (household) has a positive or negative effect on the household well-being. Despite that fact that this contributes to labour force, family size is only beneficial if the members are in the working age group. If most of members are unproductive, then increased household size impinges on household welfare. I therefore, grouped household size into two categories of 0 – 5 and above 5 people, Table 3 gives a

summary of the distribution. Of the interviewed 12, 271 households, 8, 637 of them (representing 70.4 percent) comprised of members in the range of 0 to 5 people while 3, 634 households (about 29.6 percent) had above 5 people.

As this study wants to determine the impact of FISP on food security among others, whether the households benefited from FISP or not was another variable of interest, which was later used as dependent variable in the determination whether households can be food secure or not. Table 1 gives the distribution of households by whether they benefitted or not from FISP. Table 3 also shows that of the interviewed 12, 271 households, 8, 465 of them (about 69 percent) benefitted while 3, 806 households (about 31 percent) did not benefit.

Quantity and value of the harvests are some of the common measurement mechanism of FISP that has been used in this study and maize being the staple food and mainly at the centre of FISP, its harvested quantity (in 50KG bags) and sold values (in Malawi Kwacha) have been categorized and isolated for the purpose of the analysis. On harvested quantity, Table 3 shows that of the interviewed 12, 271 households, 454 of them (about 3.7 percent) harvested less than 1 bag, 6, 285 households (about 51.2 percent) harvested between 1 and 5 bags, 1, 355 households (about 11 percent) harvested between 5 and 10 bags while 4, 177 households (about 34 percent) harvested over 10 bags.

As some households sell the harvested crops as a source of income for other money demanding issues, Table 3 also gives the distribution of the quantity sold out of the harvested. It is revealed from the table that 157 households (about 1.3 percent) sold less than 1 bag of their harvested maize, 574 households (about 4.7 percent) sold between 1 and 5 bags of their harvested maize, 254 households (about 2.1 percent) sold between 5 and 10 bags of their harvested maize while 11, 286 households (about 92 percent) sold over 10 bags of harvested maize. Having sold most of the food, households were asked if they at least kept something to keep them going until the next harvesting time. Table 3 also gives the distribution of how the households stored their harvested maize. Of the interviewed 12, 271 households, 12,123 of them (about 98.8 percent) stored less than 1 bag, 75 of them (about 0.6 percent) stored between 1 and 5 bags, 28 of them (about 0.2 percent) stored between 5 and 10 bags while only 45 households (about 0.4 percent) stored over 10 bags.

Market availability and access is another factor of farming enterprises that helps in the development and growth of farmers. In this study, distance to the market in KM is used as a measure of access and availability of markets. Table 3 also gives the distribution of market access as reported by household. Of the interviewed 12, 271 households, 11, 852 (about 96.6 percent) reported to have availability and access to the market within less than 1 KM, 192 households (about 1.6 percent) reported having markets available and accessible within 1 to 2 KM while 227 households (about 1.8 percent) reported having markets available and accessible over 2 KM away. This indicated that most households had available markets which were also accessible for their agricultural production.

One way to avoid selling farm produce such as maize is availability and access to other money sources that one can use for other monetary demanding issues. In this case, other sources of money such as Income Generating Activities (IGAs) and Remittance have been described in Table 3. On whether the households have income generating activities, Table 4.1 shows that of the interviewed households, 2, 592 of them (about 21.1 percent) had IGAs while 9, 679 (about 78.9 percent) did not have any IGAs. The households were asked if they receive any remittance and Table 3 also gives the remittance distribution. Of the 12, 271 interviewed households, 127 of them (about 1 percent) reported to have received money from other sources while majority of them (12, 144) representing 99 percent did not receive any money from other sources.

Finally, geographical setting of households has been summarized in Table 3. This reveals that majority of the interviewed household (10, 038 representing 81.8 percent) were in rural areas while 2, 233 households (about 18.2 percent) were in urban. On describing further those who either benefitted from FISP or not, this study further wanted to determine the benefit by geographic area.

### **6.04.3 ESTIMATION OF STOCHASTIC PRODUCTION FUNCTION – EFFICIENCY ANALYSIS**

The coefficients of the Maximum Likelihood Estimates (MLE) of the parameters of Cobb-Douglas stochastic frontier models of smallholder maize farmers using Equation 3 is shown in Table 4. These parameters represent the percentage change in the dependent variable as a result of the percentage change in the independent variables, and the relative importance of these variables to maize production in Malawi. For those variables that have positive coefficients, it implies that as each of them is increased, maize output also increases, while those with negative signs means that as each of them is increased, little or nothing has been added to maize output. The magnitude of the coefficients of significant variables indicates that farm output is inelastic to change in any of the variables used in the analysis.

Of all variables analyzed, farm size, which was included to capture efficiency advantages and disadvantages associated with the size of the plot had the highest coefficient (0.87), indicating that it is the most important variable in maize production in Malawi. One of the main constraints facing agriculture in Malawi is the small land holdings among smallholder farmers that are becoming smaller and smaller through the subdivision to family members Chirwa *et al.* (2003). The average plot size of 0.5 hectare in an economy with agricultural labour surplus leads to uneconomic combination of factors of production leading to technically inefficient production levels. Given that maize is the staple food in Malawi, efficient food production and food security can be enhanced through policies that increase the land size holdings such as resettlement schemes or land redistribution programme. Referring to Table 3, about 68 percent of farmers had farms of less than 1 ha. This means that no matter how fit, their increased production would mainly rely on the size of their farms. Thus, a 1 percent increase in farm size will induce an increase of about 87 percent of maize output in the farming households. This result is similar to those of Baloyi *et al.* (2012); Chiona *et al.* (2014); Sihlongonyane *et al.* (2014). Likewise, for age, the positive coefficient indicates that older farmers have higher chances of having increased output than younger farmers. This result was also

observed by Beniam *et al.*(2004) and Chiona *et al.* (2014) who argued that older farmers have more experience to be conversant to farming issues than younger farmers who might not be well-posed to apply inputs or implement certain agronomic practices sufficiently quickly. As timely application of inputs and implementation of management is expected to enhance efficiency, young farmers may find this challenging.

As shown in Table 4, the estimated coefficient of family size is negative (-0.17) and statistically significant at 1 percent. This indicates increases in the family size of farmers results in declines in their technical efficiency. The implication of this is that large household size increases pressure on the farmer's limited resources due increases in household spending on other equally important issues and this reduces timely operation of farm activities. This means that as family increases by a single person, maize output decreases by about 17 percent. An income generating activity and getting remittances are essential as a cushion for supplementary source of funds for the extra purchase of farm inputs as those from FISP are inadequate. However, most farmers in the study had no IGAs and did not receive remittances, which was a disadvantage. The estimated coefficient of IGA was the second and third highest respectively and had a positive signs meaning that a farmer that had an IGA and receive remittance is induced to increase the output by about 81 and 71 percent respectively. As those farmers had a better financial muscle to purchase extra inputs.

In this study, the positive coefficient observed for the education variable indicates that educated farmers would increase output by about 53 percent than the less educated farmers. It is quite possible that although some farmers adopted fertilizer technology, given the low level of education among most smallholder farmers and the small land holdings such technologies may be applied inappropriately. The study findings are consistent with earlier studies by Dzimadzi *et al.* (2001) and Sibale *et al.* (2001) on the effect of literacy on output.

A positive and significant coefficient was also observed for the farming experience of a farmer. Experienced farmers had a chance of increasing output by about 14 percent compared to those with less experience. Marital status of a farmer also had a negative

impact in this study, implying that unmarried farmers were disadvantaged as this status contributed to a loss of about 28 percent of the total output. Most unmarried farmers are not motivated to work hard in farming activities or other income generating activities because they have either little responsibility or no responsibility at all because they have no spouses and dependents to take care of.

Another factor that negatively impact on maize production in Malawi was the distance to the market where farmers can access farm inputs. The farmers who stay far away from the market are more likely to lose about 11 percent of the total output compared to those who live near to the market. The cost of transportation and the poor road infrastructure affects the yield that is delivered to the market.

Sex is not statistically associated with farmer's efficiency in maize production. This is similar to the findings of Chirwa (2003) but contrary to Udry *et al.* (1995) and Udry (1996) findings that female-controlled farms are more efficient than those controlled by males.

Lastly, FISP had little effect on maize production in Malawi in the period under review as those who benefited from it only managed to increase output by only about 9 percent compared to those who did not benefit. This is not a surprise as a study by Lunduka *et al.* (2014) found out that there is conflicting evidence of FISP. They wondered as to whether rural poverty rates among smallholder farmers have risen or declined in the recent years based on FISP. As stated by other FISP critical reviewer such as Dorward and Chirwa (2011), Dzimadzi *et al.* (2001) and many others, for FISP to be beneficial, there is a need for beneficiaries' complementary inputs such as land, labour, quality soil and good management for its effectiveness.

Referring to Table 4, the variance parameters, sigma-squared and gamma were 0.79 ( $p < 0.05$ ) and 0.82 ( $p < 0.05$ ) respectively. The gamma implies that about 82 percent of the variation in the output of maize production is due to the differences in the technical efficiency. Thus, inefficiency effects were present and make a significant contribution to the efficiency of smallholder farmers maize production.

**Table 4 : Parameter estimates of Stochastic Production Frontier and Technical Inefficiencies Models**

Variable	Parameter	Coefficients	<i>t</i> -Ratios	Standard Deviations
<b>Stochastic Production Frontier Model</b>				
Constant	$\beta_0$	7.61**	3.62	0.71
Seeds	$\beta_1$	0.25**	1.73	0.001
Farm Size	$\beta_2$	0.87***	11.9	0.06
Labour	$\beta_3$	-0.17**	3.17	0.01
Fertilizer	$\beta_4$	-0.26**	-0.02	0.001
<b>Technical Inefficiency Model</b>				
Constant	$\delta_0$	-0.45	-0.06	0.03
Age	$\delta_1$	0.22***	0.81	0.16
Marital Status	$\delta_2$	-0.28**	1.56	0.23
Sex	$\delta_3$	0.01	0.03	0.45
DM	$\delta_5$	-0.11*	0.46	0.07
Farming Experience	$\delta_6$	0.14**	0.52	0.042
Family Size	$\delta_7$	-0.17***	-2.07	0.34
Remittance	$\delta_8$	0.71**	-2.85	4.31
Education Years	$\delta_9$	0.53**	2.98	0.03
IGA	$\delta_{10}$	0.81***	-4.81	2.92
FISP(1 = Yes)	$\delta_{11}$	0.09*	-2.12	3.01
<b>Diagnostic Statistics</b>				
Sigma Squared	$\sigma^2$	0.79**	4.32	0.21
Gamma	$\gamma$	0.82**	23.1	
Likelihood Function		142.4		
Mean Technical Efficiency		0.613		

\* =  $p < 0.1$ , \*\* =  $p < 0.05$ , \*\*\* =  $p < 0.01$  Source: Authors estimate from Research data

Consistent with the main objective of the study to investigate the impact of FISP among smallholder farmers in Malawi, the parameter estimates of the production function of FISP beneficiaries was also estimated. The results are presented in Table 5.

*Table 5: Stochastic Frontier Function of Smallholder maize farmers who have benefitted from FISP*

<b>Variable</b>	<b>Parameter</b>	<b>Coefficients</b>	<b>t-Ratios</b>	<b>Standard Deviations</b>
Constant	$\beta_0$	12.6**	7.69	1.71
Age	$\beta_1$	0.31*	0.76	0.46
Farm Size	$\beta_2$	1.87***	11.9	0.36
Family Size	$\beta_3$	-0.31**	-1.71	0.43
Labour	$\beta_4$	-0.74**	1.17	0.31
Fertilizer	$\beta_5$	0.03**	-0.24	0.01
Farming Experience	$\beta_6$	0.34**	1.09	0.02
Seeds	$\beta_7$	0.65**	2.13	0.04
Remittance	$\beta_8$	1.21**	-4.12	4.01
Education Years	$\beta_9$	0.71**	2.98	0.12
IGA	$\beta_{10}$	2.8***	-3.19	1.72
<b>Diagnostic Statistics</b>				
Sigma Squared	$\sigma^2$	0.56**	3.13	0.56
Gamma	$\gamma$	0.75**	13.8	0.33

\* =  $p < 0.1$ , \*\* =  $p < 0.05$ , \*\*\* =  $p < 0.01$  Source: Authors estimate from Research data

The parameters estimate of the production function of FISP beneficiaries as presented in Table 5 shows that age of the farmer, farm size, family size, type of labour used, amount of fertilizer applied, type of seeds planted, whether a farmer receives remittances, whether a farmer has an IGA and education years of a farmer have significant influence on maize production output. The signs of these parameters have important policy implications as positive signs imply a positive effect on the efficiency while a negative sign implies a negative effect on efficiency. For instance, the positive coefficients have a direct relation to

the dependent variable as a 1 percent increase in each of these positively signed variables result in 1 percent increase in maize output. Those that have negative signs induce a negative effect on the dependent variable in that a 1 percent increase in each of them results in a 1 percent decrease in maize output, *ceteris paribus*. The values of sigma-squared is 0.56 ( $p < 0.01$ ), attesting to a good fit of the model. Also, the variance ratio (gamma) – a measure of level of the inefficiency in the variance parameter that ranges from 0 to 1, which is 0.75 ( $p < 0.01$ ) revealed that inefficiency effects exist among FISP beneficiaries. This implies that about 75 percent of the variation in the maize production by smallholder farmers who benefit from FISP is due to issues surrounding the FISP program.

#### 7.04.4 TECHNICAL, ALLOCATIVE AND ALLOCATIVE EFFICIENCY ANALYSIS

The frequency distribution of the efficiency estimates of smallholder maize farmers who benefitted from FISP is presented in Table 6.

*Table 6: Summary of frequency distribution of TE, AE and EE*

Class	Technical efficiency		Allocative Efficiency		Economic Efficiency	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
0.10 - 0.20	130.0	1.5	0.0	0.0	126.0	1.5
0.20 - 0.30	594.0	7.0	529.0	6.3	759.0	9.0
0.30 - 0.40	876.0	10.3	962.0	11.5	1 383.0	16.3
0.40 - 0.50	1298.0	15.3	901.0	10.8	1 862.0	22.0
0.50 - 0.60	790.0	9.3	1784.0	21.3	2 005.0	23.7
0.60 - 070	1879.0	22.2	1578.0	18.9	1 079.0	12.7
0.70 - 0.80	2898.0	34.2	1465.0	17.5	1 251.0	14.8
0.80 - 0.90	0.0	0.0	1146.0	13.7	0.0	0.0
>0.90	0.0	0.0	0.0	0.0	0.0	0.0
Total	8 465.0	100.0	8 465.0	100.0	8 465.0	100.0
Mean	61.3		66.9		59.2	
Minimum	15.7		23.5		14.1	
Maximum	78.9		86.2		74.6	

*Source: Authors estimate from Research data*

TE indices varied widely, with an average of 61.3 percent and ranged from 15.7 to 78.9 percent. The variation is huge and this could be attributed to differentiated individual and farm level characteristics. Majority of the smallholder farmers have TE that is above average and this means that there is still a room for improved TE. AE indices varied widely, with an average of 66.9 percent and ranged from 23.5 to 86.2 percent. The variation is huge and this could also be attributed to differentiated individual and farm level characteristics. Majority of the smallholder farmers have AE that is above average and this means that there is still a room for improved AE.

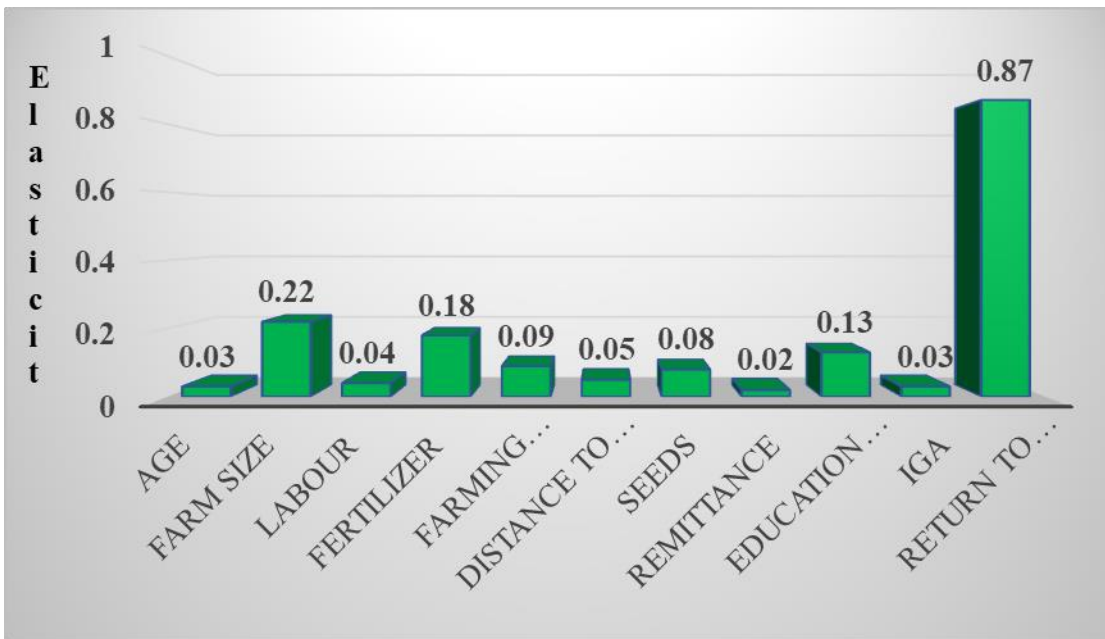
EE indices varied widely, with an average of 59.2 percent and ranged from 14.1 to

74.6 percent. The variation is huge and this could also be attributed to differentiated individual and farm level characteristics. Majority of the smallholder farmers have EE that is above average and this means that there is still a room for improved EE.

### 8.04.5 INPUT ELASTICITY AND RETURN TO SCALE

Determination of elasticities is necessary for the estimation of the responsiveness of yield to inputs. The parameter estimate in C-D production function is the elasticities and the sum gives the return to scale. The estimated elasticities evaluated by means of relevant data points and defined by Equation (14) are presented in Figure 3.

Figure 1: Distribution of elasticities of production and return to scale



Source: Authors estimate from Research data

As presented in Figure 3, all elasticities are positive and are significantly different from zero at 5 percent significance level. As presented in Figure 3, maize output has high responsiveness to farm size, which was found to have the highest elasticity (0.22), followed by fertilizer (0.18), education years (0.13), farming experience (0.09), distance to the market (0.05), labour (0.04), IGA and age, which both have (0.03) and remittance (0.02). It means that ceteris paribus, a 1 percent increase in the quantity of farm size for each smallholder farmer would increase maize output by 22 percent, a 1 percent increase in fertilizer would increase the output by 18 percent, a 1-year increase in farmer's age gives a likelihood of being productive in maize output by 13 percent, a 1 year increase on farmers' farming experience has the potential of increased output by about 9

percent, making farm inputs accessible would increase the output by about 5 percent, increasing farm labour has the potential of increasing output by about 4 percent, older farmers who have income generating activities have a chance of increasing their outputs by 3 percent and those farmers receiving remittances have a chance of increasing their outputs by about 2 percent.

All inputs elasticities are inelastic indicating that a 1 percent increase in each of the inputs results in a less than 1 percent increase in maize output. RTS, which represents the return to scale coefficient or total output elasticity computed as the sum of output elasticities for all inputs is estimated as 0.87, indicating that on average, maize production by smallholder farmers in Malawi would decrease by about 13 percent, hence farmers would be food secure and have decreased income levels that beat the aim of FISP. The study finding is consistent with the earlier findings by Kibaara, (2005) who found all input elasticities inelastic. In other words, if all factors are varied by the same proportion, in the long run, the function coefficient (RTS) indicates the percentage by which output will be increased.

## Chapter 5

### SUMMARY, CONCLUSION AND RECOMMENDATIONS

#### 5.1 Chapter Summary

This study was set out to empirically investigate levels of technical, allocative and economic efficiencies in maize production among smallholder farmers in Malawi. This study followed the stochastic production function approach to estimate technical, allocative and economic efficiency scores and determined factors associated with maize production efficiency among smallholder farmers using a dataset from 2010 IHS3. Therefore, this chapter gives the conclusion of the work done, suggests some recommendations and also gives possible weakness of the study findings.

#### 5.2 Conclusion

Maize is the main staple food in Malawi and as such high productivity and efficiency in its production is critical for food security in the country. Despite heavy investment in agriculture by the government some five decades ago, most households remain food secure as evidenced by aggregates of maize production indices that do not show a sustainable pattern in food production. There are several factors (both farmers' and farm level) that both negatively and positively impact maize production in Malawi. Farmers' age, farming experience, education years, benefiting from FISP, having income generating activity and receiving remittances positively affect maize production while farmers' marital status, family size and distance to the market negatively impact maize production.

Malawi is one of the poorest countries in the world, with a rural poverty rate of 43 percent. Maize is the staple food crop in Malawi, grown by 97 percent of farming households (GoM, 2006). However, Malawi has struggled to improve agricultural productivity from its low levels to enhance food and nutritional security. It has been argued that the adoption of agricultural technologies such as improved maize varieties and subsidized fertilizer increase food security, not only through higher productivity but also through the freeing up of land for agricultural diversification Dzimadzi *et al.* (2001). GoM (2006) tried to

encourage uptake through the provision of subsidies, as well as extension services. Most recently, the large-scale Farm Input Subsidy Program that started in 2005 tried to target millions of poor farmers to increase their access to these technologies.

The results from the econometric model in this study show that maize production in Malawi is done mainly under a decreased return to scale. Most farmers are technically, allocatively and economically inefficient with mean TE score of 61.3 percent that ranged from 15.7 percent to 78.9 percent and the modal TE score is 33 percent in the class of 0.40 to 0.50. The mean AE score is 66.9 percent that ranged from 23.5 to 86.2 percent and the modal EA score is 35 percent in the same modal class as TE (0.40 to 0.50). The mean EE score is 59.2 percent that ranged from 14.1 to 74.6 percent with the modal EE score of 23.7 percent, which is in 0.50 to 0.60 class. These mean efficiency levels are within the range of most African countries whose means range from 55 to 79 percent. These results also support the hypothesis that TE increases with large farms, type of seeds used, farmers' education, farmers' age, income generating activities, remittances and amount of fertilizer applied.

Surprisingly, FISP that captures whether a farmer benefits or not from subsidized farm inputs show no any association with TE, AE and EE. This may imply that though most of these smallholder farmers are recognized as FISP beneficiaries, there is a possibility that they might be misusing the program. Despite continued government investment in Agriculture sector through agricultural inputs and other related resources, smallholder maize farming remains technically, allocatively and economically inefficient in Malawi. Among other factors that affect the efficiency of these smallholder farmers are their ages, farming experience, education years, type of labour used, type of seeds used, farm size, distance to the market, if a farmer receives remittance and has an income generating activity, with some having negative effects while others have positive effects.

Smallholder maize farming, which constitutes a larger proportion of agriculture farming in Malawi plays a major role in food security, poverty alleviation and income

generation. It is concluded, therefore, that higher productivity and thereby high technical, allocative and economic efficiency levels in maize production is critical to food security, poverty alleviation and income generation in Malawi. The production function analysis revealed that inefficiency exists among smallholder farmers in Malawi.

### **5.3 Recommendations**

FISP was implemented with an objective of increasing smallholder farmers' access to improved agricultural inputs as a way of achieving food self-sufficiency and increased farm income levels. Despite the programs' acclaims for contributing to improved maize production, smallholder maize farming has remained technically, allocatively and economically inefficient despite continued government heavy investment in the agricultural sector through agricultural inputs under FISP and promotion of new technology, the following policy issues are being suggested from the results of the study.

1. Much as understanding the constraints limiting agriculture and developments is an essential starting point in understanding issues surrounding FISP's potential, scarcity of farm lands needs to be effectively addressed. It is therefore recommended that distributional structure of FISP needs also to be revisited in relation to farm level factors rather than universal policy of equal inputs for all.
2. Like many other parts of the world, climatic change in Malawi is skewed disproportionately towards agriculture, Malawian subsistence farmers suffer from climatic change stresses in different forms ranging from drought, dry spell, floods to erratic and unreliable rainfall. It is therefore recommended that implementation structures of FISP should take into account climatic change if reaping good results are to be realized.
3. Education, which had a positive significant impact on smallholder farmers' efficiency, is another factor for improved agriculture production since it improves farmers' skills enabling them to achieve higher output for given inputs. Secondly, it enhances their ability to obtain, understand, and utilize new inputs and practices.

Thirdly, it improves farmers' overall managerial ability.. Evidence is available that suggests that investment in public goods such as agricultural research, extension and roads constitutes one of the most effective tool available to stimulate economic growth and poverty reduction. It is therefore recommended that the government should encourage these farmers to improve their education level by enrolling in adult or continuing education centres. Also to be considered in educating these farmers is an enhanced and revamped extension services that would help in educating farmers on these new or modern farming technologies to enhance their efficiency levels.

4. Market and conventional seeds availability and access are another ingredients of farming that help in development and growth of farmers as farmers need to buy inputs and sell their products. Distance to the markets and use of hybrid were found to have an impact in the smallholder maize farming efficiency, it is therefore recommended that government efforts should also focus on improving access to improved inputs such as certified seed and fertilizer.

#### **5.4 Limitations of the study results**

Despite IHS3 dataset being a nationally representative survey of smallholder maize farming, in the analysis it was not possible to control for differences in farming lives of these farmers and their natural abilities due to limited number of plots cultivated.

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