

**Estimating Farm-Level Technical Efficiency of Sunflower in Lango Sub-Region in
Northern Uganda: A Stochastic Frontier Approach**

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DECLARATION

I, GRACELINE AKONGO OKWIR, do here declare that this thesis is my own work and has not been submitted for a Degree Course in any other University.

Signature



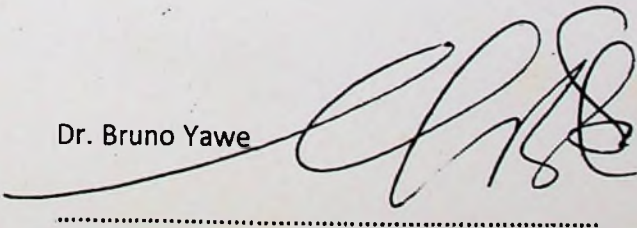
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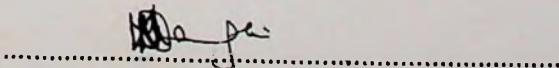
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Date

7/12/2010

DEDICATION

To my father David O.O Obong, my mother Rosemary Okwir, my dear husband Mr. Opolo Emmanuel Peace and my sons Bray Ben and Bram.

ACKNOWLEDGEMENT

I wish to express my gratitude to the sunflower farmers who provided the data used in the analysis. Secondly I thank the officials from UOSPA and Mukwano who provided relevant information pertaining to sunflower production in the region and also helped in identifying their agents who were eventually used as enumerators. Not forgetting to thank those who assisted me during data collection as enumerators, these were agents from UOSPA and Mukwano drawn from the districts of Lira, Apac, Dokolo and Oyam.

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I owe my family for standing by me throughout my studies: My uncle David Obong, a father in deed who has supported my education and all that is required of a parent. My husband Peace and aunt Joan Obong for their material and emotional support during my pursuit; to my siblings Alfred, Ester, Joyce, Judith and Sarah. The children Mercy, Allan, Masha, Bray Ben, Emma and Bram peace patiently gave me ample time to complete this work. Amidst all these support from institutions, friends and family, there was the ALMIGHTY GOD who filled all the necessary gaps.

ACRONYMS

AE	Allocative Efficiency
APEP	Agriculture Productivity Enhancement Programme
APP	Average Physical Product
C-D	Cobb-Douglas
DEA	Data Envelop Analysis
EE	Economic Efficiency
VIF	Variable Inflation Factors
GoU	Government of Uganda
IFAD	International Funds for Agricultural Development
iid	independently and identically distributed
MFC	Marginal Factor Cost
MLE	Maximum Likelihood Estimate
MPP	Marginal Physical Product
NARO	National Agricultural Research Organisation
OLS	Ordinary Least Square
PMA	Plan for the Modernisation of Agriculture
RTS	Returns to scale
TE	Technical Efficiency
TPP	Total Physical Product
UBOS	Uganda Bureau of Statistics
USAID	United States Agency for International Development
VODP	Vegetable Oil Development Project

ABSTRACT

Information on efficiency in sunflower production is generally lacking and this in turn has severely limited the ability to devise promising policy initiatives in sunflower industry. This study was therefore motivated by the desire to ensure that policy makers and planners make informed policy on how to increase sunflower productivity with the existing resources and available technologies. The general objective was to assess the possibilities for productivity gains that can be made from the current resources by sunflower farmers in Lango in view of guiding policy makers. The specific objectives were to; estimate farm-level technical efficiency of sunflower in Lango Sub-region. And identify factors which influence technical efficiency among sunflower farmers.

Using cross-sectional data from 196 households from four districts of Lango Sub-region, data was collected to measure farm level technical efficiency in sunflower production. The study employed stochastic frontier approach where the results of C-D functional form showed that coefficient of inputs had positive value of 1.1136 indicating increasing returns to scale. The observed technical efficiency ranged from 16.76% to 96.20% with a mean of 81.2%, indicating a wide variation among the different farmers. Further inquiry indicates that education of household head, contract farming and access to credit had significant influence on technical inefficiency.

The study therefore calls for attention of the policy-makers and the planners to give top priority to strengthening of rural and agricultural supporting institutions in order to enhance agricultural productivity. Such policies inclusion promoting operation of big private companies which can contract producers. Perhaps the government could also form commodity authority for sunflower like the case of coffee and cotton development

authorities or cooperatives. Improve accessibility to credit facilities by farmers will go a long way in addressing their resource use constraints thus improving efficiency problems. Encouraging farmers to adopt and utilize conventional inputs such as subsidies could help them to improve efficiency. Such policies could go hand in hand with strengthening government extension link in sunflower currently is lacking.

The study also recommends the need for further research to look into allocative efficiency. Additional study can be conducted by employing stochastic cost function model to explore input-cost minimization or data envelop analysis. Additional study can be done that look at oxen as one of the main input variables.

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CHAPTER I

INTRODUCTION

1.1 Background

Currently, Uganda is witnessing a big challenge in meeting the ever growing demand for edible oils by achieving self-sufficiency in oilseed production. The unsustained supply of oilseeds to the processing sector has led to a steep increase in oil prices and the ordinary Ugandan cannot afford (UBOS and UOSPA, 2005). Strategies for meeting this challenge have included a shift from import dependency towards domestic production increase through enhanced research and extension efforts. Under the Uganda Plan for the Modernisation of Agriculture (PMA), sunflower seed is being promoted to improve the livelihoods of rural households and secondly to boost edible oilseed industry. The National Agricultural Research Organization (NARO), in partnership with Vegetable Oil Development Project (VODP) and private sector such as Uganda Oilseed Producer Association (UOSPA) and APEP/USAID has been on the forefront in promoting the sector (NARO, 2007).

Popularization of sunflower seed production through introduction of high yielding varieties has greatly increased its production. Consequently, since 2000 its production in terms of acreage has increased from 1,219 tonnes to 40,000 tonnes in 2006 and is expected to reach 150,000 tonnes by 2010. Currently, the crop contributes up to 86% of the domestically available raw material for edible oil production and this has led to a

reduction in edible oil imports from 500,000 tonnes in 1998 to 48,000 tonnes as of 2004, (VODP; UOSPA, 2007). More than 60% of the farm households in Lango region are engaged in sunflower production, leaving cotton which used to be the main cash and oilseed crop. The crop has a shorter payback period and has lower production cost advantage over other crops.

However, there exists a considerable yield gap in oilseeds production, particularly, the current yield of sunflower is 1200 kg/ha against expected 2500 kg/ha. The observed production growth since 2000 is merely due to expansion in acreage under production rather than increase in output per unit area/input. Among other factors that may contribute to this low productivity is inefficient use of production resources. However, currently there is no information regarding efficiency in sunflower production which could have guided policy recommendation in the sector. Besides, much of the policy initiatives focus in promoting adoption of new technology without considering the importance of efficiency in production of existing resources (GoU, 2000).

1.3 The Objectives of the Study

The general objective of this study was to assess the possibilities for productivity gains that can be made from the current resources by sunflower farmers in Lango in view of guiding policy makers and farmers. Specifically, this study seeks to:-

1. Estimate technical efficiency of sunflower farmers in Lango Sub-region;
2. Identify factors which influence technical efficiency among sunflower farmers.

1.4 Hypotheses

This study was based on the following testable assumption:

1. Sunflower farmers in Lango region are operating on the technically efficient production frontier;
2. Factors such as age, education, access to extension services, and credit, experience, and contract, distance of plots from access road network, gender, household size, and membership to farmers' organization have no influence on the observed level of technical inefficiency among sunflower farmers in Lango region.

Nevertheless, improving productivity of sunflower has two basic components: firstly through availing new technologies and secondly through improving efficiency (cost minimization given prevailing prices or output maximization given the technology). Therefore, increasing efficiency of farmers is no longer debatable but a great necessity, especially in LDCs where resources are meager as evident by the dwindling sectoral budget allocation to agriculture. And the opportunities for developing and adopting new technologies are limited for resource poor farmers.

1.2 Problem Statement

Although efficient use of existing sunflower production resources is part and partial of raising farm-level productivity, as stipulated in the PMA, the current status of efficiency in sunflower production at farm-level is not known. No known study has been conducted on sunflower farm efficiency. Basically, there is lack of information pointing otherwise on its current resource use efficiency and farm management practice and institutional factors that relate to efficiency in Uganda as a whole. Therefore, this information gap has severely limited the ability to devise promising policy initiatives in sunflower industry. Literature available in sunflower production in the country focuses only on agronomic issues. Therefore, this study has been motivated by the need to ensure that the path of policy reform is filled with less peril if such information base is instituted.

1.5 Justifications

More important to measuring level of technical efficiency is the need to discover reasons for the difference in technical efficiency; this is more fundamental to improving the resource use and increasing sunflower output level in the sub-region. Therefore, developing economies can benefit much from efficiency studies which shows possibilities for increasing productivity by increasing efficiency in current resource base without the need for new technologies or increasing value of resource, Frank Ellis (1988); Karl D. Skold and Victor N. Popov (1992). Measurement of the extent and determinants of efficiency indicates which aspect of farm characteristics can be addressed by public investment to improve productivity. As such and given the important of the crop, this study aim at providing policy makers with opportunity to make informed decisions on how to increase sunflower production by determining the extent to which it is possible to raise farm-level efficiency with the existing resources.

1.6 Scope of the study:

This study was intended to cover technical efficiency which is a sub component of economic efficiency. Specifically it examined technical efficiency and its determinants among sunflower farmers. It was concentrated in the Lango sub-region of Northern Uganda. The study population was farm households producing sunflower and analysis was limited to farm-level production using data for second season harvest of 2007.

1.7 Organization of the Study

Chapter one introduces background, problem statement, objectives to the study, hypothesis, justification and scope of the study. Chapter two review literature and theories which include: over view of sunflower industry in Uganda, meaning of efficiency, production theory and efficiency, review of empirical studies concerning technical efficiency and theoretical approaches to measuring technical efficiency. Chapter three describes study area, sampling and sampling techniques, data collection and analysis techniques, model estimation (Cobb-Douglas functional form and inefficiency model), definition of variables used in the model, data reliability and validity, and model implementation. Chapter four presents and discusses results. Finally chapter five draws conclusion, policy recommendations and recommendation for further research.

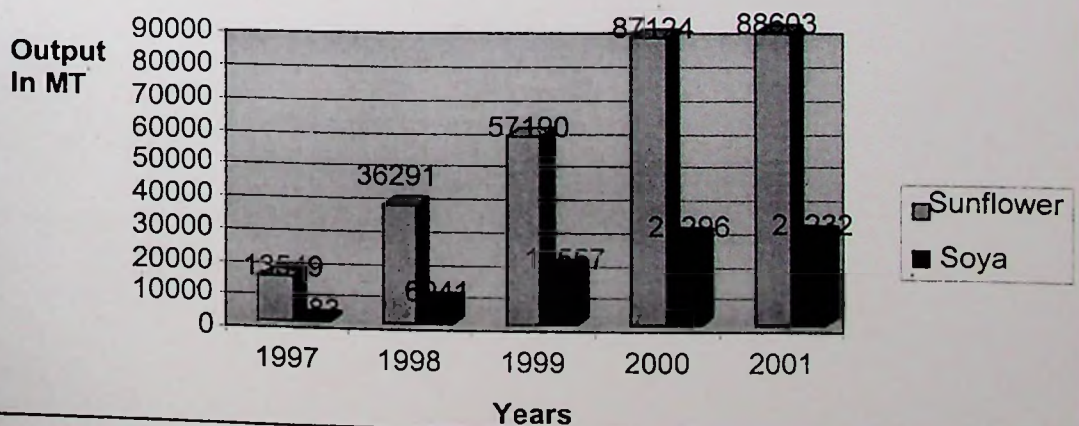
CHAPTER II

OVERVIEW OF SUNFLOWER INDUSTRY AND THEORETICAL REVIEW

2.1 Sunflower Industry In Uganda

Uganda's edible oil industry appears to be recovering from being a net importer in the 1970s to 1990s. Thanks to the introduction of high yielding varieties of sunflower which currently contributes up to 86% of raw material for vegetable oil (NARO 2007). Sunflower is mainly grown in the drier Northern, Eastern (Teso region) and Masindi districts of Uganda. To-date, number of research has been done to improve yield, oil content and ease of processing. The varieties are high yielding (about 2500 kg/ha), has a greater oil content (25 – 40%). Figure 1 shows the supply of crushable sunflower and soybean to the oil mills in Uganda for the period 1997-2001.

Figure 2.1: Sunflower and Soya output in MT 1997-2001



Data source: UOSPA

Production increase has also stimulated investments in agro-processing which in turn has provided employment as well as revitalization of domestic edible oil industry. A part from serving as source of income in agricultural households, the by-products (cakes) are used as livestock feeds. Although sunflower occupy a small area under production in comparison to other crops such as coffee, bananas, and cassava, the area under cultivation is expanding. Currently, over 255,600 hectares is produced on average with yields of 306,720 metric tonnes. Processed oil amount to 76,680 metric tonnes (sh138b), and 236,000 tonnes of seed cake (Ush34.5b). In Lango region, the major promoters of sunflower production are UOSPA and Mukwano group of companies. The later however, promote production through contract farming where the company provides inputs (seeds) and the farmers are expected to sell their produce to the company. Despite of the support farmers get in terms of access to seeds and market, they still face a number of production challenges such as scarcity of seeds (those producing outside contract arrangement), few rural-based stores, inaccessibility to market information, low farm-gate price, lack of supportive credit facilities, and high input costs.

2.2 Meaning of Efficiency

The concept of efficiency, as defined by Farrell (1957), has two components; technical, and allocative efficiency. Technical efficiency (*TE*) is the ratio of observed output to the corresponding frontier output, conditioned on inputs used. Its ability to avoid waste by producing as much output as input allows or using as little input as output production allows (producing on the frontier isoquant). Mbowa S (1996) in his study on sugarcane defined an efficient farm as that which utilizes less resource than others to generate a given output. Yilma M (1996), while studying efficiency among coffee producers referred to an efficient farm as that which produces more output than that one which produces less from the same inputs. Therefore, technical efficiency can be looked at as a physical phenomenon of producing on the production frontier. Meanwhile technical inefficiency is the deviation of output from the frontier isoquant.

Allocative efficiency (*AE*) is the extent to which a farmer can use inputs to the level at which their value of marginal product is equal to factor costs (ability to produce at a given level of output using the cost-minimizing input ratios). Allocative efficiency has to do with the profit maximizing principle (Fan, 1999). Akinwumi and Djato et al (1996) in their study of relative efficiency of women farm managers in Cote d'Ivoire define allocative efficiency as the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to production value is equal to factor costs. Failure to equate revenue product of some or all factors to their marginal cost is at the very core of economic theory (Timmer et al, 1971; Gauri, 2006).

2.3 Production Theory and Efficiency

In measuring production efficiency, one needs to understand farm and farmer production characteristics. These characteristics influence input usage and therefore the resulting output. This relationship is expressed using a production function;

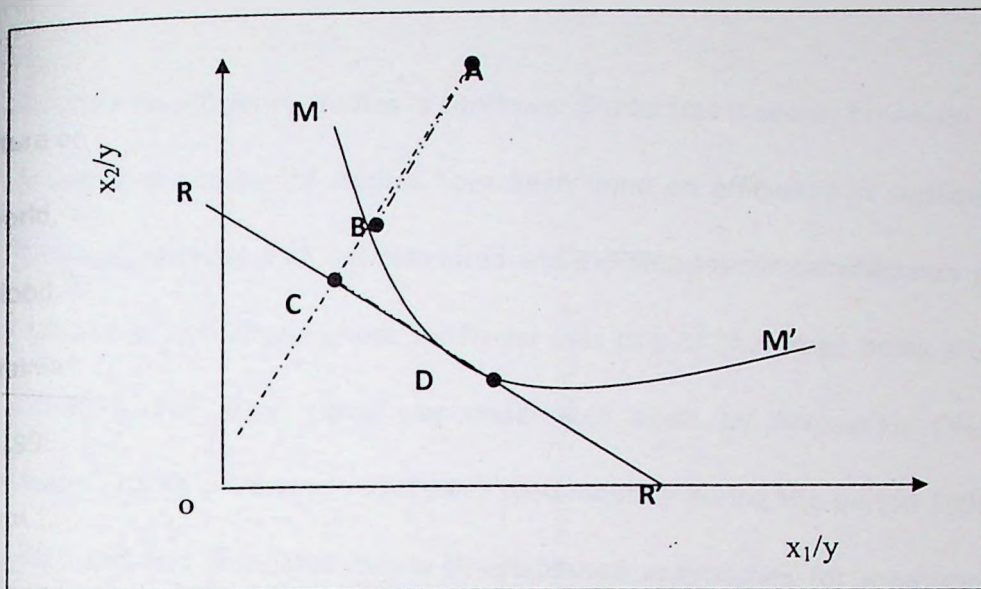
$$Y = f(L, K) \dots\dots\dots (2.1)$$

Where $f(\cdot)$ shows maximum output that can be produced using combinations of inputs. Y is output (TPP), L and K are inputs used. The objective of a farmer is to maximize profit by increasing quantity of Y or by reducing cost of producing Y . As such efficiency according to Frank Ellis (1988) is a major component of productivity which itself is a measure of farm performance. Therefore, a farm gets closure to the frontier when the input ratio is on both the isoquant and the expansion path. This can be illustrated using figure 1 below. MM' is an isoquant estimated with available technology (best practice). Point B on the isoquant represents efficient reference of observation A . Technical efficiency of a farmer operating at point at A is measured by the ratio;

$$OB/OA \dots\dots\dots (2.2)$$

Or $1 - BA/OB$, it takes the value between 0 and 1 and hence any value less than 1 is an indication of technical inefficiency. The value 1 indicates that the farmer is fully technically efficient as illustrated by point B which lies on the efficient isoquant.

Figure 2.2: Stochastic Production Frontier



If the input price ratio represented by the slope of the isocost line RR' is known, then allocative efficiency of a farm operating at A is defined as;

$$OC/OB \dots\dots\dots (2.3)$$

Since the distance CB represents a reduction in production costs that would occur if production were to occur at the allocatively efficient point D , instead of occurring at the technically efficient but allocatively inefficient point B . The distance CA can also be interpreted as cost reduction. In practice however, the farm may not operate at point B which is technically efficient or at point D which is allocatively efficient.

2.4. Empirical Studies

Literature on efficiency studies in sunflower production is scanty however, elsewhere in the world, a number of studies have been done on efficiency in sunflower industry. Trueblood, Michael A (2004) measured and explained technical efficiency performance in Ukrainian agriculture where sunflower was one of the crops being studied during 1991-1996. The same study was undertaken again by Nivyevs'kiy Oleg, Zelenyuk Valentin (2004) in Ukraine's sunflower seed industry during the period 1998-2002. The study used and compared two well-established approaches for measuring technical efficiency: data envelopment analysis (DEA) and stochastic frontier analysis (SFA). DEA is a linear programming approach, whereas SFA uses econometric techniques. The authors examined the link between price and trade liberalization, as well as institutional reforms, such as land reform and enterprise privatization, with the technical efficiency performance of Ukrainian farms. They found no strong evidence for positive influence of 2000 Land reform on efficiency of sunflower seeds industry operation. Thus, it is unclear what effect land privatization policies in this case had on technical efficiency.

The authors therefore suggested that other factors, such as slow credit and labor market developments and intermittent government interventions, probably have hurt efficiency which was found to be inefficient at 50%. Their study was however limited in scope in the sense that it focused only on examining land reform and did not endeavor to examine other farm specific socio-economic characteristics that could have affected efficiency in the seed industry. The fact that land reform had no relationship with the

level of inefficiency in the seed industry meant that there was need for additional inquiry into other factors that could explain prevailing inefficiency in the seed industry.

Similar study was done by Mruthyunjaya, Sant Kumar, Rajashekharappa, Pandey, Ramanarao and Prem (2005) on Indian Edible Oilseed Sector. Their analysis focused on technical inefficiencies and factors responsible for inefficiencies in production and processing of four major edible oilseeds, viz. groundnut, rapeseed, mustard, soybean and sunflower. Analysis revealed presence of $1/4$ to $1/3$ technical inefficiencies in oilseed production along with allocative and scale inefficiencies. The combined technical inefficiencies in the oilseed was $1/2$ to $2/3$, which were enormous as compared to past studies which estimated technical efficiency in oilseeds from 8 to 53%. The study observed that the critical inputs like seed, fertilizers, and irrigation were underutilized and varied from 32 to 99 per cent in groundnut, 40 to 87 per cent in rapeseed and mustard, and 25 to 98 per cent in sunflower. In addition, soil quality, seed and education were found to be the major determinants of efficiency. Sunflower had the highest efficiency of 76% compared to other oilseeds. Lack of assured market for oilseeds and lack of timely and assured supply of quality seeds and raw materials for processing are some of the important factors for the poor performance of the industry.

Karl D. Skold and Victor N. Popov (1992) used SFA and applied both translog and C-D functional forms to measure technical efficiencies of 5 crops in Stavropol region. The RTS was 1.08 which suggests increasing return to scale for sunflower production. All

elasticity parameters for sunflower were positive. The minimum level of TE was 14.6% and max was 96.2% and average was 69.0%. Collective farms were found to be more efficient than state farms. Years of experience were found to influence efficiency in vegetables and not in sunflower. However previous experience on a farm tended to have lower technical efficiency in sunflower. Improved use of existing resources could greatly improve productivity of the crops. However, while some farms were more efficient than others, improvement can still be realized in the production with existing resources. This will require more detailed analysis of production decisions and resource allocation in the low-efficiency farms as well as in the farms that successfully manage their resources. The authors concluded that more efficient use in resources could be attained by moving farms to collective structure such as departments or shops.

Although no known study on technical efficiency in sunflower had been done in Uganda, several other studies on efficiency exist: Rogers matte (1998) fitted translog and estimated technical inefficiency and its determinants in small scale manufacturing industries. Obwona Morris (2002) determined technical efficiency among tobacco farmers using translog. Hyuha (2006), estimated farm-Level profit efficiency of rice In Eastern and Northern Uganda using translog. Yawe Bruno (2006) used DEA to measure technical efficiency in referral hospitals. Bagamba Fred (2007); conducted a study on market access and agricultural production in banana using both C-D and translog SFP model. Yilma M (1996) used three approaches to estimate efficiency in coffee and bananas namely, deterministic, SFA and DEA in Masaka district.

2.5 Theoretical Approaches to Measuring Technical Efficiency

Since Farrell's concept of efficiency in the 1950s, two well-established approaches for measuring technical efficiency were developed: data envelopment analysis (DEA) and stochastic frontier analysis (SFA). DEA is a linear programming approach, whereas SFA uses econometric techniques. Both approaches provide a static measure of Farrell technical efficiency while estimating production possibility frontier and distances from each observation unit to this frontier (Farrell 1957). Both methods have advantages and disadvantages over each other, which is why both methods were used. Some advantages of DEA include the fact that it does not assume that firms are not fully efficient and does not require a functional form to be specified in the model. The SFA method, on the other hand, accounts for noise and can be used to conduct conventional hypothesis tests. With the nonparametric DEA approach, technical efficiency is estimated with either an input or an output orientation, Margarita Grazhdaninova, Zvi Lerman (2005).

Since then, modeling, estimation and application of stochastic frontier production functions to economic analysis assumed prominence in econometrics and applied economic analysis during the last five decades. Early applications of stochastic frontier production function to economic analysis include those of Aigner (1977); Battese, G.E., and Safraz, H. (1998); Bravo-Ureta and Penheiro (1997) and recently, researchers like S. Ojo and Ajibefun (2000); Thiam, Boris Bravo-Ureta, E., and Teodoro, E. R (2001);

Obwona Morris (2002); Okuruwa and Ogundele (2004); Betty Wambui (2005); Ogundari Kolawole (2006); Hyuha (2006); Ogundari Kolawole and S.O. Ojo (2007); Fred Bagamba (2007) and I.C. Idiong (2007) have widely applied the model. SFA was arrived at as a result of weakness in deterministic frontier analysis, both models are parametric. The main difference between deterministic and stochastic frontier is that, stochastic frontier attempts to differentiate effects of noise from that of inefficiency. While deterministic frontier lumps effects attributed by noise and that attributed by inefficiency together and call the combination inefficiency. Stochastic frontier analysis predicts output from inputs by the relationship;

$$Y_i = f(X_i; \beta) \varepsilon_i \dots\dots\dots (2.4)$$

Where i is the farm being evaluated, β is unknown parameter. Residual ε_i is composed of random error v_i and inefficiency part u_i . When $v_i = 0$, SFA is reduced to deterministic frontier analysis. If at the same time $u_i = 0$, then SFA is reduced to a central tendency analysis, (Kumbhakar & Lovell, 2000). The structure of deterministic frontier model is;

$$Y = f(X, \beta) \varepsilon^{-u} \dots\dots\dots (2.5)$$

$f(\cdot)$ denotes production frontier function; according to Taylor & Shonkwiler et al, (1986); Tewodros Aragie Kebede, (2001), the model is in full agreement with production theory, but its main weakness is that all the variations are accounted for by the management practices while statistical noise (random errors, omitted variables and shocks) are

unaccounted for. All error attributed to u and can't be separated. To address this weaknesses in (2.5) above, v was introduced into the deterministic model to form a symmetric component accounting for pure random factors as specified below;

$$Y = f(x, \theta) \varepsilon^{v-u} \dots\dots\dots (2.6)$$

The i^{th} farm producing maximum output possible using the best techniques (technically efficient) is therefore, described by neoclassical production functions as:

$$Y^*_i = f(X_i, \theta) = f(X_i, \theta) \exp(v_i) \dots\dots\dots (2.7)$$

In practice however, farms may not operate at the optimum, in such a case, slackness in production is represented by modifying the neoclassical production function to represent possible inefficiency and deviation away from best frontier as;

$$Y_i = f(X_i, \theta) \varepsilon_i = f(X_i, \theta) \exp(v_i - u_i); i = 1, \dots, n \dots\dots\dots (2.8)$$

V is two-sided $(-\infty < +\infty)$ normally distributed random error $(V_i \sim N(0, \sigma_v^2))$ that captures factors outside. U is one-sided with half-normal distribution $(u_i \sim N(0, \sigma_u^2) |)$ that captures inefficiency (shortfall in Y_i from its max value Y^*_i). Rewriting 2.8 using 2.7;

$$Y_i = Y^*_i \exp(-u_i) \dots\dots\dots (2.9)$$

Therefore, the difference between (Y_i) and (Y^*) is embedded in U . When $U=0$, production is on the frontier ($Y=Y^*$) and a farmer is efficient. But if $U>0$, he is inefficient since production is below the production frontier and is given by;

$$TE_i = Y_i/Y^*_i = f(X_i, \beta) \exp(v_i - u_i) / f(X_i, \beta) \exp(v_i) = \exp(-u_i) \dots \dots \dots (2.10)$$

A farmer faces own $f(X_i, \beta) \exp(u_i)$; a deterministic part $f(X_i, \beta)$ common to all and farmer-specific part $\exp(u_i)$. It follows that MLE of equation (2.10) yields estimates for β and λ , where $\lambda = \sigma_u / \sigma_v$, and $\sigma^2 = \sigma_v^2 + \sigma_u^2$; $\gamma = \sigma_u^2 / \sigma^2$, so that $0 < \gamma < 1$. Jondrow et al, (1982) showed that TE_i can be determined from conditional expectation of u_i given;

$$\varepsilon_i E[u_i | \varepsilon_i] = \sigma_u \sigma_v / \sigma [f^*(\lambda \varepsilon_i / \sigma) / 1 - F^*(\lambda \varepsilon_i / \sigma) - (\varepsilon_i \lambda / \sigma)]; i=1, \dots, n \dots \dots \dots (2.11)$$

f^* and F^* are standard normal density and distribution functions respectively, evaluated at $\varepsilon_i \lambda / \sigma$. The variance of the random errors, $\sigma^2 v$ and that of the technical inefficiency effect $\sigma^2 u$ and overall variance of the model σ^2 are related thus: $\sigma^2 = \sigma^2 u + \sigma^2 v$, measure the total variation of output from the frontier which can be attributed to technical inefficiency (Battese and Corra, et al 1977)¹. Estimation of equation (2.10) requires specification of functional form such as C-Douglas or translog as specified in equation (2.12 and 2.13) respectively.

¹ Battese and Coelli et al (1993) provided log likelihood function after replacing $\sigma^2 u$ and $\sigma^2 v$ with σ^2 and thus estimating gamma (γ) as: $\gamma = \sigma^2 u / \sigma^2$. The parameter (γ) represents the share of inefficiency in the overall residual variance with values in interval 0 and 1. A value of 1 suggests the existence of a deterministic frontier, whereas a value of 0 can be seen as evidence in the favour of OLS estimation

$$\ln Y_i = \beta_0 + \sum_i \beta_i \ln X_{ij} + v_i - u_i \dots \dots \dots (2.12)$$

$$\ln Y_i = \beta_0 + \sum \beta_1 \ln X_{ij} + \frac{1}{2} \sum \sum \beta_{ij} \ln X_{ij} + \ln X_{ij} + v_i - u_i \dots \dots \dots (2.13)$$

Cobb-Douglas and translog have been widely used in frontier estimation, the C-D functional form is popular and is frequently used to estimate farm efficiency despite its known weaknesses S.O. Ojo (2003); (Okoruwa and Ogundele (2004); Pius Chinwuba and Odjuvwuederhie Emmanuel (2006); Bagamba Fred (2007). The translog model has its own weaknesses as well, but it has also been used widely (Obwona Morris (2002); Betty Wambui Kibaara (2005); Hyuha Theodora Shuwu (2006), Bagamba Fred (2007);). The main drawbacks of the translog are its susceptibility to multicollinearity and potential problems of insufficient degrees of freedom due to the presence of interaction terms. The interaction terms of the translog don't have economic meaning (Abdulai and Huffman et al, 2000).

Variations in efficiency estimates at plots can arise due to farmer specific characteristics and thus variations in output are modeled as a function of equation (2.14)

$$u_i = \alpha_0 + \sum \alpha_i Z_j \dots \dots \dots (2.14)$$

Z_j is a vector of explanatory variables which are associated with inefficiency and δ is the corresponding vector of parameters to be estimated. W_i is a random error term. To

incorporate the determinants of technical efficiency, TE scores are regressed on chosen Z_i variables that are likely to influence efficiency. This can be done either in a single step or in two steps. Battese and Coelli et al (1995), use the single step procedure, which simultaneously estimates the parameters of the production function and those of the efficiency determinants by making use of the error term described as a function of the Z_i variables in (2.14). In the two step procedure, the obtained technical inefficiency scores are further regressed as dependent variable usually by incorporating a limited dependant variable estimation method, since the TE scores lie between 0 and 1. However, the two stage procedure has been criticized with respect to the assumptions made regarding technical efficiency in the first stage, viz., they are *iid*. This assumption would be contradicted if these efficiency estimates are regressed on explanatory variables as *iid* would no longer hold and a causal relationship between efficiency estimates and the right hand side variables is assumed (Kumbhakar and Lovell, 2000). For inefficiency terms, distribution assumptions of normally distributed, exponential, truncated normal and normal gamma are most commonly used.

2.6 Conclusion

A number of definitions for technical efficiency have been advanced by different studies and for the purpose of this study, technical efficiency can be looked at as a physical phenomenon of producing on the frontier and any deviation of output from the frontier isoquant results into inefficiency. Therefore in measuring production efficiency, one needs to understand farm and farmer production characteristics. These characteristics influence input usage and therefore the resulting output. There is no existing literature on efficiency studies in sunflower production Uganda. However; studies elsewhere in the world have used different approaches in advancing knowledge in this field. The most commonly used approaches in the literature are parametric SFA which is an econometric technique and DEA which is a linear programming approach. In the literature, C-D and Translog functional forms are the most two popularly applied models in measuring efficiency.

CHAPTER III

METHODS AND PROCEDURES

3.0 Introduction

The purpose of this chapter is to provide approaches and procedure used in addressing the study objectives. The objectives of this study were twofold. The first objective was to quantitatively measure technical efficiency performance of sunflower farms during 2007 cropping season. Technical efficiency was measured as the degree to which producers are able to maximize physical output from given input levels. The second objective was to examine farmer specific socio-economic characteristics and institutional variables that were found to be important in explaining technical efficiency performance in sunflower seed production in Lango sub-region.

The chapter describes the study area, data sources, and data collection techniques and elaborates on approaches to measure technical efficiency and its determinants. It explains, justifies and discusses the implementation of the Cobb-Douglas functional form adopted in this study. The chapter provides procedure used in testing for data reliability, validity and hypothesis tests as well as model implementation and draw conclusions on methods and materials adopted.

3.1 Description of Study Area

Lango sub-region is located in the mid-North of Northern Uganda and has five districts which include; Lira, Apac, Oyam, Amolatar and Dokolo. It has a population of 1,434,007 (UBOS, 2002) and an area of 13,935km². The area is suitable for mechanized agriculture and the annual rainfall varies between 1,000 mm to 1,500 mm with temperatures ranging between 25-35°C. These physical characteristics make it suitable for sunflower growing. Other leading crops are cassava, maize, rice, beans, simsim and groundnuts. Over 90% of the rural population is subsistence farmers, (anonymous, 2005).

3.2 Sampling and Sampling Techniques

A two-stage sampling technique was used; stage one dealt with site selection where four (4) districts out of the current five (5) were selected purposively based on prevalence of the crop. The same criterion for selecting districts was used to select four sub-counties as the final study sites. Stage two dealt with selection of farmers where random sampling was applied to select 200 sunflower farmers. The list of farmers was obtained from registry for UOSPA and Mukwano. This sample size was adequate to make inference about the study population since sunflower production system in the region is relatively homogenous i.e. the biophysical characteristics of the farming system is similar. Also the study focuses on only farmers who on average cultivate up to 2 acres of sunflower seeds.

3.3 Data, Data Collection and Analysis Techniques

This study used cross sectional data as oppose to time series data and the reason being that time series data was not readily available and its reliability / accuracy was questioned. Cross-sectional data on the other hand was easy to obtain since the study focus on farm level production and covers a small geographical setting. In addition, secondary data used in this study was sourced from UBOS, UOSPA, VODP, Mukwano group of companies and NARO.

Structured questionnaire was developed to collect data across sampled sunflower farms in the region. The questionnaire captured information in two sections. Section one contained information on production such as: data on production function which included physical quantity of sunflower output, land under sunflower, and labour in man-days and sunflower seeds. While section two covered information on farmers' socioeconomic characteristics such as age, years of experience in sunflower production, education level, extension contacts, contract farming, credit access, gender of household head, membership to farmers' organization, distance from markets/access road network, and household size. The questionnaire was pre-tested, modified before being applied to gather information from a sample of 200 farm-households through face-to-face interviews. Data was cleaned, coded and analysis was done using frontier model found in stata.

3.4 Model Estimation

This section provides and discusses the empirical models that are used in estimating technical efficiency and its determinants. It examined appropriateness of Cobb-Douglas against translog functional and proceeded with the rest of analysis using Cobb-Douglas which was found to be the most appropriate functional form. The section also addresses data reliability and validity and provides method for hypothesis tests.

3.4.1 Cobb-Douglas functional form

This study used Cobb-Douglas functional form to address objective one i.e. estimation of technical efficiency of sunflower farms. The Cobb-Douglas Stochastic Frontier Model for the sunflower farms was explicitly specified as follows;

$$\ln Y_i = \theta_0 + \theta_1 \ln X_{1i} + \theta_2 \ln X_{2i} + \theta_3 \ln X_{3i} + v_i - u_i \dots \dots \dots (3.1)$$

Where subscripts i and refer to the i^{th} farm being studied, $\ln$ is natural logarithm, v_i is random errors while u_i is the shortfall in Y_i .

- Y = total yield of sunflower seed in kilograms;
- X_1 = land is total area under sunflower seed production measured in acres;
- X_2 = sum of labour in person days;
- X_3 = quantity of sunflower seed cultivated in kilograms.

3.4.2 Inefficiency model

This section attempts to address objective two i.e. identifying determinants of technical efficiency among sunflower farms. This study used inefficiency model to identify factors which influences the level of technical efficiency. Inefficiency model was specified to examine effects of farm specific characteristics and institutional influence on (u_i) as;

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7 + \alpha_8 Z_8 + \alpha_9 Z_9 + \alpha_{10} Z_{10} \dots\dots\dots (3.2)$$

Where;

- Z_1 = age of farmers;
- Z_2 = education in years;
- Z_3 = household size;
- Z_4 = years of farming experience (sunflower only);
- Z_5 = distance to access road/market
- Z_6 = contract farming (1 = contract farming; 0= otherwise);
- Z_7 = membership to farmers organisation (1=yes; 0=otherwise);
- Z_8 = credit access (1= access; 0= otherwise);
- Z_9 = Sex of household head (1=male; 0=female);
- Z_{10} = extension contact (1 = contacts; 0 = otherwise).

3.5 Definition of Variables Used in Model Estimations

Land is a very critical factor in agriculture and is expected to have positive impact on outputs. Labor is included in the model because it is one of the primary factors of production. However, empirical studies have used different approaches in estimating labour: Bagamba, 2007 disaggregated labour into hired and family labour. These two were further disaggregated into male, female and children. However, Hyua, 2006 treated all the categories of labour as one by aggregating all the labour and normalized it with the output price. This study treated labor of men and women to be equivalent while labour for children was treated as a half of adult labour. The last variable that was included in the production frontier function was seed.

Education is normally included in the inefficiency model for two reasons: firstly, education may improve technical efficiency in the sense that it improves the quality of labour and promotes adoption of new technologies. On the other hand education may also have negative impact on technical efficiency since it creates off-farm opportunities and therefore limiting efforts on-farm. However, questions that arises is whose education should be included in the model, is it education of the household head or that of the active family members? This study captured education of the household head and hypothesis it to have negative impact on technical efficiency. This is because of the possibility of diversifying efforts to non-farm activities and leisure by the highly educated household's heads.

Extension is a strong link between technology developers and farmers and therefore, access to extension is a platform for adoption and diffusion of new technology among farmers. Several studies have examined extension as a factor in explaining efficiency by including it in the inefficiency model (Hyua, 2006). However, Bagamba, 2007 included extension as a variable in the production frontier model. Either way, extension contact is expected to raise output and efficiency. This study hypothesizes access to extension services to have positive effect on technical efficiency.

Access to credit determines whether a farmer will adopt and utilize new technologies and conventional purchased inputs. Farmers are usually trapped in the vicious circle of financial hardships to carry out their daily farm operations. Therefore, relaxation of financial constraint of the farmers through access to credit should play a crucial role in efficiency improvement. Thus in this study credit was hypothesized to be positively related to technical efficiency.

Years of experience has positive impact on the level of efficiency and therefore, a farmer with many years of experience in sunflower production is expected to be more efficient arising from years of trials and errors. Over time, the farmer will have learnt and made adjustment to inputs-output ratio. This farmer is also expected to make the right choice on best technology practices and hence more efficient. He is expected to realize optimal timing and allocation of resources. However, Wilson et al., (1998) found a positive relationship between experience and inefficiency in potato production in UK,

implying that farmers with fewer years of experience achieved higher levels of efficiency. The reason may be that those with little experience are likely to seek out for new technology and knowledge, unlike those with experience. This study hypothesized a positive relationship between experience and efficiency.

Age of a farmer is an important factor in decision making and, has a significant effect on farm productivity. A farmer begins to put less effort in production as he gets older; unlikely to contact extension, less willing to adopt new practices and less productive. Younger farmers however, are more likely to have formal education, access information and understand new production practices. Some studies have viewed experience as a proxy for age and therefore do not include age in the model. However, by putting experience as a proxy for age, one will be ignoring contribution to efficiency coming from age independently. For instance a farmer may have fewer years of age but with more years of experience in production than the one with older age.

Long distance from farms to access to roads limit access to input and output markets as well as flow of information to the farmers. On the one hand farmers located near access roads and markets will have higher demand for modern inputs and are therefore, more productive since inputs are within reach and this implies adequate and timely application of inputs. There are research evidences showing positive relationship between use of chemical fertilizer and farm to market distance (Ahmad and Chaudhry et al 2000), the study predicted negative relationship between efficiency and distance.

Household size was another variable that was included in the inefficiency model and was hypothesized to have positive relationship with efficiency. Larger households have timely supply of labour on-farm implying that production activities are done timely. Small families however, may rely on hired labour which is sometimes constraint by lack of capital implying that they are unable to carry out their activities timely.

Empirically, women are known to play a key role in production due to extra effort (close supervision) which raises farm productivity and efficiency. The male counterparts usually have other off-farm occupation which implies that they allocate their time based on opportunity cost. On the other hand male farmers possess better opportunities to access information and this helps them to improve their productivity. So the impact of gender on efficiency was hypothesized to take either positive or negative sign.

Contract arrangement especially with agribusiness firm can be very valuable for small-scale farmers it facilitates access to input and also secure markets for their crops as well as some technical assistance. When contract agreement concerns outputs, the agribusiness firms expects good outcomes from yields and therefore tend to support the farmer to realize adequate yield. This is expected to improve efficiency by reducing risk since risk itself predetermines resource allocation by the farmer.

Finally, membership to farmers' organization was included in the model because it allows for information sharing among farmers as well as diffusion of technologies. This

gives them opportunity to improve on their production practices thereby increasing efficiency. Secondly, most rural development programmes aimed at transforming subsistence farming are now being channeled through farmers' organizations. Relationship here is hypothesized to positively correlate with efficiency.

3.6 Data Reliability and Validity

Data reliability and validity, measurement and sampling errors were controlled through: pre-testing the questionnaire to ensure clarity of questions and relevancy of the data. In addition, training of enumerators was done to ensure that they understood the contents of the questionnaire. Filled questionnaires were spot checked to ensure that response were consistent. Thirdly, only farmers who grew sunflower in the second season of 2007 were sampled to minimize difference in outputs across seasons arising from factors outside farmers' control (weather). Several tests were carried out to ensure getting unbiased estimates. These tests included testing for normality of residuals, multicollinearity and heteroskedasticity. Normality of residual was tested using One Sample Kolmogorov-Smirnov test. The results suggest that, all the variables tended towards normality of the data. Nevertheless, the data were further transformed by use of logs to ensure conformity to normality assumption. The Variance Inflation Factor (VIF) method was used to detect multicollinearity and the result indicated no multicollinearity among the independent variables since their specific values was less than 10. The test for homogeneity of variance was conducted using Breusch-Pagan/Cook-Weisberg test

for heteroskedasticity, and the null hypothesis of constant variances of the residuals was accepted ($p > 0.000$). The Ramsey test was conducted to test for omitted variables. The null hypothesis of no omitted variables was accepted ($F = 0.761$).

3.7 Model Implementation

Stata statistical software program was used to estimate the SFA model. In order to adopt the most appropriate functional form, Cobb-Douglas functional form model was compared and tested against translog functional form model using log likelihood ratio tests, the hypothesis that Cobb-Douglas model is appropriate was not rejected, the F-statistic for Cobb-Douglas model, 1.93, was less than the critical value of 2.32 at the 1% significance level. And the rest of analysis proceeded with Cobb-Douglas.

Central to this study were tests for two hypothesis²; the first null hypothesis explores the test that specifies each farm is operating on the technically efficient frontier and that the systematic and random technical efficiency in the inefficiency effects are zero, that is to say, $0 = \gamma$, against the alternative that $0 \neq \gamma$. The gamma (γ) tests whether the observed variations in efficiency are simply random or systematic³. The second null

² The tests follow a chi-square (χ^2) thus defined by: $\chi^2 = -2 \ln \{LR(H_0) / LU(H_a)\} - 2 \{ \log [Likelihood(H_0)] - \log [Likelihood(H_a)] \}$. This was rejected in favor of the presence of inefficiency effects.

³ The parameter is defined as the ratio of the unexplained inefficiency error term of (σ_u^2) to the total sum of errors (σ^2). That is, $\gamma = \sigma_u^2 / \sigma_u^2 + \sigma_v^2$. The gamma (γ) is bounded by 0 and 1, where if γ is zero inefficiency effects are not present in the model, and if it is one inefficiency exists and is not random. In other words, if

hypothesis determines whether the variables included in the inefficiency effects model have no any effect on the level of technical inefficiency. $H_0: \delta_0 = \delta_d = 0, \nabla_d$, the null hypothesis is rejected confirming that the joint effect of these variables on technical inefficiency is statistically significant. The fixed critical confidence levels were got from Kode and Palm (1986). A one stage process was adopted where the determinants of technical efficiency are simultaneously obtained in a one step regression and assumed exponential, distribution assumption.

γ is not significantly different from zero, the variance of the inefficiency model equation 4.2 reduces to average response function (C-D function or deterministic model).

CHAPTER IV

RESULTS AND DISCUSSIONS

4.0 Introduction

The general objective of this study was to assess the possibilities for productivity gains that can be made from the current resources by sunflower farmers in Lango in view of guiding policy makers and farmers. Specifically, the findings in this study provides estimate for technical efficiency of sunflower farms in Lango Sub-region and; factors which influence technical efficiency among the sunflower farms. Technical efficiency scores were obtained using Cobb-Douglas stochastic production frontier. Meanwhile the determinants of technical inefficiency were arrived at using inefficiency model in a one step (simultaneous) procedure.

4.1 Socio-Demographic and socio-economic Characteristics

Description of data on sunflower production and socioeconomic characteristics is given and summaries are presented in Table 4.1. The mean yield of sunflower per acre is 358kg which is far below the national average of 600kgs per acres and the expected yield potential of 1000kgs per acre. There is a wide variation in outputs yields among the plots as indicated by the large standard deviation. While average plot size allocated to sunflower production is 2.17 acres. The mean labour requirement in a season is 62.91

person days, per acre, but some farmers were allocating up to 226.5 man-days per acre. Although recommended seed rate is 1kg/acre, farmers planted 1.24 kilograms on average while other planted up to 3.75kg/acre. The average age of the farmers was estimated at 41 years and average year of schooling was 6 years and this constitutes the majority. The majority (88%) of the household heads producing sunflower are male. This is an indication that the men take up cash oriented enterprises and therefore, women take time in production of food crops (women have higher role in food security drive than men). At the same time, 76% of the farmers had access to extension services during 2007 although all these extension visits were from UOSPA which is a private organization. None of the extension visits were from government extension department. This implies that extension services from government department is lacking to sunflower farmers. An average year of enterprise production experience is approximately 5 years and maximum years being 14. Household size on average is 5 compared to the regional household size of 7 members. About 69.9% of the farmers belong to farmers' organizations. Only 14% of the farmers have access to credit for sunflower operational activities and about 53% are under contract arrangement.

Table 4.1: Descriptive Statistics of Variables Used in the Analysis

Variable	Unit of Measurement	Mean	Minimum	Maximum	std. Dev
Yield of sunflower	Yields in kilogram per acre	357.97	54	920	128.014
Plot under sunflower	Plot area under sunflower in acre	2.17	0.5	7	1.191
Labour in man-days	Person-days per acre	62.91	23.5	226.5	32.136
Sunflower seeds planted	Seeds in kilogram per acre	1.24	0.67	3.75	0.458
Age of household head	Age in years	41.65	16	80	13.845
Education of head	Years of schooling	6.45	0	15	3.441
Sex of household head	If male =1 and 0=otherwise	0.88	0	1	0.329
Experience	years of production	4.86	1	14	3.065
Household size	Number of persons	5	1	16	2.277
Membership	If yes =1 and 0=otherwise	0.64	0	1	0.480
Distance to market	Distance in kilometers	3.52	0	17	2.705
Contract farmers	If yes =1 and 0=otherwise	0.53	0	1	0.500
Extension services	If yes =1 and 0=otherwise	0.76	0	1	0.428
Access to credit	If yes =1 and 0=otherwise	0.14	0	1	0.345

4.2 Technical Efficiency Estimates

This result addresses objective one of this study which was to determine position of sunflower farms on the production frontier. The null hypothesis that specifies that each farm is operating on the technically efficient frontier and that the systematic and random technical efficiency in the inefficiency effects are zero was rejected. The maximum likelihood estimates using exponential distribution from Cobb-Douglas stochastic production frontier are shown in table 4.2. The share of inefficiency in the overall residual variance lied between 0 and 1 hence qualifying SFA over deterministic analysis. At the same time, random errors and inefficiency components were different from zero and this again was in favour of maximum likelihood estimation rather than OLS estimation. Estimates of λ (1.3501) and σ (0.5020) are large and significantly different from zero indicating a good fit and correctness of exponential distribution assumption. Estimates of γ which is the ratio of the variance of farm specific technical efficiency to the total variance of output implies that over 64% of variation in outputs among farms is due to difference in technical efficiency.

Estimated coefficients of input variables included in the stochastic frontier model were positive and significant. Coefficient of land showed positive value of 0.7988 with a 1% level of significance, labour was 0.1414 with a 5% level of significance, while that of seeds was 0.0619 with a 10% level of significance. Given the current level of technology, sunflower production still exhibit increasing returns to scale given by the total elasticity

of 1.1136, which means that on average, farms can still push to the frontier by reorganization input combination to maximize outputs. In related study, Karl D. Skold and Victor N. Popov (1992) estimated returns to scale at 1.08 which suggests increasing return to scale for sunflower production.

Comparative analysis of coefficient estimates for the three inputs show that land is a very significant input in production of sunflower and therefore, a 1% increase in land under sunflower increases output by 78%. Labour gave lower elasticity relative to land and this contradict many efficiency studies in agriculture in LDCs where elasticity for labour is often higher than other inputs. This is because our agricultural technology is labour intensive. The contrary finding could be due to the fact that animal traction (oxen) is the most predominant method of land preparation in the region. Unfortunately the study could not adequately obtain information on oxen as an input variable in sunflower production. An increase in labour leads to a 0.1414% increase in output. Elasticity of seed was also estimated at 0.0619 implying that a 1% increase in sunflower seed increases output by 0.0619%.

Estimated mean technical efficiency of 81.2 percent indicates that for an average farmer to be fully efficient in the short-run there is a scope for increasing output by 18.8%. This allowance for improvement should therefore be able to raise the current average of 358kgs per acre to the national average of 600kgs and eventually to the expected yield potential under best practice of 1000kgs per acre. This result conforms to results

obtained in sunflower elsewhere such as Mruthyunjaya (2005) found average technical efficiency in sunflower at 76%. Technical efficiency level ranged from 16.76% to 96.20%, indicating a wide variation in technical efficiency levels among the farms. Again this variation of technical efficiency is similar to the findings from Karl D. Skold and Victor N. Popov (1992) who found variation of technical efficiency between 14.6% and 96.2% and average was 69.0%. Nivyevs'kiy Oleg and Zelenyuk Valentin (2004) on the other hand found technical inefficiency of 50% which is similar to our case for inefficient farms. Nevertheless, 81% of farmers lie above 75 percent level of technical efficiency while only 18% of farmers lie on the inefficient level of below 50 percent level (table 4.3). Results of technical efficiency estimates from translog and transcendental are appended in Appendix B and Appendix C..

Table 4.2: Technical efficiency and Stochastic Production Frontier function

stats	Coeff	Std.Err.	Z	p>z	(95% CI)	
Land	0.7988	0.1071	7.46	0.000	0.5889	1.0087
labour	0.1414	0.0524	2.70	0.007	0.0388	0.2441
seed	0.1734	0.0994	1.74	0.081	-0.0214	0.3682
cons	5.5052	0.1779	30.95	0.000	5.1566	5.8539
Parameter estimates						
Log	Sigma	Sigma	Sigma v^2	Sigma v^2	Lambda	Gamma
likelihood	(σ_v)	(σ_u)	(σ_v^2)	(σ_u^2)	(λ)	(γ)
-56.7487	0.2136	0.2884	0.0456	0.0832	1.3501	0.6458
Technical efficiency score estimates						
Statistic	Minimum	Mean	Maximum	Std. dev	Skewness	Kurtosis
Scores	16.76%	81.06%	96.20%	0.0106	-2.03%	7.00%

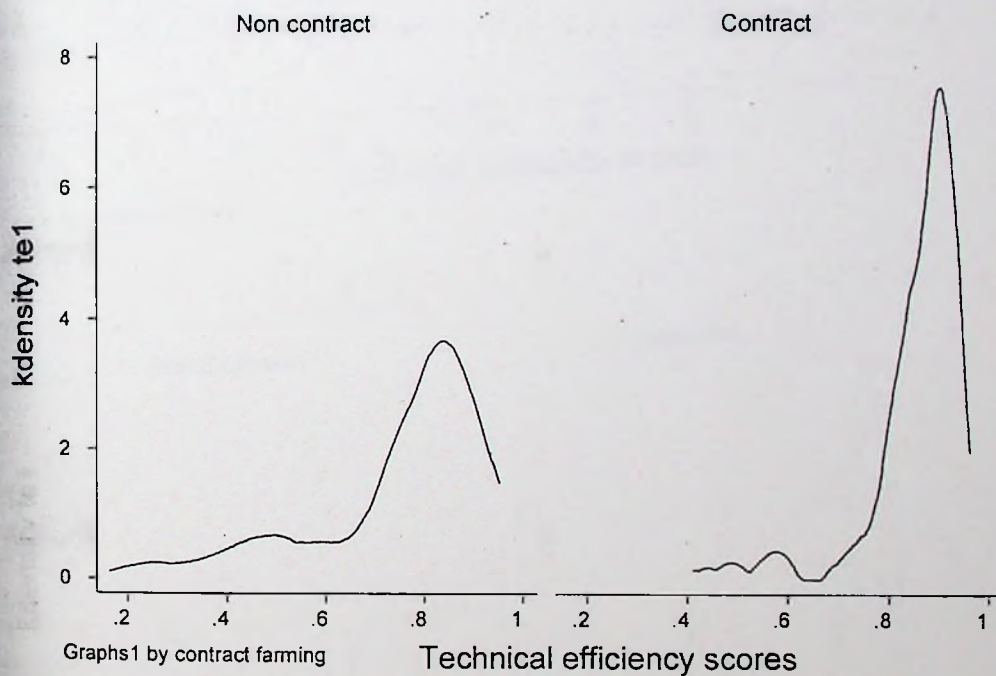
The variables are significant at 1%, 5% and 10% levels of significance

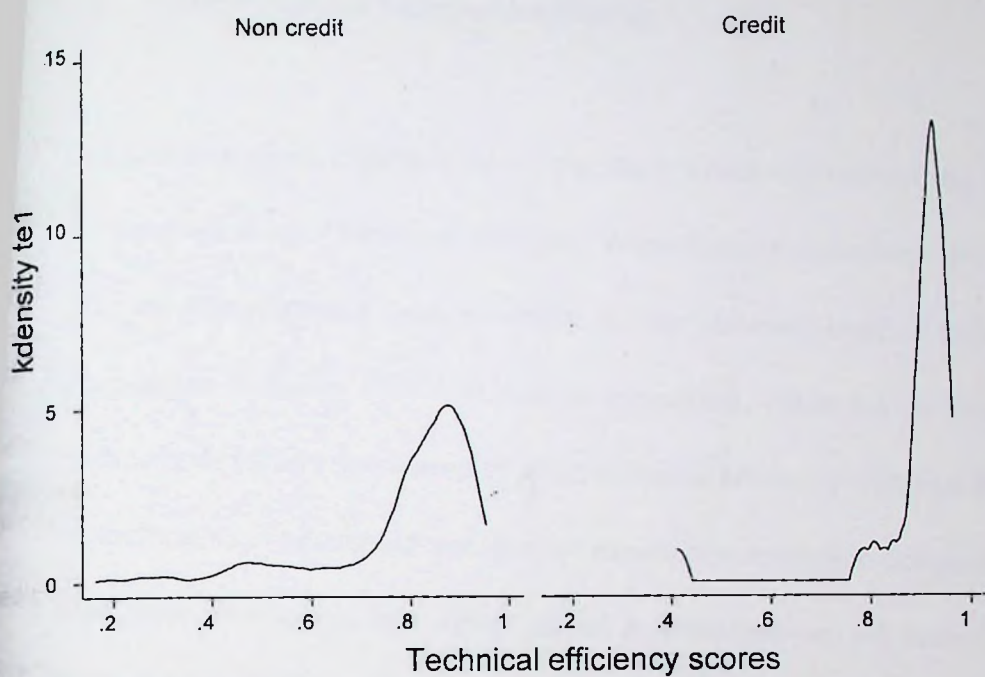
Table 4.3: Frequency Distribution of Farm- Specific Technical Efficiency Index

Technical efficiency	Frequency	Percentage	Cumulative
0 - 25%	2	1.02	1.02
26 - 50%	13	6.63	7.65
51 - 75%	22	11.22	18.88
76 - 100%	159	81.12	100.00

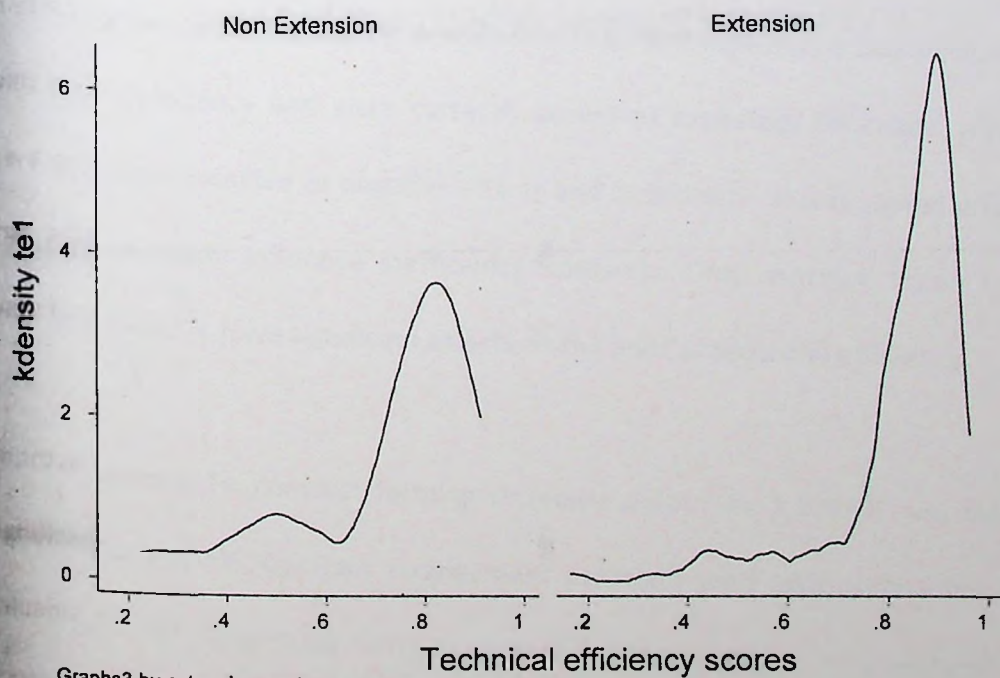
Figure 4.1 show shows kernel density comparisons of technical efficiency among different groups of sunflower farmers. Farmers who are in constant touch with extension agents, those accessing credit and those producing sunflower seed under contract arrangement have technical efficiency scores above 0.8.

Figure 4.1: Kernel density estimates of technical efficiency by contract (graph 1), access to credit (graph 2), and access to extension services (graph 3).





Graphs2: by access to credit



Graphs3 by extension contact

4.3 Determinants of Technical Inefficiency

This section answers objective two of the study which determined the factors affecting the observed level of technical efficiency in sunflower production. The null hypothesis that farm characteristics have no effects on the observed level of technical efficiency was rejected in favour of the alternative hypothesis. Table 4.4 summaries estimated coefficients of factors considered to affect technical efficiency. The results indicate that, the coefficients of household size, gender, experience, extension contacts, contract, and credit were all negative and rightly signed as expected. Sex of household head was expected to take either sign but in this case, sex of male headed household had negative effect on efficiency. However, distance to market had a negative relation with inefficiency but was signed as expected. Age and experience had positive relationship with inefficiency and were correctly signed as expected. Education was expected to have either positive or negative effects and in this case, it was signed positive meaning that education influence inefficiency positively. Only contract, credit and education were found to have significant effects on the level of technical efficiency.

Improvement in contract farming increases output by 1.5725% and this was highly significant at 5%. Contract arrangement especially with agribusiness firm can be very valuable for small-scale farmers since it facilitates access to input and also secure markets for their crops as well as some technical assistance. This is expected to improve efficiency by reducing market risk and timely availability and application of inputs.

Credit was significant at 10% with a coefficient of -1.2202 implying that improved access to credit reduces technical inefficiency. Farmers are usually trapped in a vicious circle of financial hardships to access inputs or timely operation of their farm activities. Farmers who had access to credit and credit facilities had efficiency score of above 0.8 indicating that credit increases technical efficiency (see kernel density scores for technical efficiency in figure 4.2). Therefore, increasing access to credit by 86% of sunflower farmers currently without access could reduce technical inefficiency by 1.2202%. This is because adoption and use intensity of purchased inputs usually depends on adequacy of working capital.

Education had negative influence on technical efficiency and was found significant at 10%. The coefficient was 0.1130 indicating that as a farmer progresses with his/her education, his/her level of technical efficiency in sunflower production reduces by 0.1130%. These findings concur with previous studies such as Lindara M.J.K, Fred H. Johnsen and Herath M. Gunatilake (2004) who found that education reduces technical efficiency. The possible explanation in this study is that more educated farmers take farming as a part time activity besides their main occupation and therefore put less attention. Their professional jobs also provide an alternative source of income to farming.

Table 4.4: Inefficiency Model - Stoc. Frontier normal/exponential model

Stats	Coefficient	Standard Err.	p>z	(95% conf. interval)	
Age	0.0186	0.0144	0.192	-0.006	0.0468
Education	0.1130	0.0608	0.063	-0.0062	0.2322
HH size	-0.3914	0.1061	0.427	-0.2922	0.0708
Experience	-0.1196	0.0760	0.116	-0.2686	0.0293
Extension	-0.6795	0.4603	0.140	-1.5816	0.2226
Contract	-1.5725	0.5128	0.002	-2.5775	-0.5675
Membership	0.5877	0.4524	0.194	-2.2990	1.4744
Credit	-1.2202	0.6816	0.073	-2.5562	0.1157
Gender	-0.3914	0.1011	0.398	-0.2037	0.1127
Distance	-0.0826	0.0847	0.329	-0.2486	0.833
Cons	-1.5497	0.9743	0.112	-3.459	0.3598

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This section make conclusions on the findings as presented in chapter four, it evaluate the strength and weakness associated with approaches adopted, it relates the study in light of critical issues in the literature and relates the finding to practical situations, it finally make recommendations on policies and future action based on the findings and study limitations.

5.1 Conclusions

Efficient production requires adequate inputs and this implies that if access to these inputs is increased, output would automatically increase by a proportion. However, a part from seeds, farmers are not using other purchased inputs such as fertilizer, pesticides and herbicides which could have otherwise brought them closer to the frontier than the current average.

Generally, farmers are technically efficient as indicated by 81% of farmers above 75 percent level of technical efficiency while only 18% of farmers lie on the inefficient level of below.

Contract farming plays a very significant role in enhancing technical efficiency although currently only 50% of the farmers are contract farmers. This means that promoting contract arrangement between farmers and agro-business firms would improve input and output markets. All these moves will encourage farmers to take sunflower farming as a lucrative investment with positive returns and shorter payback period.

Extension contact was found to highly correlate with efficiency and this was attributed mainly to extension services being provided by UOSPA which is a private organization in the area. However, government extension service is still lacking in the areas for sunflower. Government should extend extension advisory services to sunflower farmers if it's to achieve transforming agriculture in totality.

Access to credits was found to improve efficiency in sunflower production however; only 14% of the farmers are able to access credit facilities for their farm operation timely. This means that the rest of the over 86% of the farmers will not access desired input quantity and also unable to undertake timely farm operational activities.

5.2.1 Policy Recommendations

Sunflower farmers are using inputs efficiently and this means that the policy on promoting productivity should orient more to increasing technology generation, transfer, and final adoption by the farmers. The Government and other supporting organizations should put more resources and emphasis on generating new technologies as well as enhancing adoption of these technologies by the farmers.

Contract farming highly promotes efficiency and this means that if the majority of the farmers producing sunflower could benefit from advantage of contract arrangement such as market for produce and input supply, then they would be able to produce more efficiently. However, at the moment, contract arrangement is being done by Mukwano only and limited to only fewer farmers. Conducive policy environment which allows for operation of big private companies which can contract producers should be put in place. Perhaps the government could also form commodity authority for sunflower like the case of coffee and cotton development authorities. Cooperative unions which use oversee timely availability inputs, markets and institute commodity price control systems could be revitalized. Creation of farmers' input-supply and out market cooperatives capable of pooling the flows, reducing the risks and this in turn is expected to improve efficiency. However, with the phasing out of most of the government parastatals and the takeover by private sector, forming new commodity authorities will be of a challenge.

The positive relationship between access to credit and efficiency of the farmers implies that policies that will enhance accessibility to credit facilities by farmers will go a long way in addressing their resource use constraints thus improving efficiency problems. This include establishment of agricultural credit scheme, relaxation of conditions for accessing credit from these scheme. Some banks have started offering credit facilities but limited to only large scale farmers. Micro-finance policies that enhance operation of credit institutions should target village credit scheme dealing in agricultural loans for small scale farmers. In addition, putting less string (repayment period, interest rates and collaterals) on agricultural loans should be promoted to enhance access to credits.

Sunflower is a feeder crop and this implies that farmers should use fertilizers for soil enhancement. However, none of the farmers in the study was found to be using fertilizers. Policy aim at encouraging farmers to adopt and utilize conventional inputs such as subsidies could help them to improve efficiency. Such policies could go hand in hand with strengthening government extension link in sunflower which is lacking.

Policies and programmes on agriculture should be made to target lesser educated farmers who mainly depend on agriculture for their livelihoods rather than the educated counterparts.

5.2.2 Recommendations for Further Research

This study looked at only technical efficiency in sunflower production however; there is need for further research to look into allocative efficiency in the crop.

Different approaches have been employed in measuring efficiency however; this study utilized only stochastic frontier analysis. Additional study using data envelop analysis could be done.

One of the major inputs in production in the Lango sub-region is oxen, however this study could not get adequate information on oxen and the variable was omitted from the analysis. Additional study can be done that look at oxen as one of the main input variables in sunflower production.

REFERENCES

- Aigner, D.J., Lovell, C.A.K., and Schmidt, P. (1977). Formulation and estimation of SF production function models. *Journal of Econometrics*, 6, 21-37
- Ahmad, Munir, Chaudhry, Ghulam Mustafa and Iqbal, Muhammad (2002); Wheat Productivity, Efficiency, and Sustainability: A Stochastic Production Frontier Analysis. Pakistan Institute of Development Economics. MPRA Paper No. 3672 Online at <http://mpra.ub.uni-muenchen.de/3672/>
- Bagamba Fred (2007); market access and agricultural production, the case of banana production in Uganda. University of Wageningen.
- Battese, G.E., and Safraz, H. (1998). Technical efficiency of cotton farmers in Vehari District of Punjab Pakistan. Centre for Efficiency and Productivity Working Papers.No8/98). Department of Econometrics, University of New England , Armidale, Australia. <http://www.une.edu.au/econometrics/cepawp.htm>
- Betty Wambui Kibaara (2005); Technical Efficiency In Kenyan's Maize Production: An Application Of Stochastic Frontier Approach. Colorado State University.
- Bravo-Ureta, Boris E. and E. Antonio Pinheiro. 1997. "Technical, Economic and Allocative Efficiency in Peasant Farming Dominican" *Developing Economics*, 35(1): 48- 67.
- Farrell, M. J. (1957). The measurement of productivity efficiency. *Journal of Royal Statistical Society Series*, 120, 253-290.
- Frank Ellis (1988); peasant economics, farm households and agrarian development Chapter 2 and 4. WYE studies in agricultural and rural development.
- Gauri Khanna (2006); Technical Efficiency in Production and Resource Use in Sugar Cane: A Stochastic Frontier Production Function Analysis. HEI working paper No: 15/2006. Graduate institute of international studies; Geneva
- Government of Uganda, Ministry of Agriculture Animal Industry and Fisheries (2000). Plan for modernization of agriculture: Eradicating poverty in Uganda: Government strategy and operation framework, Uganda.
- Hyuha Theodora Shuwu (2006), Estimating Farm-Level Profit Efficiency Of Rice In Eastern And Northern Uganda: A Stochastic Frontier Approach
- I.C. Idiong (2007), Estimation of Farm Level Technical Efficiency in Smallscale swamp rice

Production in Cross River State of Nigeria: A SFA. Department of Agricultural Economics and Extension, University of Calabar, Nigeria. World Journal of Agricultural Sciences 3 (5): 653-658, 2007

Karl D. Skold and Victor N. Popov (1992): The relationship between technical efficiency

And farm characteristics in the Stavropol region. Working paper 92-WP 101. Centre for agricultural and rural development. Iowa state university. Ames, Iowa 50011

Kumbhakar SC, Lovell CAK (2000) SFA. Cambridge University Press, Cambridge

Lindara M.J.K. Lindara, Fred H. Johnsen and Herath M. Gunatilake (2004): Technical efficiency in the spice based agroforestry sector in Matale, Sri Lanka. Noragric Working Paper No. 34. Noragric. Agricultural University of Norway

Matte Rogers (1998), technical inefficiency and its determinants in Uganda's small Scale industries

Margarita Grazhdaninova & Zvi Lerman (2004); Allocative and Technical Efficiency Of Corporate Farms in Russia. *Analytical Centre for Agri-Food Economics, Moscow*. Discussion Paper No. 12.04.

Mbowa, S. (1996). Farm size and economic efficiency in sugar cane production in Kwazul-Natal. Un published doctoral dissertation, University of Natal, Durban.

Mruthyunjaya, Sant Kumar, M.T. Rajashekharappa, L.M. Pandey, S.V. Ramanarao and Prem Narayan (2005); efficiency in Indian edible oilseed sector: analysis & implications. Agri econ research review vol. 18 jul-Dec 05 pp153-166

NARO (2007); Uganda Edible Oil Demand Up. 3rd Sunflower Symposium for Developing Countries, Uganda. Dec10-14, 2007.

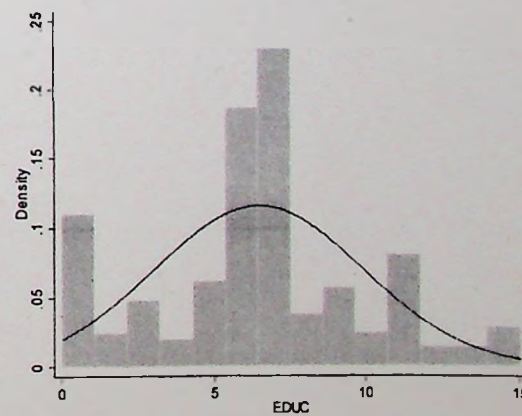
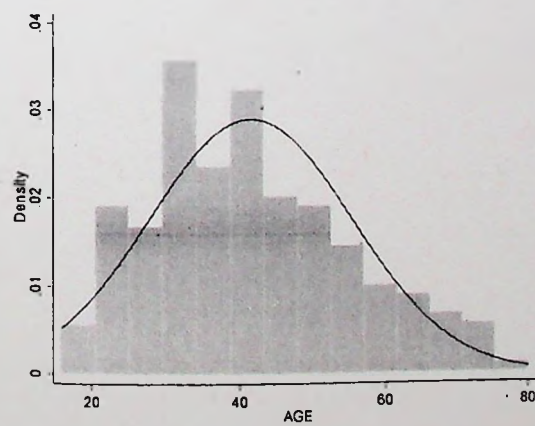
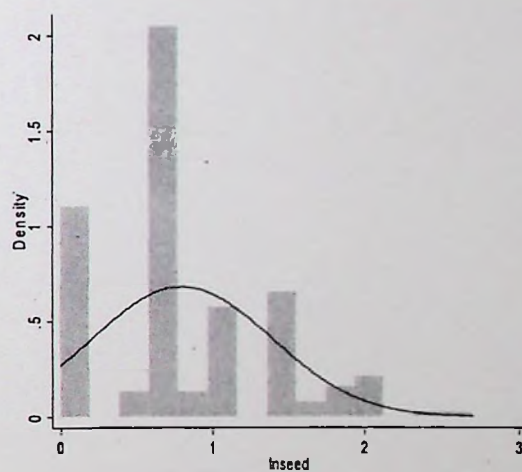
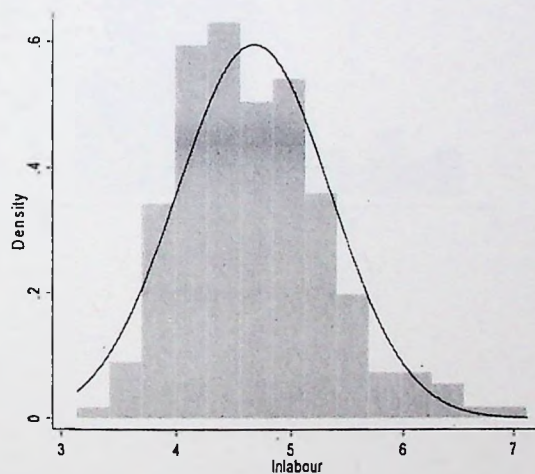
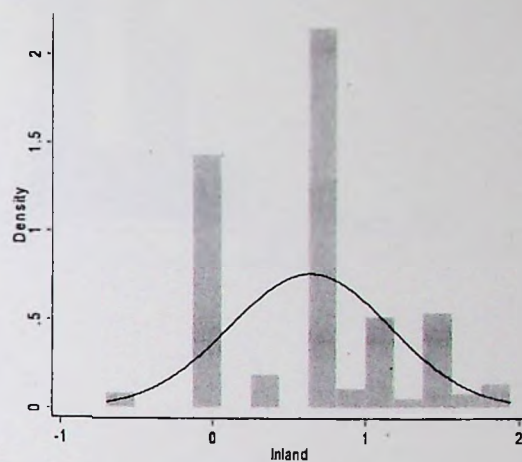
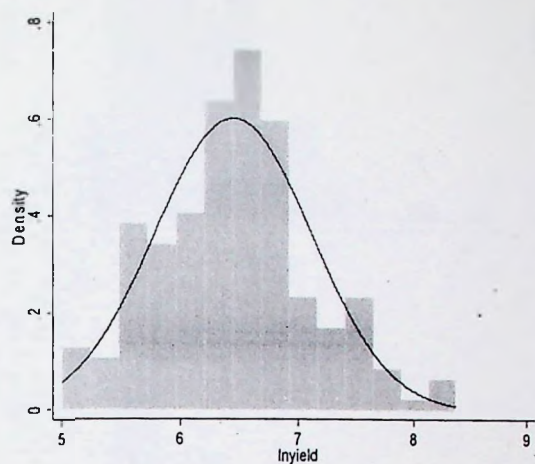
Nivyevs'kiy Oleg, Zelenyuk Valentin (2004), efficiency change in Ukraine's sunflower seed industry: 1998-2002

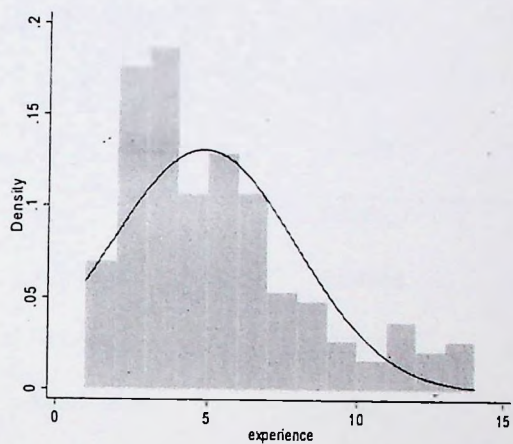
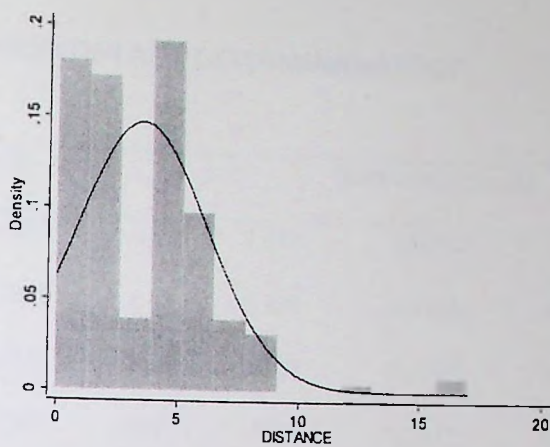
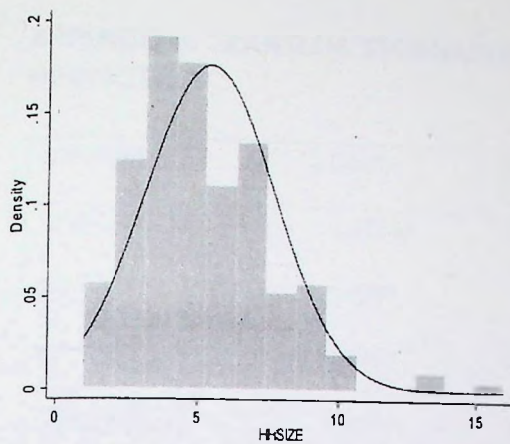
Obwona Morris (2002), determinants of technical efficiency among small & medium scale tobacco farmers in Uganda. Publication of EPRC

Ogundari Kolawole (August 12-18, 2006). Determinants Of Profit Efficiency Among Small Scale Rice Farmers In Nigeria (2006): A Profit Function Approach. Dept. of Agric Economics and Extension Federal University of Technology.

- Ogundari Kolawole and S.O. Ojo (2007); economic efficiency of small scale food Crop Production in Nigeria: A Stochastic Frontier Approach. Department of Agricultural Economics and Extension, Federal University of Technology Akure, Nigeria © Kamla-Raj 2007 J. Soc. Sci., 14(2): 123-130 (2007)
- Okoruwa And O.O., Ogundele (2004), Technical Efficiency Differentials In Rice Production Technologies in Nigeria.
- Pius Chinwuba Ike And Odjuvwuederhie Emmanuel Inoni (2006); Determinants Of Production And Economic Efficiency Among Small-Holder Farmers In Small-Holder Farmers In Southeastern Nigeria.
- S.O. Ojo (2003): Productivity And Technical Efficiency Of Poultry Egg Production In Nigeria. Department Of Agricultural Economics And Extension, Federal University Of Technology, P.M.B. 704, Akure, Nigeria Used Cd. International Journal Of Poultry Science 2 (6): 459-464, 2003. © Asian Network for Scientific Information.
- Tewodros Aragie Kebede, (2001); farm household technical efficiency: a stochastic frontier analysis. A study of rice producers in Mardi watershed in the western development region of Nepal.
- Thiam, A., Boris Bravo-Ureta, E., and Teodoro, E. R. (2001). Technical efficiency in developing country agriculture: A meta-analysis. *Agric Econ*, 25, 235-243.
- Trueblood, Michael A (2004): Measurement and Explanation of Technical Efficiency Performance in Ukrainian Agriculture, 1991-1996. Publication: Journal of Agricultural and Applied Economics. <http://www.lexisnexis.com/>
- UBOS and UOSPA (2005), the edible oil industry in Uganda
- Uganda Bureau of Statistics (2002). The 2002 Uganda Population Housing Census, Main Report The Republic of Uganda.
- Yilma, M. (1996). Measuring smallholder efficiency: Uganda coffee and food crop production. Unpublished, Goteborgs Universitet : Ekonomiska Studier Utgivna av Nationalekonomiska Institutionen Handelsh, Kompendiet-Goteborg, Sweden.

APPENDIX A: DATA NORMALIZATION





APPENDIX B: TRANSLOG STOCHASTIC FRONTIER AND DETERMINANATS OF INEFFICIENCY

Variables	Coeff	Std.Err.	z	p>z	(95% conf.interval)	
land	0.57746	0.6272	0.92	0.357	-0.6518	1.8067
seed	0.4987	0.5865	0.85	0.395	-0.6508	1.6483
Inland2	0.0497	0.1434	0.35	0.729	-0.2314	0.3307
Inlabour2	0.4864	0.0834	-0.58	0.56	-0.212	0.1148
land/labour	0.0347	0.1916	0.18	0.856	-0.3408	0.4102
seed	0.056	0.0284	1.97	0.049	0.0003	0.1117
cons	4.8525	1.0411	4.66	0	2.812	6.8929
age	0.0171	0.0158	1.08	0.278	-0.0138	0.048
education	0.13304	0.0665	2	0.045	0.0027	0.2633
hhsiz	-0.0804	0.1068	-0.75	0.451	-0.2897	0.1289
experience	-0.0852	0.0804	-1.06	0.289	-0.2429	0.0724
extension	-0.9638	0.4984	-1.93	0.053	-1.9406	0.013
contract	1.7302	0.5743	3.01	0.003	0.6047	2.8558
membership	-0.743	0.4859	-1.53	0.126	-1.6952	0.2094
credit	-1.2625	0.7816	-1.62	0.106	-2.7945	0.2694
gender	-0.2362	0.6576	-0.36	0.719	-1.5251	1.0527
distance	-0.0756	0.0952	-0.79	0.427	-0.2621	0.111
con	-3.0202	1.1779	-2.56	0.01	-5.3289	-0.7115
sigmav	0.2329	0.2123			0.1948	0.2786
Insig2v	-2.9139	0.1826	-15.95	0	-3.2719	-2.556
Log likelihood	-55.799					

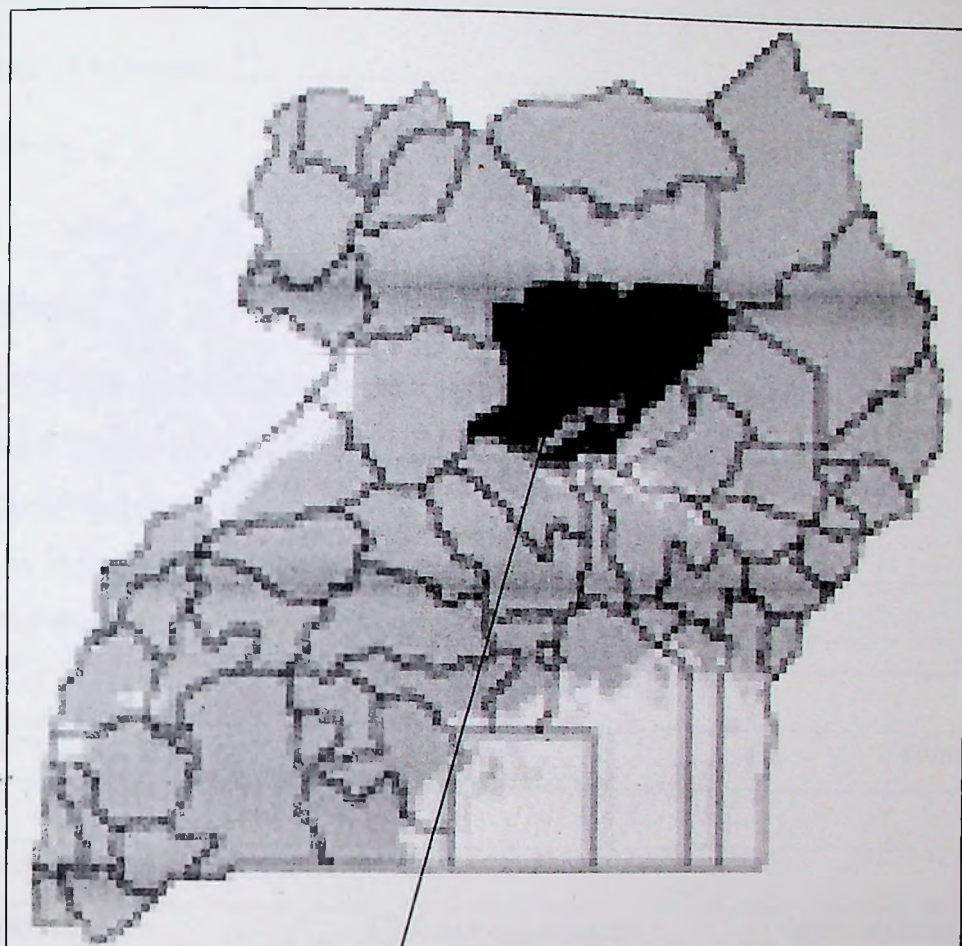
Number of obs 196
Wald chi2 (3) 643.81
Prob > chi2

APPENDIX C: TRANSCENDENTAL STOCHASTIC FRONTIER AND DETERMINANATS OF INEFFICIENCY

variables	coeff	std.err	z	p>z	{95% conf.interval}	
Inland	0.9372	0.206	4.55	0	0.5334	1.3411
lnlabour	-0.0424	0.1858	-0.23	0.82	-0.4065	0.3218
land/labour	-4.6059	5.3021	-0.87	0.385	-14.9979	5.7861
seed	0.0614	0.02298	2.67	0.008	0.0164	0.1065
cons	6.2806	0.8145	7.71	0	4.6842	7.8771
sigma2v	-2.9217	0.1797	-16.26	0	-3.274	-2.5694
sigmav	0.232	0.0157			0.1946	0.2767
age	0.0183	0.0663	1.17	0.243	-0.0124	0.0498
education	0.1395	0.663	2.1	0.035	0.0096	0.2694
hhsize	-0.0814	0.106	-0.77	0.443	-0.2892	0,1265
expereince	-0.8856	0.0797	-1.11	0.266	-0.2447	0.0676
extension	-1.0088	0.4911	-2.05	0.04	-1.9714	-0.0462
contract	1.7295	0.5673	3.05	0.002	0.6176	2.8413
membership	-0.7343	0.4827	-1.52	0.128	-1.6803	0.2117
credit	-1.2622	0.7725	-1.63	0.102	-2.7762	0.2519
gender	-0.3131	0.6468	-0.48	0.628	-1.5809	0.9547
distance	-0.0762	0.0946	-0.81	0.421	-0.2617	0.1093
cons	-2.976	1.1725	-2.54	0.011	-5.274	-0.6779
number of ob	196					
wald chi2	649.02					
prob>chi2	0					
log likelihood	-55.9078					

Source: data obtained from field survey

APPENDIX D: MAP SHOWING LANGO SUB-REGION



LANGO SUB-REGION (comprising the districts of Lira, Apac, Dokolo, Oyam and Amolatra)

APPENDIX E: HOUSEHOLD QUESTIONNAIRE

Name of Enumerator

Date of Interview

District

Sub country

Parish

PART ONE: SOCIO-DEMOGRAPHIC

Name of respondent

1. Respondent sex. Male / Female

2. Age of household

3. How many are you in the household including non-biological? No

No. of adults		No. Children <18	
Males	Females	Males	Females

4. Membership to organizations

Organization	Type of organization	Years of membership

PART TWO: SUNFLOWER PRODUCTION

5. Are you engaged in contract farming (sunflower only)? Yes/no

6. If yes name the organization and types of contract

Organization	Type of contract

7. How much land (total) do you have? No. of acres.....

9. When did you start growing sunflower? Year.....

10. What variety do you grow and why?

11. What is the area of plots under sunflower, varieties grown and who owns them?

Plot	Area/acres	Variety	Type of ownership
1.			
2			
3			

12. Did you use inputs (fertilizers, manure, pesticides) last season in sunflower? Yes / No

13. If yes which ones did you use and how much?

14. If no, why?.....

15. What farm implements did you use in sunflower production?

Equipment	No. owned	No borrowed	No. hired	No bought	Year bought	Value when bought
Hoes						
Ox plough						
Others (specify)						

16. What inputs did you use in operating the following sunflower production activities.

Indicate quantity and costs if purchased/hired and also the source if not purchased/hired.

Inputs	Unit	Quantity	Local cost	Market cost	Dist to market	Transport cost
Activity 1: Land opening						
Land (own)						
Land (hired)						
Labor (family)						
Labor (hired)						
Activity 2: Seed bed preparation (1 st ploughing)						
Labor (family)						
Labor (hired)						
Oxen (own)						
Oxen (hired)						
Tractor						
Activity 3: Seed bed preparation (2 nd ploughing)						
Labor (family)						
Labor (hired)						
Oxen (own)						

Oxen (hired)						
Tractor						
Activity 4: Planting						
Seed (own)						
Seed (bought)						
Labor (family)						
Labor (hired)						
Oxen (own)						
Oxen (hired)						
Activity 5: Weeding (1 st weeding)						
Labor (family)						
Labor (hired)						
Herbicide						
Activity 6: (2 nd weeding)						
Labor (family)						
Labor (hired)						
Herbicides						
Activity 7: Application pesticide / fertilizer / manure						
Labor (family)						
Labor (hired)						
Pesticide						
Fertilizer						
Activity 8: Harvesting, threshing & transporting home						
Labor (family)						
Labor (hired)						
Gunny bag						
Activity 9: Drying and bagging						
Labor						
Activity 10: Marketing						
Marketing						

PART THREE: POST-HARVEST HANDLING AND MARKETING

17. How many bags of sunflower seeds did you harvest last season?
18. What was the weight in kgs per bag?
19. How far is the mill / market from your home? No of Kms.....

PART FOUR: ACCESS TO INFORMATION AND CREDIT

20. How did you first get information on sunflower production?
21. Did you get any extension services on sunflower production last season? Yes / No.
22. Please state the source of extension
23. If yes, how many times last year? 1) Once a month 2) 3 times a month 3) Once in 6 months 4) Not at all.
24. If visited, what message did they carry?.....
-

25. If they did not come, did you try to look for advice from extension agents? Yes/No

26. If yes, what type of information did you look for and from whom?

Type of information	Source

27. Apart from extension agents how else do you get information on production of sunflower? 1) Radio 2) neighbor 3) newspapers 4) family

28. What type of information did you get?

Type of information	Source

30. Did you get any credit (formal or formal) for sunflower production operation last season? Yes / No.

31. If yes, fill the following table

Type of credit	Formal	Informal
From where/whom		
Amount		
Interest rate		

32. If no, why not