DETERMINANTS OF ECONOMIC EFFICIENCY AMONG SMALLHOLDER COWPEA FARMERS IN SOUTH AFRICA: A CASE STUDY OF CAPRICORN AND WATERBERG DISTRICTS IN LIMPOPO PROVINCE

by

Shiluva Valentine Chauke

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ABSTRACT

Legumes are crops that are rich in protein and if households are made aware of their importance, they can be acquired at lower costs and dependency on animal proteins can also be reduced. The cowpea smallholder producers in Africa are faced with numerous challenges such as persistent pests such as aphids that reduce yields, lack of improved varieties and the inability to produce in quantities large enough to sell to local or broader markets in South Africa.

The aim of this study was to examine economic efficiency of cowpea production among smallholder cowpea farmers in Capricorn and Waterberg districts of Limpopo province. The descriptive statistics indicated that interviewed farmers years of schooling ranged from 0 to 13 years, with an average of five years of attending school. Farmers' age ranged between 33 and 78, with an average age of 61 years. The average income received on monthly basis from the overall agricultural produce was R1735.83 per farmer.

The Data Envelopment Analysis (DEA) results showed that the Technical Efficiency (TE) scores of cowpea farmers had a mean of 0,9588 with a minimum of 0,7500 and maximum of 1,000. This means that 95% of the farmers were technically efficient. The allocative Efficiency score ranges from a minimum of 0,4070 and a maximum of 1,000 with a mean of 0,6519. The Allocative Efficiency (AE) scores imply that farmers were not utilizing inputs. The Economic Efficiency scores ranges from a minimum of 0,3820 to 1,000 with a mean score of 0,6218. This implies that cowpea smallholder farmers were economically inefficient on average and that the cost of cowpea production for each farm could be decreased on average by approximately 38% to obtain the same level of output.

The Tobit regression model found that the explanatory variables which were significant are age, educational level, primary income source, farm size, method of intercropping, purpose of growing cowpea and source of field labour. The study recommends that there is a need to provide primary education to the farmers for them to be able to measure and calculate the inputs they use and output they attain in order to improve their efficiency levels.
Key words: Economic Efficiency, Smallholder Farmers and Data Envelopment Analysis (DEA).

DEDICATION

This dissertation is dedicated to my late father Hlengani Phillip Chauke.

DECLARATION

I, Shiluva Valentine Chauke declare that this research project is submitted for the Master's degree Agricultural Economics and this is original and has not been previously submitted for a degree purpose at this university. The information provided in this paper is true and the information provided is my own work, and any information used in the study from various sources was acknowledged.

Full Names: Shiluva Valentine Chauke

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Signature **Date**

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ABBREVIATIONS

AE	Allocative efficiency
BFAB	Bureau for Food and Agricultural Policy
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Data Envelopment Analysis
DEAP	Data Envelopment Analysis Programme
DMUs	Decision Making Units
DRS	Decreasing Returns to Scale
EE	Economic Efficiency
FANRPAN	Food, Agriculture and Natural Resources Policy Analysis Network
FAO	Food and Agriculture Organization of the United Nations
ILVs	Indigenous Leafy Vegetables
RRVP	Rice Research Verification Program
SFPF	Stochastic Frontier Production Function
StatsSA	Statistics of South Africa
TE	Technical Efficiency
UL	University of Limpopo
WRC	Water Research Commission
WWF	World Wide Fund for Nature

CHAPTER ONE: BACKGROUND OF THE STUDY

1.1. INTRODUCTION

South Africa is characterised by a dual economy that has thriving commercial farming as well as smaller-scale communal farming that is located in the former homeland areas (Brand,1969). According to StatsSA (2017), the agricultural sector (including forestry and fisheries) economy grew by more 22% contributed a relative share of the total GDP of about 0,4% in the third quarter of 2017. South Africa is also classified as a semi-arid land with an annual average rainfall of 464mm. Like all African countries, South Africa is not immune to climate change and its effects.

The South African National Development Plan acknowledges the agricultural sector as a sector to expand, with intensive, export orientated industries particularly identified as key in creating jobs within the rural economy (BFAP, 2016). In 2015, South Africa experienced severe drought that resulted in a decrease in agricultural production levels where provinces such as KwaZulu-Natal, Eastern Cape and Limpopo experienced decreased maize production and a major loss of livestock. The recent severe drought also had long term financial and debt implications for farm businesses.

The Bureau for Food and Agricultural Policy (BFAB) policy brief (2016) further revealed that poor rural households in South Africa continue to be dependent on household agricultural production and more than 1.2 million individuals were affected by the recent drought, which had a significant impact on maize yields leading to food insecurity. The table below indicates the effects of the recent 2015/ 2016 drought, through the changes in volumes of agricultural production in South Africa.

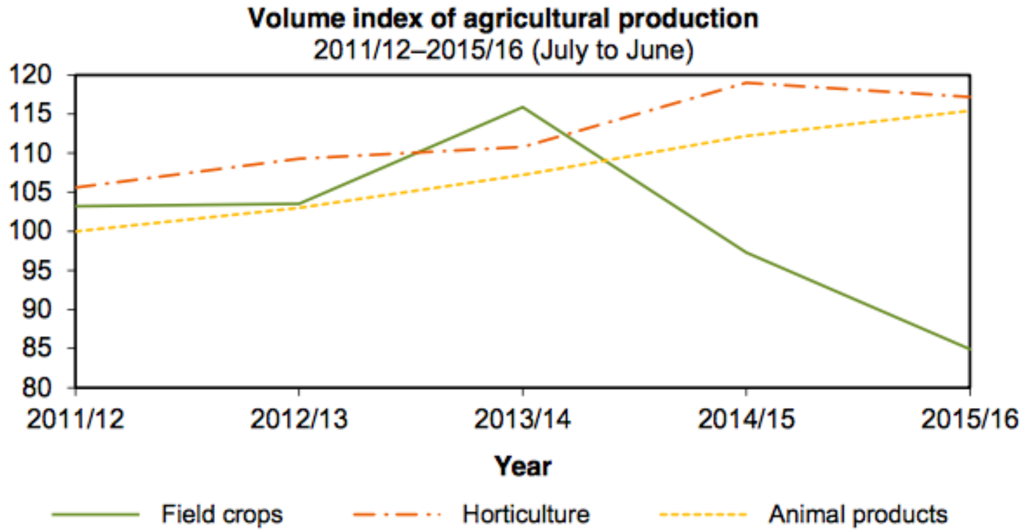

Figure 1.1: Volume index of agricultural production in South Africa

Source: DAFF (2016) Trends in the Agricultural Sector

The graph above illustrates the changes in the agricultural sector from the production season 2011/12 to 2015/16 in South Africa. Due to the effect of drought, field crop production yields decreased by 12,7 % mainly due to decrease in maize and sorghum yields. Maize production decreased by 2,9 million tons (27,6%) and sorghum by 36 800 tons (26,6%) from the previous season.

The drought experienced in the production season 2015/16 in South Africa resulted in a decrease in yield of various crops and livestock production. South Africa has been previously reported to be the net exporter of maize into most southern African countries such as Mozambique, Swaziland, Botswana Lesotho and Namibia. According to BFAP (2016), it has been stated that South Africa is an importer of maize (both white and yellow), it is expected to import 856 000 tons of white maize and 1.9 million tons of yellow maize that is estimated to cost R11.5 billion.

Maize Imports are estimated to increase to 1.2 million tons and 2.2 million tons respectively and this increment will be at a cost of R14.5 billion by 2019. This calls for the promotion of consumption of crops that are nutritious and can withstand drought, particularly legumes such as cowpeas and dry beans. Furthermore, promotion of these crops will assist in terms of improvement of farmers' income and also reduce food insecurity, malnutrition and poverty.

The inefficient production in the agricultural sector comes as a result of climate change and other factors such as the inability of farmers to fully utilize available technologies, attributing to inefficiency of production. According to Harwood (1987), efficient use of various inputs in any sector contributes as a determinant of the sustainability of that sector. The ability to produce efficiently can decrease the production costs and enhance yield in cowpeas as well as improve the farmers' livelihoods through higher income earned from selling cowpea.

1.2. PROBLEM STATEMENT

The cowpea in Limpopo province is currently grown for home consumption with a small quantity being sold in the market. This is attributable to poor agronomic practices, lack of improved cowpea varieties and inadequate good quality seeds (DAFF, 2011). The low importance placed on cowpea as an income generating crop also has a negative impact on the production of cowpea in the Limpopo province of South Africa. According to DAFF (2011), cowpea production in South Africa is done in KwaZulu-Natal, Mpumalanga and Limpopo provinces of the country. Capricorn and Waterberg districts of Limpopo are the main producers of cowpea in Limpopo province.

Cowpea has been produced as an indigenous legume for ancient years in Africa. mainly for home consumption and with few producing for income generation. Cowpea smallholder farmers in Limpopo are faced with numerous challenges such as the inability to produce in larger quantity enough to sell to local or broader markets in South Africa. Additional challenges faced by farmers include plant diseases and pests, lack of access to credit and information about financial assistance, lack of or poor access to markets, as well as lack of improved seed varieties among others.

In South Africa, emphasis has been on field crops such as maize, dry beans, soybeans, wheat sunflower and sorghum and there is not much documentation about the production of cowpeas or its introduction to households as a crop that can withstand drought and be used as a source of protein in Limpopo and most of the studies done on arable crops focused on these crops with very few studies on cowpeas. This has resulted in production inefficiency among smallholder cowpea farmers especially with the rising cost of production. This study therefore analysed the factors that influence and limit the production of this legume in the study area**.**

1.3. RATIONALE

Legumes are crops that needs to be prioritised in African countries such as South Africa where there are more than 30 million people leaving in poverty (StatsSA, 2017). Legumes are crops that are rich in protein and can be acquired at lower costs. There is need to create awareness of the importance of these legumes, this will assist in ensuring that households reduce their dependence on animal protein for nourishing their bodies. They also have the ability to reduce malnutrition and food insecurity in South Africa by providing proteins, minerals and energy. They can also be a source of income for smallholder farmers.

Figure 1.2. Matured Cowpea

Source: Photo taken by author during survey (2017)

The motivation for the study arises from the need to determine the current efficiency levels of cowpea production and to raise awareness on the ability of the crop to generate income for smallholder farmers and potential to reduce malnutrition and food insecurity. This study determines the factors that affect economic levels of cowpea production. Based on the continuous effect of climate change on the agriculture sector, there is need to alert smallholder farmers about the importance of prioritizing cowpeas since maize, wheat and sorghum won't be able to sustain households in the near future.

There is an urgent need to provide information about planting techniques that can yield more cowpeas for famers to consume at household level and be able to sell at market level. These techniques include allocating resources efficiently and technically producing cowpea. Most South African households needs to be provided with alternatives ways of cooking cowpeas rather than boiling, since poor cooking skills and meal preparations are also reasons the cowpea is not largely planted by South African farmers. This study will also serve as a tool for the government in addressing agricultural-nutrition challenges and assisting legume smallholder farmers.

Despite cowpea`s contribution to the diet of rural families, its use as livestock feed and as a soil fertility enhancer, it is one of the neglected crops in South Africa (Asiwe, 2009). Producers of cowpea are faced with numerous challenges that result in low productivity. Based on the low production of cowpeas in South Africa and Limpopo in particular there is a need to conduct studies that will provide information and alternative ways of producing this legume in larger quantities in order to address the persistent food insecurity in the study area.

The study revealed some of the main constraints to economic efficiency of cowpea production. An increase in efficiency of cowpea production could lead to improvement in the welfare of farmers, their dietary intake and consequently a reduction in their poverty level and food insecurity. Profitability of cowpea enterprises could be a motivating factor for farmers to produce cowpeas. Farmers are assumed to be rational and thus they tend to make production decisions in favour of crops that will yield the most benefits to them, whether market or non-market.

1.3.1. Aim of the study

The aim of this study was to examine the economic efficiency of cowpea production among smallholder farmers in Capricorn and Waterberg Districts of Limpopo Province.

1.3.2. Research questions

This study intended to provide answers to the following research questions:

i. What are the socioeconomic characteristics of smallholder cowpea farmers of Capricorn and Waterberg districts?
ii. What are the determinants of economic efficiency among smallholder cowpea farmers in the study area?

1.3.3. The objectives of the study

i. Identify and describe the socioeconomic characteristics of smallholder cowpea farmers in the study area.
ii. Examine determinants of economic efficiency among smallholder cowpea farmers in the study area.

1.4. ORGANIZATIONAL STRUCTURE

This study comprises of five chapters. Chapter one constitutes the overall introduction of the study, which is made up of the background, problem statement, rationale (aim and objectives of the study) and research hypothesis. Chapter two constitutes of literature review that outlines previous views expressed and studies conducted in South Africa and globally. Chapter three is where the methodology and analytical procedures are outlined on how the study was conducted. Chapter 4 indicates the results obtained and their interpretation. The last chapter which is chapter five comprises of the summary, conclusion and policy recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1. INTRODUCTION

This chapter presents the literature on various concepts, approaches and techniques that were utilized to analyse efficiencies of farmers in agricultural production. It comprises of the background and importance of cowpeas, definition of concepts, previous studies on efficiencies which were conducted on different agricultural produce within South Africa and internationally. In South Africa, numerous studies were conducted on efficiency of different agricultural commodities but there is little documentation on cowpeas compared to other cowpea producing countries.

2.2. BACKGROUND OF COWPEA

The cowpea (*Vigna unguiculata* (L) Walp) is one of the most time-honoured crops known to man (Martin *et al.*, 1967) and the centre of its genesis is in West Africa (Ng and Padulosi, 1988). It is an essential legume and a useful component of the traditional cropping systems in the semi-arid tropics including Asia, Africa, Central and South America (Mortimore *et al.*, 1997; Singh and Tawarali, 2003). In Africa the largest producer and consumer of the cowpea legume is Nigeria with around 5 million ha and over 2 million mt production yearly, followed by Niger with (650,000 mt) then Brazil with (490,000 mt) (Singh, 2002).

The Consultative Group on International Agricultural Research (2011) revealed that the land that is under cowpea cultivation annually is around 14.5 million hectares worldwide and in 2010, the production of cowpea globally stood at 5.5 million metric tons. The study conducted by Coulibaly and Lowenberg-DeBoer (2000) noted that the demand for cowpeas in West Africa had risen due to high population growth, poverty and demand for food that cost less.

2.2.1. Importance of Cowpea

Developing countries are characterized by rapidly growing populations. This is followed by major crises such as food insecurity, malnutrition and poverty; these issues are in one way or the other reduced by increasing food production either from crops, legumes or livestock. Cowpea is one of the legumes that can reduce these issues with the assistance of other crops, livestock and other agricultural produce. The cowpea is of great importance to the nourishment and livelihoods of millions of people in less-developed countries of the tropics (Singh *et al.*, 2003). According to Odindo (2007), cowpeas can play a significant role in food security initiatives aimed at addressing problems of food production in these regions.

Vigna unguiculata is a leafy crop that is drought tolerant due its ability to withstand warm weather conditions. According to Manjula, (2011), this legume is well adapted to areas that are drier and where other food legumes struggle to strive well. It develops well in poor soils with, more than 85% sand and with less than 0.2% organic matter and low amounts of phosphorus (Manjula, 2011). This legume has numerous benefits; it can be used as a livestock feed supplement during dry seasons, its young shoots and leaves can be consumed as leafy vegetables, it can be used as manure or as a cover crop and its dried seeds can be used as a coffee substitute (Odindo,2007).

2.2.2. Definition of concepts

Economic efficiency consists of technical efficiency and allocative or factor price efficiency. It represents the efficient resource input mix for any given output that minimizes the cost of producing that level of output - the combination of inputs that for a given amount of money maximize the level of production (Mushunje, 2005). Udoh, (2005) strongly argues that "efficiency is at the heart of agricultural production because the scope of agricultural production can be expanded and sustained by farmers through efficient use of resources".

Farrell (1957) proposed that the efficiency of a firm composes of two components, technical efficiency and allocative efficiency. Technical efficiency demonstrates the firm`s ability to attain maximal output from a given set of inputs, and allocative efficiency (AE), indicates the ability of a firm to utilize the inputs in optimal proportions, given their respective price. He strongly argued that these two measures are combined to give a measure of total economic efficiency. He employed a frontier production function to differentiate between technical and allocative (price) efficiency in the production of goods and services. He further outlined that technical efficiency is the ability to attain the highest quantity of output with the least quantity of inputs under certain technology; while allocative efficiency refers to the ability of choosing optimal input levels for given factor prices.

Xu and Jeffrey (1998) also agreed that economic or total efficiency is the outcome of technical efficiency and allocative efficiency. Adeniji (1988) points out that Economic efficiency is the ability of producers to expand profit and is also described as the product of technical and allocative efficiency. He further stated that economic efficiency serves as an indicator of costs per unit of output, for a firm which perfectly attains both technical and price efficiencies.

Koopmans (1951) stated that technical efficiency is defined as the ability to minimize the use of resources or inputs while sustaining a given level of output level, or the ability to maximize output production while fixing the quantity of resource use. Technical efficiency and allocative efficiency are elements of economic efficiency and they are derived from the production function. The study adopts the definition of economic efficiency of Farrell (1957) to examine the determinants of economic efficiency of cowpea smallholder farmers in Limpopo province. The study used both non-parametric and parametric approaches to analyse the economic efficiency of the cowpea farmers.

It is important to note that, a farm utilizing technically efficient resource combination may not be producing optimally depending on the predominant factor prices. Thus, the allocative efficient level of production is where the farm runs at the minimum– cost combination of resources. A farmer is said to be allocative efficient when production resources are allocated based on their relative prices (Torkamani and Hardaker, 1996). According to Oh and Kim (1980), “allocative efficiency is the ratio between total costs of producing a unit of output using actual factor proportions in a technically efficient manner, and total costs of producing a unit of output using optimal factor proportions in a technically efficient manner”.

The non-parametric deployed by the study is called Data envelopment analysis and the parametric approach is called stochastic production function. They are used in this study to compare the outcomes of each model and to determine whether there is a link between these approaches. One approach will be used to uncover and address the limitations of the other. Data Envelopment Analysis (DEA) closely is a non-parametric approach for assessing the performance of tangled organization referred to as called Decision Making Units (DMUs) which change numerous inputs into numerous outputs. DEA as a linear programming technique computes a relative ratio of outputs to inputs for each DMU, which is outlined as the relative efficiency score (Cvetkoska, 2011).

2.2.3. Review of previous studies

Baloyi (2011), conducted a study to determine the level of technical efficiency of 120 maize small-scale farmers in Limpopo province in rural community called Ga-Mothiba. The level of technical efficiency of the maize small-scale farmers was determined by the use of the Cobb-Douglas production function. The variables that influence the technical efficiency of maize production were analysed by the use of Logistic regression model. The results obtained from the study outlined that there were significant positive relationships between farm size, fertilizers and technical efficiency of maize production. The study further indicated that there was a significant relationship between cost of tractor hours (this was used as proxy for capital) and technical efficiency.

It was also revealed that small-scale farmers in Ga-Mothiba are encountering decreasing returns to scale (DRS) stipulating that small-scale farmers are experiencing technically inefficiency in the production of maize., which means they are over-utilizing factors of production. Logistic regression results stipulated that variables such as level of education, income of the household on monthly basis, farmer`s farming experience, farm size, cost of tractor hours, fertilizer application, purchased hybrid maize seeds, etc. were found to be significant and gender, age and hired labour were found to be non-significant. However, farm size was found to be the most significant variable at 99% level, showing a positive relationship to small-scale maize producer`s technical efficiency. The study recommended that government should perform on-farm training since farmers mostly depend on trial and error and farmers should have access to enough arable land and tractor services.

Mahlangu (2014), investigated the economic potential of commercializing indigenous leafy vegetables in rural South Africa. The study used Stochastic Frontier Production Function to determine the productivity and the socio-economic characteristics of Indigenous Leafy Vegetables (ILVs) producers. The study revealed that there were several significant socio-economic factors that affect ILVs production and there are also factors which limit farmers from commercializing ILVs. Productivity of ILVs in the study area varied among producers; some farmers had high productivity but utmost farmers had a low productivity.

ILVs producers had no formal marketing route; therefore, they sold their produce straight to consumers or via hawkers. The study recommended that there should be integration of science/modern technology and indigenous knowledge, to improve the productivity of ILVs. The study further recommended that since farmers are technically inefficient, it is important to run workshops that will help them enhance their production and marketing expertise and how to market their produce. Or create booklets that have information on how to efficiently produce ILVs. The study lastly recommended that there should be a multi-disciplinary approach in developing the ILVs; more stakeholders should be involved so as to make the crop appealing.

Van Der Merwe (2012), explored the relationship between economic literacy and allocative efficiency of small-scale producers in South Africa. The study was conducted in Eksteenskuil, where small-scale farmers exported raisins through the fair-trade strategy. A structured questionnaire survey was utilized to gather data regarding production inputs and their relative prices. Data Envelopment Analysis was used to calculate the allocative efficiency of farmers.

The study hypothesized that economic literacy of individuals had influence on the ability of the producers to assign their resources efficiently. The results from the DEA indicated solid inefficiencies between small-scale raisin producers of Eksteenskuil, showing that a significant capacity for cost efficiency enhancement exists.

The enhancement of cost efficiency of producers led to expansion of profit of producers. The results obtained showed that economic literacy did affect the decision-making ability of individuals when it comes to assigning the production inputs. A study that was aimed at analysing factors that influenced technical efficiency of Arabica coffee producers in Cameroon was conducted by Nchare (2007). The translog stochastic frontier function was used to carry out the analysis. The study specified technical inefficiency as a function of socio-economic variables. The actual results of the study indicated increasing returns to scale in coffee production. “The mean technical efficiency index was estimated at 0.896% and 32% of the farmers surveyed had technical efficiency indexes of less than 0.91%” (Nchare, 2007). The analysis further outlined that educational level of the farmers and access to credit facilities were the main socio- economic variables affecting the farmer’s technical efficiency.

Machete (2016) conducted a study that focused on the economic and marketing aspects of the smallholder broiler producers in Limpopo, the study was limited to Mopani district. The study used the gross margin analysis to estimate the profitability of smallholder broiler production. A logit model was used to analyze the determinants of market participation between the smallholder farmers in Mopani district. The study further utilized the stochastic frontier production function to determine the technical efficiency of these farmers. The Gross Margin Analysis indicated costs incurred for feeds were the higher, taking up 70.61% of the entire costs of production. Feed costs were followed by the cost of stock consist of 15.11% of the overall production costs.

The results obtained from the Stochastic Frontier Production Function (SFPF) showed that there`s a positive relation between the productivity of the producers in the broiler production and these aspects labour, feeds, stock size and vaccines. The results further indicated that chicken feeds were significant at 10% whereas stock size and vaccines were significant at 1% level (Machete, 2016). The study showed that the technical efficiency of smallholder broiler producers in the study area could spare an average of 23.4 % in production costs and gain a maximum cost saving of 95.8% in production costs. The study recommended that there should be establishment of linkages between the formal markets and the smallholder farmers not participating in the market. Producers who attain profit and are more knowledgeable in broiler production should be provided with a platform to expand into commercial farming. This can be achievable through subsidies or providing of other incentives that are key to enhancing expansion, such as land and funds.

According to Jirgi *et al* (2010) “efficiency and productivity potentials are also high if the farmers use more of improved seeds, family labour, agrochemicals, less of hired labour and land”. The studies that were conducted on technical efficiency of smallholder farmers have related variables like farmers` age, educational level of farmers, access to extension services, credit access, land holding size, ownership of dwelling, farmers` household size, gender, access to market, as well as farmers` ability to obtain improved technologies such as fertilizer, agro-chemicals, tractor and improved seeds with favourable effect on technical efficiency (Amos, 2007).

Sofoluwe and Kareem (2011) conducted a study in Nigeria, the study was about the technical efficiency of cowpea production. The study focused on estimation of technical efficiency of farmers using stochastic parametric estimation methods the study concluded that cowpea production is profitable and the mean technical efficiency of 0.66 could be increased by 34% through better use of available resources. The study therefore recommended that for an effective improvement in the level of efficiency among the cowpea farmers, provision should be made by governments and other stakeholders in the agricultural sector to provide farmers with access to affordable inputs such as seed, pesticides as well as making provision for an alternative from family labour.

The main producers of cowpea in Zambia are small-scale farmers, who mostly produce it as a food crop rather than cash crop. “Cash crops are to a great extent grown by male farmers while food security crops such as cowpeas are grown by female farmers" (Unit District Planning, undated). Zulu (2011) conducted a study on the profitability of cowpea production in Zambia. The study carried out the gross margin and regression analysis. The gross margin was found to be positive and factors that influenced the profitability of cowpea are area planted, farm gate price production costs, yields and land tenure. Based on the results, cowpea production in Zambia was concluded to be profitable. According to Zulu (2011), the implication of the results found was that farmers should be motivated or encouraged to produce cowpeas not only for consumption but also as a cash crop.

The study conducted by Ya`aishe*, et.al* (2010) which examined the economic analysis of cowpea production among women in Nigeria revealed that cowpea production is profitable and viable economic means of earning a livelihood. Production of cowpeas in the study area would be increased through appropriate use of chemical, fertilizer and improved varieties of seed. Efforts should also be geared towards providing solutions to identified problems with a view to increase productivity thereby maximizing profits. The study further recommended that formal credit facilities should be provided by both the governmental and nongovernmental organizations involved in funding agriculture to target cowpea farmers via direct loans or bank loans.

Nsanzugwanko *et al.* (1996) used the stochastic frontier production function to estimate the technical efficiency of individual peasant farmers in the Ethiopian agricultural sector. The variable labour was left out despite its importance and also omitted some important socio-economic variables, which could be useful in estimating technical efficiency. These variables were; age, education and experience of farmers' as well as access to credit and infrastructure. The Cobb-Douglas type of the stochastic production function was used, and the maximum-likelihood estimates of the parameters were obtained using the computer program, frontier, version 2.0.

Biam *et.al* (2016) deliberate the level and determinants of economic efficiency in small scale soya bean production in Nigeria. The Cobb-Douglas stochastic frontier cost function was employed to analyse data. The average economic level was found to be 52%. The study concluded that farm size, age and household size are negatively and significantly associated with economic efficiency at 5% and 1% significance levels. Factors such as education, farming experience, access to credit and fertilizer use was significantly and positively associated to economic efficiency. There was no significant relationship that was found between economic efficiency and factors such as extension contact and membership of farmers` associations. The study recommended that policies that will increase farmers' economic efficiency level should be focused on enhancing their educational levels and easy access to credit and fertilizer; on the other hand, the experienced farmers should be encouraged to continue producing soya beans.

Taru *et.al.* (2011) conducted a study to analyse the technical efficiency of sole cowpea production in the Northern part of Adamawa. The stochastic frontier model was used to analyse the data. The technical efficiency of cowpea producers was less than one, showing that the farmers were not operating on the efficiency frontier. The study revealed that factors such as Farm size, seeds, agro-chemicals and hired labour were positive and significant on output at 1% significance level. The results of the study further revealed that the mean technical efficiency index was 0.89 while the minimum efficiency was 0.55 and maximum efficiency was 0.95. Therefore, this means that the cowpea producers were not fully efficient as the yield was 11% less than the maximum output. The study stated that there is an urgent need that is required to address factors that hinder efficiency in cowpea production; these factors include lack of agrochemicals and other inputs that will mend the gap between demand and supply of the essential inputs in cowpea production.

This study intends to provide information about planting techniques that can yield more cowpeas for famers to consume at household level and be able to sell at market level. Outline cooking techniques that can be used in meal preparation by households. It also aims to identifying factors that limits the production of cowpeas in South Africa and providing recommendations on how cowpeas can be re-introduced to farmers for them to diversify their farm production. This study will also serve as a tool for government addressing agricultural-nutrition challenges and assisting small-holder legume farmers.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. INTRODUCTION

This chapter provides the description of the study area and explains the methods and techniques which were used to collect and analyse data. The study used two techniques to analyze data, the DEA and Tobit regression models. The DEA was used to explain technical, allocative and economic efficiency of cowpea farmers and also the socio-economic factors that result in inefficiency. This will also severe as a guideline for conducting efficiency studies in the agricultural sector. The study also used descriptive statistics to describe socioeconomic characteristics of cowpea farmers and constraints pertaining cowpea production.

3.2. DESCRIPTION OF THE STUDY AREA

The study was carried out in Limpopo Province, one of South Africa's nine provinces found in the northernmost part of the country. This province was formerly known as Northern Province and its capital city was named Pietersburg from 1994 until 2003. Its name has since been changed to Limpopo province and its capital city is now known as Polokwane. According to StatsSA (2011) the land area of Limpopo province amounts to 125 745 square kilometres which are 10.4 %of the total land of South Africa. It is therefore the fifth largest province in South Africa with a population size of 4 995 462 people (StatsSA, 2011).

Limpopo consists of five districts namely Capricorn, Vhembe, Sekhukhune, Mopani and Waterberg. This study only focused on two districts, Capricorn and Waterberg. These were selected based on the location of the bigger project of the Water Research Commission. The climate of the Limpopo province is suitable for cowpea growth. According to DAFF (2011), Waterberg and Capricorn Districts are some of the main cowpea producing areas of the Limpopo Province. The study focused on Bela-Bela municipality of Waterberg district and Lepelle- Nkumpi municipality of Capricorn district.

Figure 3.1: The map showing Limpopo Province and its District Municipalities

Source: Municipalities of South Africa (2015)

3.2.1. Capricorn District Municipality

The Capricorn district consists of five municipalities namely Aganang, Blouberg, Lepelle-Nkumpi, Molemole and Polokwane. The district covers up to 21 705 square kilometers of the Limpopo province. The study focused on Lepelle-Nkumpi municipality. Agriculture is one of the most important driving forces of the district in terms of employment and food supply to households. The main economic sectors are manufacturing, community services, electricity, finance, trade, transport, construction and agriculture.

Figure 3.2: The map showing Capricorn District Municipalities

Source: Municipalities of South Africa (2015)

3.2.2. Waterberg District Municipality

The District Municipality is made up of five local municipalities, which are Thabazimbi Bela-Bela, Mookgophong, Lephalale and Mogalakwena. The total area that is covered by the district is at least 44 913 square kilometres of land of the Limpopo province. Bela-Bela is the local municipality that was surveyed. The main economic sectors in the district are agriculture, tourism and Mining.

Figure 3.3: The map showing Waterberg District Municipality.

Source: Municipalities of South Africa (2015)

3.3. DATA COLLECTION AND SAMPLING PROCEDURE

Purposive sampling was used to select the study area. Cowpea farmers in both districts were selected as outlined in the Water Research Commission (WRC) project (R096). Primary data was collected through administration of a structured questionnaire on representative farmers selected from the two districts based on probability proportionate to size. Data was collected on variables such as socioeconomic characteristics, production inputs and other production constraints. The data of the study was obtained from 60 cowpea farmers for the 2016 / 2017 production season.

3.4. ANALYTICAL TECHNIQUES

The study used descriptive statistics DEA and Tobit regression models to analyse the primary data. The study made use of DEA to obtain technical, allocative and economic efficiency scores for cowpea producers. This study made use of Tobit regression model to analyse the determinants of economic efficiency among cowpea smallholder cowpea producers in the study area.

3.4.1. Descriptive statistics

Descriptive statistics were used in analysing and describing the socio-economic characteristics of smallholder cowpea farmers. The results are expressed in a form of tables and graphs frequencies elaborated in percentages, sums and averages.

3.4.2. Data Envelopment Analysis (DEA)

Background of the Approach

The Data Envelopment Analysis (DEA) is known as a non-parametric, linear programming (LP) approach that is used to measure relative efficiency among a set of decision-making units (DMUs), in this study the DMUs are Cowpea Farmers of Capricorn and Waterberg Districts of Limpopo province.

DEA was originally developed by Farrell (1957) and was advanced by Charnes *et.al* in 1978 and modified by Banker *et.al* in 1984. Farrell initiated the idea of comparative efficiency in which the efficiency of a certain DMUs may be compared with another DMU within a given group. DEA is a mathematical method that measures the relative impacts of the DMUs which are assumed to be uniform by using multiple inputs-outputs. The assumption of DEA consisted of cost returns to scale (CRS) and variable returns to scale (VRS) at optimal scale (Javed *et.al*, 2010). Firms cannot operate at the optimal scale when there are factors such as financing constraints, competition among others.

Classification of efficiencies

Farrell (1957), classified and identified the three different types of efficiency, technical, allocative(price) and economic(overall) efficiency. He suggested that efficiency of any given firm comprises of its technical and allocative components. Charnes *et al.* (1978) defined DEA as the corner stone for all successive developments in the non-parametric approach. According to Lubis *et al.* (2014), numerous methods that have been developed to estimate efficiency are classified as parametric and non-parametric approaches. DEA is characterized by having various advantages such as not requiring prior specific functional form for the production frontier, its ability to handle multiple outputs and inputs, not entailing distributional assumptions of the inefficiency term, and it has the ability to identify the best practice for every farm

The ability of a firm to produce on the Iso-quant frontier is associated with Technical efficiency (TE), furthermore TE measures the ability of a firm to produce the highest possible output from given a bundle of inputs. Allocative efficiency (AE) refers to the ability of a firm to produce at a given level of output using the cost-minimizing input ratios. AE is computed by the proportion of least production costs required by the DMU to produce a given level of outputs and the actual costs of the DMU adjusted for TE. Economic efficiency (EE) also known as cost efficiency is the product of both TE and AE (Farrell, 1957) is the combination of technical and allocative efficiency which is described as the capability of a firm to produce a pre-determined quantity of output at a minimum cost for a given level of technology. EE is calculated by the ratio of least feasible costs and actual perceived costs for a DMU.

3.4.3. Stochastic Frontier Approach Production (SFA) and Data Envelopment Analysis (DEA)

Relative efficiency indices are estimated by the use of two approaches including the parametric or stochastic frontier production approach (SFA) and the non- parametric approach or DEA approach (Coelli,1995). The SFA assumes there is a functional relationship between inputs and outputs and uses statistical techniques to estimate parameters for the function and allows hypothesis testing.

According to Chavas and Aliber (1993), technical efficiency (TE) obtained through DEA its value ranges between 0 and 1. When TE is equal to 1, the DMU is said to be technically efficient. The input – oriented DEA was used in this because the comparability of inputs in this study is higher than that of the output

Justification of Approach Selected

The two approaches differ because of the disadvantage of SFA of imposing specific assumptions on both frontier functional form and disturbance term. In contrary, the DEA uses linear programming methods to construct a hybrid frontier of data. DEA does is less sensitive to misspecification compared to SFA. Both methods seem to achieve the relatively same results as most studies cant seems to make any conclusion on which method is superior above the other. This study opted to use DEA, because it does not require or imposes a priori parametric constraint on the fundamental technology

3.4.3.1. DEA Model Specification

This study only estimated TE, AE and EE efficiency score for cowpea production in Capricorn and Waterberg Districts of Limpopo province. The DEA specified model for these efficiencies are;

(i) Technical Efficiency(TE)

(1) $$TE_n = \frac{min\ \theta_n}{\lambda_i\ \theta_n}$$

Subject to:

$$\sum_{i=1}^{I} \lambda_i\, x_{ij} - \theta_n x_{nj} \leq 0$$

$$\sum_{i=1}^{I} \lambda_i\, y_{ik} - \theta_n x_{nk} \geq 0$$

$$\sum_{i=1}^{I} \lambda_i\ = 1$$

$$\lambda_i \geq 0$$

$Where\ i = One\ to\ I\ cowpea\ farmer$;

$J = one\ to\ J\ inputs$;

$k = one\ to\ K\ outputs$;

$\lambda = the\ negative\ weights\ for\ I\ cowpea\ farmer$;

$x_{ij} = the\ amount\ of\ input\ j\ used\ by\ cowpea\ farmer\ \ i$;

$x_{nj} = the\ amount\ of\ input\ j\ used\ by\ cowpea\ farmer\ n$;

$y_{ik} = the\ amount\ of\ output\ k\ produced\ by\ cowpea\ farmer\ \ i$;

$y_{nk} = the\ amount\ of\ output\ k\ produced\ by\ cowpea\ farmer\ n$; and

$\theta_n = a\ scalar\ \leq one\ that\ defines\ the\ TE\ of\ cowpea\ farmer\ n,$

$with\ a\ value\ of\ indicating\ a\ technically\ inefficient\ fcowpea\ farmer$

$with\ the\ level\ of\ technical\ inefficiency\ equal\ to\ 1 -\ TE_n. (Coelli, 1995)$

The constraint $\sum_{i=1}^{I} \lambda_i\ = 1$ in eq (1) ensures that TE_n is computed under the Variable Returns to Scale (VRS) assumption (Coelli,1995)

(ii) Economic Efficiency (EE)

The economic efficiency (EE) score for a given cowpea farmer is given by first solving this cost-minimizing LP – model;

$$(2) \qquad MC_n = min\ \lambda_i\ x^*{}_{ij} \sum_{J=1}^{J} P_{nj}\ x^*{}_{nj}$$

Subject to:

$$\sum_{i=1}^{j} \lambda_i x_{ij} - x^*{}_{nj} \leq 0$$

$$\sum_{i=1}^{I} \lambda_i y_{ik} - y_{nk} \geq 0$$

$$\sum_{i=1}^{I} \lambda_i\ = 1$$

$$\lambda_i \geq 0$$

$Where\ MC_n = the\ minimum\ total\ cost\ incured\ by\ cowpea\ farmer\ \ n;$

$P_{nj}\ = price\ of\ inputs\ j\ purchased\ by\ cowpea\ farmer\ n$;

$x^{*}{}_{nj} = cost - minimizing\ level\ of\ input\ j\ incured$

$by\ cowpea\ farmer\ n\ given\ its\ input\ price\ and\ output\ levels$

The constraint $\sum_{i=1}^{I} \lambda_i\ = 1$ in *eq. (2)* ensures that the minimum total costs incurred by cowpea farmer are computed under the VRS assumption (Fletscher and Zepeda, 2002). The Economic Efficiency is given by the following equation:

$$(3) \qquad EE_n = \frac{\sum_{J=1}^{J} P_{nj}\, x^{*}{}_{nj}}{\sum_{J=1}^{J} P_{nj}\, x_{nj}}$$

Where $\sum_{J=1}^{J} P_{nj}\, x^{*}{}_{nj} = the\ minimum\ total\ cost\ attained\ by\ cowpea\ farmer\ \ using\ eq\ (2)$

and $\sum_{J=1}^{J} P_{nj}\, x_{nj} = the\ actual\ total\ cost\ observed\ by\ cowpea\ farmer\ \ n.$

The EE_n that takes value on a value $\leq$ 1, with an $EE_n\ = 1$ indicates that the cowpea farmer is economically efficient.

$EE_n < 1$ indicates that the cowpea farmer is economically inefficient with the level of economic efficiency = $1 - EE_n$

According to Farrell (1957), the EE for a DMU can also be expressed as the product of both TE and AE ($EE_n = TE_n\ \times\ AE_n$*).*

(iii) Allocative Efficiency (AE)

$$(4) \qquad AE_n\ = \frac{EE_n}{TE_n}$$

Where $AE_n\ is\ the\ allocative\ efficiency\ given\ by\ diving\ EE_n\ by\ TE_n$*.The* value for AE_n will be $\leq$ 1 with an AE_n = *1* indicates that the cowpea farmer is allocatively efficient and an AE_n *<1* indicates that the cowpea farmer is allocatively inefficient with the level of allocative inefficient = $1 - AE_n$. The efficiency score computed using DEA is expressed as follows:

$y_i = 1 \ if \ y_i^* \geq 1$

$y_i = y_i^* \ if \ 0 \ \leq y_i^* \leq 1$

$y_i = 0 \ if \ y_i^* \leq 0$

3.4.4. Tobit Regression Model

The Tobit regression or censored model was used to address objective (iii) of the study which was to determine the factors that attributes to technical, allocative and economic efficiency among smallholder cowpea farmers in the study area. Tobit regression was first initiated by Tobin (1958) involving a censored regression model of the economy and first analysed in the econometric literature. As the efficiency index derived from data envelopment analysis is bound between 0 and 1 value, thus it is suitable for use as a simulation analysis to identify the determinant of technical efficiency among farmers. A two limit Tobit model was used in this analysis because the scores were bound between 0 and 1, (Maddala,1983). Briefly, Tobit's regression can be written as follows:

$$y_i^* = \beta_0 + \sum_{m}^{M} \beta_m \, x_{im} + \varepsilon_i, \varepsilon_i \sim IN(0, \sigma^2)$$

Where $y_i^* a \ latent \ variable \ symbolizing \ the \ efficiency \ score \ for \ the \ cowpea \ farmer \ i$;

$\beta_0 \ and \ \ \beta_m = unknown \ parametres \ to \ estimate$;

$x_{im} = 1 \ to \ M \ explanatory \ field \ specific \ variables \ related \ with \ the \ cowpea \ farmer$;

$\varepsilon_i = error \ term \ that \ is \ autonomously \ and \ normally \ distributed$

$with \ zero \ mean \ and \ constant \ varience \ \sigma^2.$

Table 3.1 Definition of variables

Dependent Variable	Description	Measurement
Efficiency	Economic, Technical and Allocative	Number
Explanatory variables		
Gender (X_1)	Age of the farmer	1 = Female; 0= Non-Female
Age (X_2)	Years lived by the farmer	Number of years
Household Size (X_3)	Family members living with the farmer	Number of people
Marital status(X_4)	Farmer`s marital status	1 = Married, 0= Non- Married
Educational level (X_5)	The grade accomplished by the farmer	1= Primary school, Non-primary school
Years of Schooling(X_6)	The years a farmer spent schooling	Number of years
Primary Economic Activity (X_7)	The main economic activity	1 = Full time farmer, 0=Non-full time farmer
Primary Income Source (X_8)	The main source of income	1 = Farming, 0=Non Farming
Status of Land Ownership (X_9)	Land ownership	1= Own Land, 0= Non-Land Owning
Farm Size(X_{10})	The size of land owned by the farmer	Hectares
Income Earned from cowpea(X_{11})	The income earned from selling cowpeas	Rands
Method of intercropping(X_{12})	The method that farmer uses to plant	1=Strip Intercropping, 0=Non-stripping intercropping
Source of Field Labour (X_{14})	The labour used for production	1 = Family members, 0 = Non-family members
Working Hours per Day(X_{15})	The hours spent in the field in a day	Number of hours
Farm Workers Income(X_{16})	The amount the farm workers earn in a month (Rands)	Amount in Rands
Aggregated Agri-chemical costs (X_{17})	Aggregated amount of money spent on Pesticides used during production	Cost in Rands
PAN311 Seed Cost (X_{18})	The amount of money spent on purchasing the modified cowpea seed (Rands)	Amount in Rands
Experience in farming (X_{19})	The years which the farmer has been involved in farming	Number of years

Table 3.2 Description of hypothesized effect of independent variables on economic efficiency of cowpea production

Dependent Variable	Description & Measurement	Expected Sign
Efficiency	Economic, Technical and Allocative	+/-
Explanatory variables		
Gender (X_1)	Age of the farmer (Male or Female)	+/-
Age (X_2)	Years lived by the farmer (Number of years)	-
Household Size (X_3)	Family members living with the farmer (Number of people)	-
Marital status(X_4)	Farmer`s marital status (Married, not married, separated or divorced)	+
Educational level (X_5)	The grade accomplished by the farmer (not attended school, primary school, secondary school or tertiary level)	-
Years of Schooling(X_6)	The years a farmer spent schooling (Number of years)	+
Primary Economic Activity (X_7)	The main economic activity (full time farmer, part-time farmer, government employee, private sector employee, self-employed or unemployed)	+
Primary Income Source (X_8)	The main source of income (farming, Pension, salary, wage or social grants)	+
Status of Land Ownership (X_9)	Land ownership (Inherited, Communal, Leased, bought or granted by the chief)	-
Farm Size(X_{10})	The size of land owned by the farmer (Hectares)	+
Income Earned from cowpea(X_{11})	The income earned from selling cowpea (Rands)	+/-
Method of intercropping(X_{12})	The method that farmers uses to plant (broadcasting, strip – intercropping, mono – cropping or mixed cropping)	-
Purpose of Growing Cowpea(X_{13})	Reasons for planting cowpea in the field (household consumption, income generation, livestock feed, manure or soil covering)	+
Source of Field Labour (X_{14})	The labour used for production (family members, full time members or part – time workers)	+
Working Hours per Day(X_{15})	The hours spent in the field in a day (number of hours)	+
Farm Workers Income(X_{16})	The amount the farm workers earn in a month (Rands)	-
Aggregated Agri-chemical costs (X_{17})	Aggregated amount of money spent on Pesticides used during production	-
PAN311 Seed Cost (X_{18})	The amount of money spent on purchasing the modified cowpea seed (Rands)	-
Experience in farming (X_{19})	The years which the farmer has been involved in farming	+

3.5. LIMITATIONS OF THE STUDY

Financial constraints made it challenging for the author to carry out visits to farmers fields during the production periods. The author targeted farmers gatherings and agricultural events to carryout data collection to bridge the gap of financial constraints. The drought tolerant PAN 311 cowpea seed is currently unavailable on the market, this posing a challenge for farmers who may need it. The university of Limpopo in 2015 performed a seed multiplication process to ensure that the farmers purchase the seeds easily and affordably. The 2015 drought had a negative impact on the study as farmers were unable to plant due to lack of rain. The author had to conduct data collection in the year 2016 following a short rainfall season. A challenge was encountered during sampling due to unavailability of information on the actual size of the population in the sampling area.

CHAPTER FOUR: DATA ANALYSIS, RESULTS AND DISCUSSION

4.1. INTRODUCTION

The aim of the study was to examine economic efficiency of cowpea production among smallholder cowpea farmers in Capricorn and Waterberg districts of Limpopo province. The study used descriptive statistics, DEA and Tobit regression models to address the objective. The specific objectives of the study were to identify and describe the socioeconomic characteristics of smallholder cowpea farmers and examine the determinants of economic efficiency of cowpea production in the study area.

4.2. DESCRIPTIVE ANALYSIS RESULTS

Table 4.1. Socio-economic characteristics of cowpea smallholder farmers in Waterberg and Capricorn Districts

Variable	Minimum	Maximum	Mean	Std. Deviation
Age of the Farmer	33	78	61.20	11.327
Household Size	2	14	6.87	2.548
Years of Schooling	0	13	5.44	3.905
Years involved in Farming	3	58	37.53	12.580
Agricultural Income per Month	R650.00	R3500.00	R1735.833	R694.8413

Source: Computed by author from survey data (2017)

The table 4.1 indicates the socio-economic characteristics of the cowpea smallholder farmers interviewed in the study. The characteristics were age, gender, years of schooling, primary source of income and primary activity of the farmer. The study revealed that the age of the farmers ranged between the age of 33 and 78, the average age of the farmers was 61 years old. The household sizes of the farmers in the study area were found to range between 2 and 14, with an average of 9 family members per household. The study further indicated that interviewed farmers ranged from zero to 13 years of schooling, with an average of five years of attending school. On average, in this study cowpea smallholder farmers were revealed to have been involved in farming for more than 38 years, with the range between three to 58 years. The average income they received from the overall agricultural produce is R1735.83.

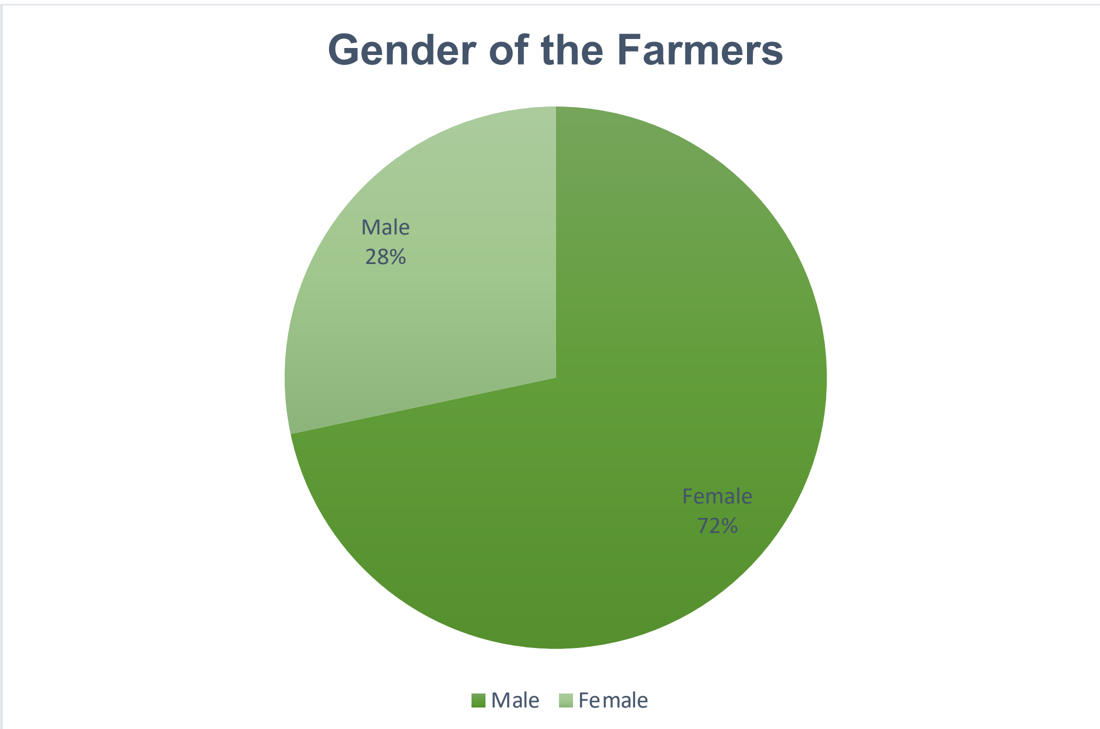

Figure 4.1 Gender of farmers

Source: Computed by author from survey data (2017)

In order to address gender inequality in agriculture there is a need to account for different roles of both men and women, this will assist in resource distribution and establishment of programmes (Gender in Agriculture Sourcebook,2009). The sourcebook further states that gender inequalities is a constraint to agricultural productivity and efficiency. According to FAO Agricultural Development Economics (2011), Women in Sub-Sahara African countries provides

60 -80% of the agriculture labour to produce food for household consumption and income. The gender of the cowpea smallholder farmers was distinguished in two categories, female and male. In both districts, the study found that female smallholder farmers were dominant over the male smallholder farmers with 72% of the farmers in the study area being female and 28% being male farmers. The female farmers were more due to that most of the households were female headed and the population female famers is greater than that of male farmers.

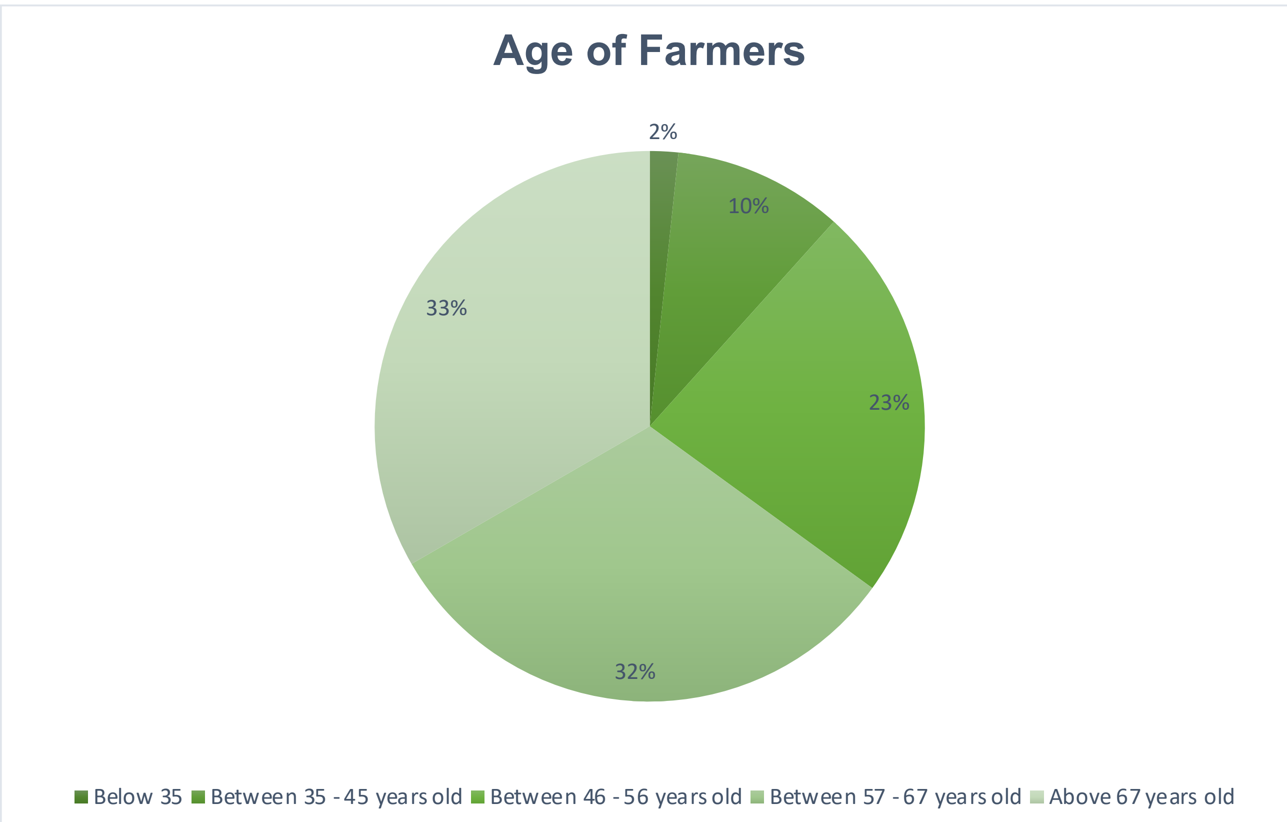

Figure 4.2 Age of farmers

Source: Computed by author from survey data (2017)

Age of the cowpea smallholder farmer was considered as one of the key socio-economic factors influencing efficiency in producing cowpea. Figure 4.2 stipulates the years farmers in the study area have been involved in farming. As indicated on the chart above, out of the 60 interviewed farmers, 2% were of the ages below 35, 10% were between 35 and 45 years of age, those who were between 46 and 56 years old constituted to 23%. On average age of the cowpea smallholder farmer in the study area was 62 years the two largest age groups of farmers were discovered to be between the ages of 57 and 67 and from 67 years and above. Most of the famers were above 50 years of age because the youth lack interest in farming hence the broader gap in between ages of farmers.

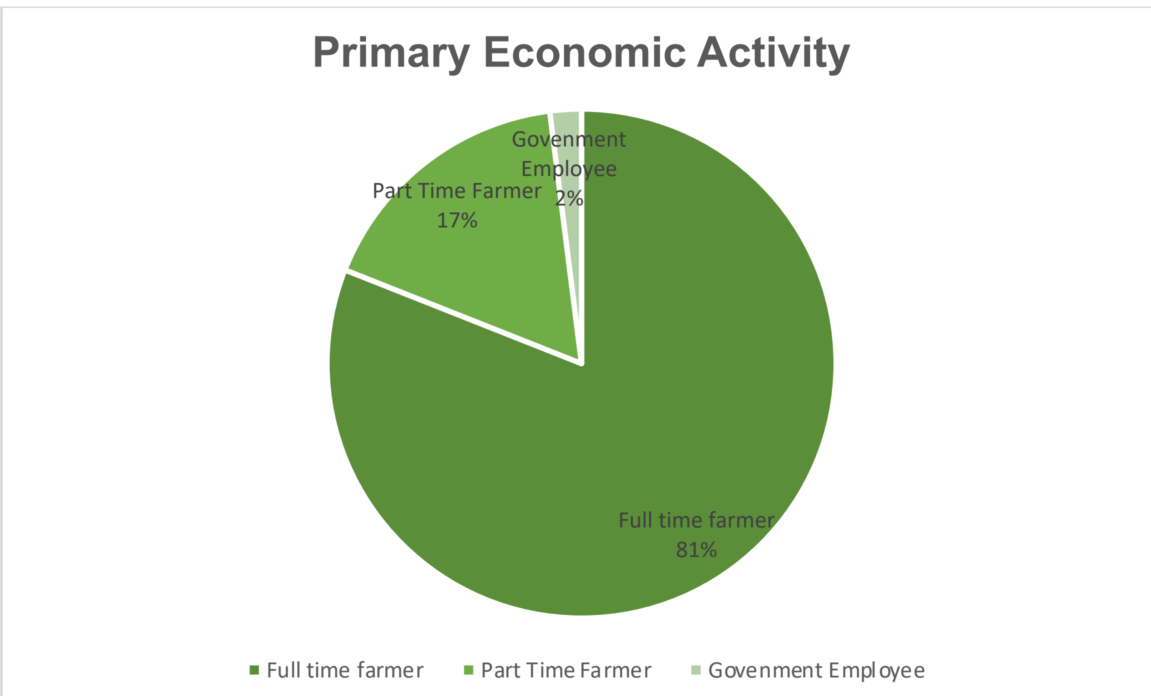

Figure 4.3 Primary economic activity

Source: Computed by author from survey data (2017)

The primary economic activity was defined at the most important activity that the smallholder farmer is involved in on daily basis. The primary economic activity variable was divided into three categories, namely; full time farmer who are fully operating in the farm and not involved in other activities, part time farmer who works part time in the farm and have other additional activities that they are involved in and lastly it was government employee, these were farmers who are owners of the land and leave their family members work in the farms while they work in government institutions. Figure 4.3 above, shows that 81% of the farmers interviewed were full time farmers, 17% were part –time farmers and 2% were fully employed as government employees who own farms and have their family members fully operating in their farms.

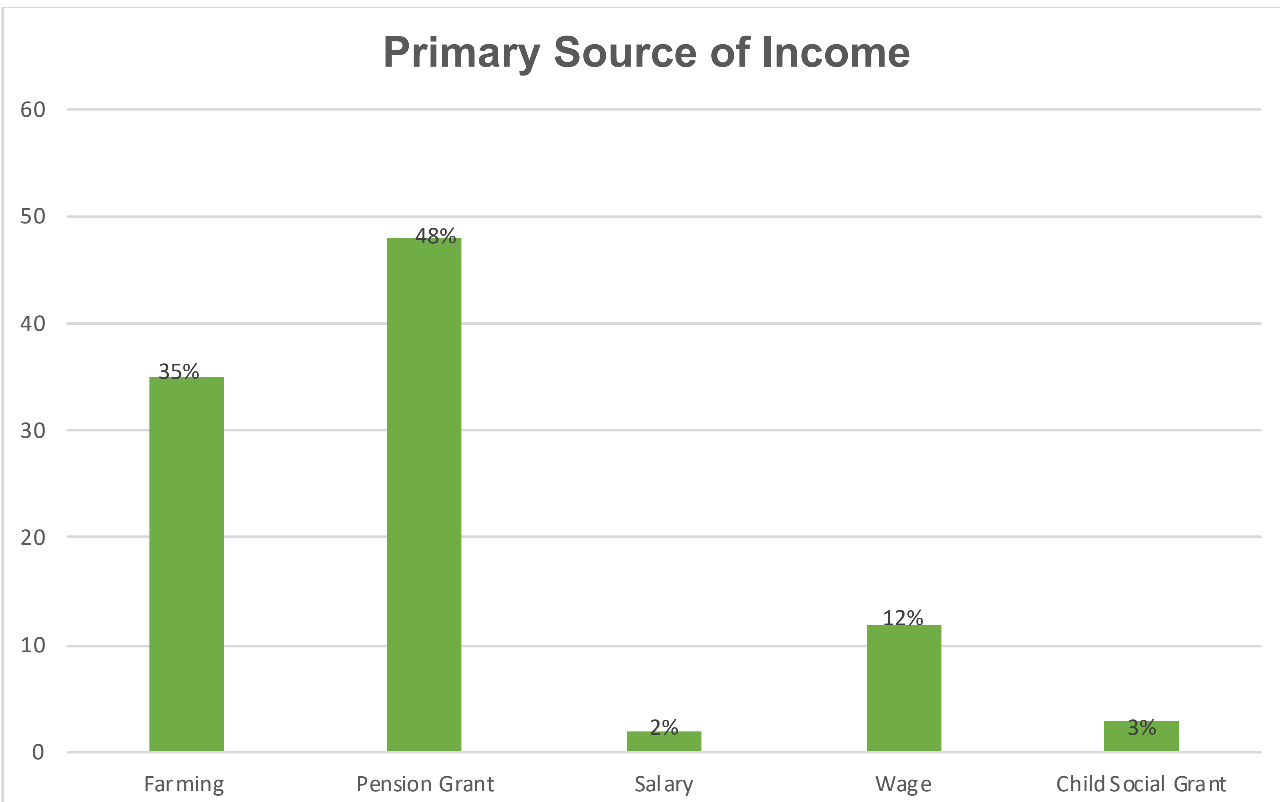

Figure 4.4 Primary source of income

Source: Computed by author from survey data (2017)

Primary source of income was an important variable of the study as it indicated the main source of income for the cowpea smallholder farmers in the study area. It was defined as the main source of income for cowpea smallholder farmers in the study area. There were five categories, namely; farming, pension grant, salary, wage and child social grant. Pension grant was revealed to have been the main source of income with 48% followed by farming with 35%, wage (12%), child social grant (3%) and salary being the least with (2%).The pension grants recipients were farmers who received grants from the government to sustain themselves. Pension grant was the highest as it is assumed that most farmers who are pension fund recipients used the money to also assist them in maintaining their agricultural production .

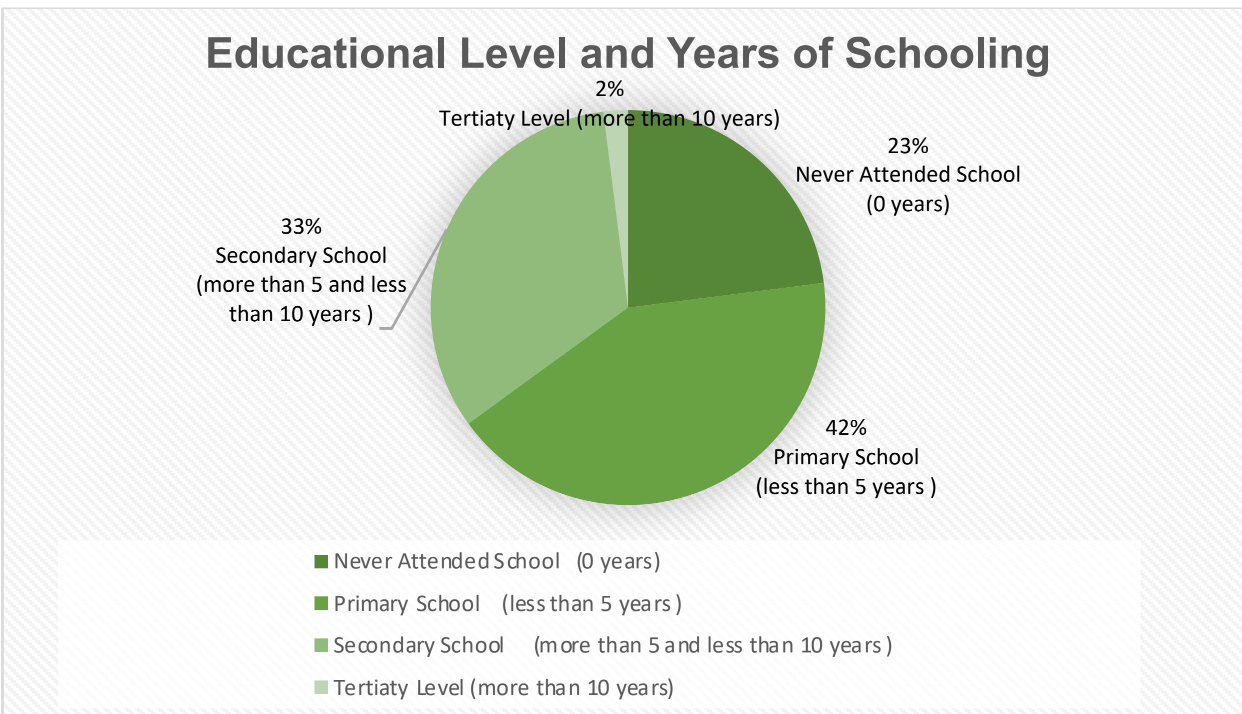

Figure 4.5 Level of education

Source: Computed by author from survey data (2017)

The educational level variable was divided into four categories, namely, never attended school, attended primary school, secondary school and tertiary school, whilst the years of schooling was defined as the number of years a farmer attended school. Figure 4.5, showed that 23% never attended school, 42% of the farmers attended primary school,33% secondary school and 2% attained tertiary education. This indicates that of the farmers interviewed 77% of the farmers went to school and were able to read and write (basic literacy). These results show that the majority of the cowpea farmers in Waterberg and Capricorn Districts are not entirely learned and lack some form of proper formal education. The level of education is high because the farmers in this study are mostly those that went to school during the time of apartheid and were privileged to acquire bantu education.

4.3. DATA ENVELOPMENT ANALYSIS RESULTS

The study used the Data Envelopment Analysis Programme (DEAP) to determine the Technical, Allocative and Economic Efficiency scores of the cowpea smallholder farmers. Table 4.2 is an overall summary of the outputs obtained from the utilization of the inputs (Cowpea seed, dual herbicide, Round-Up herbicide, Cypermetrin pesticide, Labour hours and farm size) and the cost of each output.

Table 4.2. Output, Input and Prices Summary Statistics used in DEA

Variable	*Mean*	Std. Dev	*Min.*	*Max.*
Output(Yield)				
Cowpea Bags (tons)	*3.852*	*2.065*	*1.874*	*8.509*
Inputs				
Cowpea Seed Bags (Kg)	*2.24*	*2.483*	*1*	*15*
Dual Herbicide (ml)	*1243.33*	*569.379*	*600*	*2800*
Round-Up Herbicide (ml)	*5714.83*	*2604.234*	*2700*	*12830*
Cypermetrin Pesticide (ml)	*1865.00*	*854.068*	*900*	*4200*
Aphox Pesticide (ml)	*982.50*	*444.822*	*450*	*2100*
Labour Hours (Day)	*5.45*	*.910*	*3*	*7*
Farm Size(Hectares)	*16458.3333*	*7595.32175*	*7500.00*	*35000.00*
Input Prices				
Cowpea Seed Cost (500g)	*41.77*	*6.863*	*30*	*50*
Dual Herbicide Cost (L)	*183.6167*	*5.09600*	*168.00*	*198.00*
Round- Up Herbicide Cost (L)	*198.0000*	*.00000*	*198.00*	*198.00*
Cypermetrin Pesticide Cost (ml)	*138.0000*	*.00000*	*138.00*	*138.00*
Cost of Labour (month)	*219.67*	*82.256*	*130*	*400*
Aphox Pesticide cost (ml)	*137.600*	*4.9273*	*120.0*	*145.0*

Source: Computed by author from survey data (2017)

4.3.1. Inputs in quantities

Table 4.2 above shows that on average, 2.24 kg of cowpea PAN311 seeds were used in the production of cowpea. This implies that the small-holder cowpea farmers in Capricorn and Waterberg districts of Limpopo province are utilizing over 2.24 kg of seed on a hectare of land. The 2.24 kg can produce approximately 4 tons of cowpeas. PAN311 cowpea seed showed that it has high yield, the minimum cowpea bags harvested was 2 tons per production season. For weed control famers applied dual and round up herbicides, on average they used 1243.33 ml and 5714.83 ml respectively per season.

Farmers in this study did not apply fertilizers in their field. Cowpeas are prone to aphids, the farmers applied Cypermetrin and Aphox to control aphids. For aphid control, a farmer would on average apply 1865.00ml of Cypermetrin and 982.50ml of Aphox per hectare, per season. Labour is one of the crucial inputs in cowpea production. For high and good quality cowpea yield, labourers need to spend at least 5 hours a day in the field.

4.3.2. Costs of Inputs

The average cost of the PAN 311 cowpea variety was R41.77 per 500g. For a farmer to produce on a hectare of land, a minimum of a 500g packet of cowpeas in needed. On average, the cost of dual and roundup herbicides amounted to R183.6167 per litre and R198.00 per litre respectively. The farmers pay the labourers an average of R219 per month irrespective of the days that the labourer worked in the field. The field workers are paid monthly during the production season. Each litre of Cypermetrin and Aphox for the control of aphids, costed the farmer 137.60. It was found that on average, expenses per hectare were about R918.65.

Table 4.3 Efficiency Score Summary of Waterberg and Capricorn District Cowpea Smallholder Farmers

Variable	*Mean*	*Std.Dev*	*Min.*	*Max.*
TE	*.9588333*	*.0698566*	*.75*	*1*
AE	*.65195*	*.188587*	*.407*	*1*
EE	*.6218167*	*.1750136*	*.382*	*1*

Source: Computed by author from survey data (2017)

The results of the study showed that the TE scores of cowpea farmers had a mean of 0,9588 with a minimum of 0,7500 and maximum of 1,000. This means that 95% of the farmers were technically efficient and that the farmers were able to produce over 75% of the maximum feasible output. The Allocative Efficiency score ranges from a minimum of 0,4070 and a maximum of 1,000 with a mean of 0,6519. The AE scores implies that farmers are not utilizing inputs given the input price and average costs. Given the current prices of inputs, average costs may be reduced by almost 35% to obtain the same level of output. These results concur with the results obtained by Brandley et.al (2014), that indicated a technical score that ranges from 0.440 to 1 and an allocative score that ranges from 0,332 to 1.

The Economic Efficiency scores ranges from a minimum of 0,3820 to 1,000 with a mean score of 0,6218. The implications are that cowpea smallholder farmers were economically inefficient on average and that the cost of cowpea production for each farm could be decreased on average by approximately 38% to obtain the same level of output. These results concur with the results obtained by Brandley et.al (2014), that indicated an economic score that ranges from 0,29 to 1.

4.4. TOBIT REGRESSION MODEL RESULTS

The explanatory variables used in the Tobit regression model are Gender, Age, Household Size, Marital status, Educational level, Years of Schooling, Primary Economic Activity, Primary Income Source, Experience in farming ,Status of Land Ownership, Farm Size, Income Earned from cowpea, Method of intercropping, Source of Field Labour, Working Hours per Day, Farm Workers Income, Aggregated Agri-chemical costs PAN311 Seed Costs and experience in farming.

Table 4.4. Technical Efficiency Tobit Analysis Results

Technical Efficiency	*Coef.*	*Std. Err.*	*t*	*P>|t|*
Gender	*-.0001354*	*.0006643*	*2.11*	*0.041****
Age	*-.0107634*	*.0061515*	*-1.75*	*0.088**
Educational Level				
Never attended school	*-.1705851*	*.0743186*	*-2.30*	*0.027***
Primary Source of Income				
Pension Grant	*.4370177*	*.142945*	*3.06*	*0.004***
Wage	*-.2808479*	*.1232637*	*-2.28*	*0.028***
Experience in farming	*.3786064*	*.1074765*	*3.52*	*0.001****

****1%, ** 5% and *10% significance levels*

Source: Computed by author from survey data (2017)

Table 4.4. represents the technical efficiency results of the study. Out of the 18 explanatory variables, five were found to be statistically significant at different levels. The variables which were found to be significant were Age, Educational level, Primary Income Source, Farm Size, Method of intercropping and Source of Field Labour.

4.4.1. Sources of technical efficiency in cowpea production

Gender of the farmers

Table 4.4 indicates that gender of the farmer negatively affects the technical efficiency of the cowpea producers in the study area. Gender of the farmer was found to be statistically significant at 5% significance level with a negative coefficient of .0001. This study disagrees with the results of the study conducted by Baloyi (2011) which indicated that gender was non-significant to technical efficiency of farmers.

Age of the farmers

Age of the cowpea smallholder farmers was considered as one of the explanatory variables influencing technical efficiency in cowpea production in the study area. The age of the farmer was found to be significant at 10% level, with a negative coefficient of -0.0107. This explains that age of the farmer negatively affects technical efficiency of the farmer's cowpea production. This could mean that aged farmers are inactive to undertake farm activities. Furthermore, age is indirectly proportional to the productivity in cowpea production. This study disagrees with the results of the study conducted by Baloyi (2011) which found that gender was non-significantly related to efficiency of farmers.

Educational Level

The farmers' level of education, particularly the category of those who never went to school was found to be having a negative relationship with technical efficiency with a coefficient of -0.175

and a significance level of 5%. This explains that the farmers who never attended school were found to be technically inefficient. This implied that as farmers get education, they tend to have better understanding of efficiency in production. This study concurs with the results of the study conducted by Nchare (2007) which indicated that educational level was the main variable influencing the technical efficiency level and was a significant variable.

Primary Source of Income

Based on the descriptive analysis of this study, most of the farmers were found to be recipients of the pension grant from the social development department of South Africa. The pension grant was one of the categories of source of income which were found to have a positive relationship with technical efficiency with a coefficient of 0.4370. This justifies that most of the farmers who are grant recipients use the money they receive to sustain their cowpea production expenses. The farmers who receive wages from undertaking different jobs were found to have a negative relationship with technical efficiency with a coefficient of -.2808. It was significant at 5%. This implied a positive relationship between off-farm income and the technical efficiency levels of the farmers. These results are contrary to the study conducted by Ndjodhi (2016) that stated that off-farm income showed a positive sign.

Experience in Farming

The results in Table 4.4 above indicates that experience is a significant at 1% with a positive coefficient of 0.3786. It is assumed that more the farmer gains experience in farming, the more the efficiency level is likely to increase. The results concur with the study of Mokgalabone (2015) who found a positive relationship between experience in farming and efficiency in production.

Table 4.5. Allocative Efficiency Tobit Analysis

Allocative Efficiency	*Coe..*	*Std. Err.*	*t*	*P>|t|*
Farm Size	*.0001436*	*.0001213*	*2.05*	*0.047***
Source of Field Labour *Part time workers*	.0002487	.0000798	- 0.24	0.010**
Income Earned from Cowpea	.00883408	.2514498	2.38	0.023**
Methods of intercropping *planting in rows*	.0005865	.0005133	2.09	0.030**

***1%, ** 5% and *10% significance levels

Source: Computed by author from survey data (2017)

Table 4.5. represents the technical efficiency results of the study. Out of the 19 explanatory variables, five were found to be statistically significant at different levels. The variables which were found to be significant were farm size, source of field labour, income earned from cowpea and method of intercropping.

4.4.2. Sources of allocative efficiency in cowpea production

Farm Size

There is a positive relationship between farm size and levels of production. Therefore, farm size was found to be one of the explanatory variables that influence technical efficiency in cowpea production. It was found to be significant at 5% level, with a positive coefficient of 0.001. This implies that the size of the farm has an impact on the production levels of cowpea farmers. A study conducted by Dipeolu and Akinbode (2008), indicated that farm size was found to have a significant contribution on allocative efficiency of farmers.

Source of Field Labour

The source of field Labour is one of the variables that is expected to improve the production of cowpea. The source of labour was categorized into three, full-time workers, part time workers and family labour. The farm part time workers were found to be significant 5% with a negative coefficient of 0,002. The results of this study show that the employment of part-time workers negatively affects the allocative efficiency of cowpea farmers. This concurs with the results of the study conducted by Baloyi (2011) which indicated that labour was non-significant to efficiency of farmers.

Income Earned from cowpea

The results in table 4.5 above revealed that income earned from selling cowpea positively related to allocative efficiency at the 5% level with A positive coefficient of 0.008. This implies that when the income earned from selling cowpea increases, the level of allocative efficiency is likely to increase. These results concur with the study conducted by Ndjodhi (2016) that stated that income showed a positive sign and is significant at 5% level.

Method of Intercropping

Planting for optimum cowpea yield comes as a result of planting methods. The cowpea has the ability to fix nitrogen in the soil making the field fertile for the crops either planted after cowpea or intercropped with cowpea. One can plant cowpea in three ways, broadcasting, mixed cropping or planting in rows. Farmers who planted in rows yielded more cowpeas than those that used mixed cropping or broadcasted the seed during planting. Planting in rows was found to be significant at 5% with a positive efficient of 0,005. These findings concur with the study conducted by Mustapha and Salihu (2015), that revealed that the mean technical efficiency of the farmers was 0.84 indicating that the women farmers are relatively efficient in maize/cowpea intercropping.

Table 4.6. Economic Efficiency Tobit Analysis

Economic Efficiency	Coef.	Std. Err.	t	P>t
Age	-.021559	.005873	3.67	0.001***
Education Level				
Primary school	.6266844	.2664316	2.35	0.025**
Primary Source of Income				
Pension Grant	.2414884	.1037099	-2.33	0.026**
Child Grant	.5983408	.2514498	2.38	0.023**
Status of Land Ownership				
Granted by the Chief	.1335735	.0785524	1.70	0.008*

***1%, ** 5% and *10% significance levels

Source: Computed by author from survey data (2017)

The table 4.6 represents the technical efficiency results of the study. Out of the 19 explanatory variables, four were found to be statistically significant at different levels. The variables which were found to be significant were Age, Educational level, Primary Income Source, and status of land ownership.

4.4.3. Sources of economic efficiency in cowpea production

Age of the farmers

Age of the cowpea smallholder farmers was found to be one of the variables influencing economic efficiency of cowpea production in the study area. The results in table 4.6 shows that age is significant towards the economic efficiency of cowpea farmers at 1% with a negative coefficient of -0.021559. This explains that age of the farmer negatively affects economic efficiency of the farmers' cowpea production. As the farmers grow older their effectiveness in the field gradually decreases. This study disagrees with the results of the study conducted by Baloyi (2011) which found that gender was non-significantly related to efficiency of farmers.

Educational Level

Education is believed to have an impact in decision making and allocation of resources to maximize cowpea output. Educational level was defined by three levels: never went to school, primary level, secondary and tertiary level. The primary level was found to positively influence the economic efficiency in cowpea production in the study area. The results in table 4.6 show primary education to be significantly related to economic efficiency of cowpea farmers at 5% with a positive coefficient of 0.6266. This concurs with the study conducted by Mokgalabone (2015) who concluded that education level has a positive influence on efficiency of the farmer.

Primary Source of Income

The pension and child grants were some of the categories of source of income which were found to be have a positive relationship with economic efficiency with a coefficient of 0.2424 and 0.5983 respectively. This means that farmers who are grants beneficiaries use their grants to sustain their production expenses. Pension and child grants recipients were both significant at 5%. These results concur with the study conducted by Ndjodhi (2016) that stated that off-farm income showed a positive sign and is significant at 5 %. This implied a positive relationship between off-farm income and the technical efficiency levels of the farmers.

Status of Land Ownership

The status of land ownership was found to have a positive relationship with the economic efficiency level of the cowpea farmers. Land ownership was found to be significant at 11% level with a positive coefficient of 0.1335. Farmers that own land are more courageous to produce or practice farming since they don't acquire any expenses related to renting of land. Most of the farmers were granted the land by the chief that makes the land to be solely theirs and do not share as is done in communal lands. A study conducted by Mohamed Authayla (2012) concluded that a positive coefficient of land ownership variable means that land owners achieve more output as compared to land renters.

CHAPTER FIVE: SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1. INTRODUCTION

This chapter provides a summary of the study, conclusions obtained from the results of the study. It further outlines the key policy recommendations that are applicable to enhance the production and economic efficiency of cowpea smallholder farmers in Capricorn and Waterberg districts of Limpopo province.

5.2. SUMMARY OF THE STUDY

The comprehensive aim of the study was to examine economic efficiency of cowpea production among smallholder farmers in Capricorn and Waterberg Districts of Limpopo Province. The study used two techniques to analyse data, they are Data Envelopment Analysis (DEA) and Tobit regression model. DEA was used to was to explain technical, allocative and economic efficiency of cowpea farmers and also the socio-economic factors that attributes to inefficiency. The study also used descriptive statistics to describe socioeconomic characteristics of cowpea farmers in the study area.

The study used necessary official documents, statistics, data programmes as well as relevant literature to capture information on smallholder maize farmers in the two districts of Limpopo province. The theoretical literature reviewed in chapter two showed that there are few factors like age of the farmer, education level of the farmer and farm size, which affect the technical, allocative and economic efficiency level of cowpea farmers.

The DEA results of the study showed that the TE scores of cowpea farmers had a mean of 0,9588 with a minimum of 0,7500 and maximum of 1,000. This means that 95% of the farmers were technically efficient and that the farmers were able to produce over 75% of the maximum feasible output. The Allocative Efficiency scores range from a minimum of 0,4070 and a maximum of 1,000 with a mean of 0,6519. The AE scores imply that farmers are not utilizing inputs. Given the current prices of inputs, average costs may be reduced by almost 35% to obtain the same level of output. The Economic Efficiency scores range from a minimum of 0,3820 to 1,000 with a mean score of 0,6218. The implications are that cowpea smallholder farmers were economically inefficient on average and that the cost of cowpea production for each farm could be decreased on average by approximately 38% to obtain the same level of output.

5.3. CONCLUSION

The results of the study revealed that socioeconomic factors of cowpea smallholder farmers in Capricorn and Waterberg districts can be characterised by their gender, age, household size, years of schooling (level of education), years involved in farming (experience) and agricultural income. The study revealed that 72% of the cowpea smallholder farmers were female with 28% of the farmers in the study area being male. The study found that the age of the farmers ranged between the age of 33 and 78, the average age of the farmers was 61 years old.

The household sizes of the farmers in the study area were found to range between 2 and 14, with an average of 9 family members per household. The study further indicated that interviewed farmers ranged from zero to 13 years of schooling, with an average of five years of attending school. On average, in this study, cowpea smallholder farmers were revealed to have been involved in farming for more than 38 years, with the range between three to 58 years. The average income they received from the overall agricultural produce is R1735.83 per farmer.

The study also found that socioeconomic drew factors that attributes to economic efficiency were found to be age, educational level primary source of income and status of land ownership. The age of the farmers is significant towards the economic efficiency of cowpea farmers at 1% with a negative coefficient of -0.021559. The primary level was found to positively influence the economic efficiency at 5% with a positive coefficient of 0.6266 in the cowpea production in the study area. The pension and child grants were some of the categories of source of income which were found to have a positive relationship with economic efficiency with a coefficient of 0.2424 and 0.5983 respectively.

Based on the empirical results from the analysis, the study concludes that the cowpea smallholder farmers in Capricorn and Waterberg of Limpopo are economically inefficient and that the cost of cowpea production for each farm could be decreased on average by approximately 38% to obtain the same level of output.

5.4. RECOMMENDATIONS

The results of the study indicated that there are several factors that can be considered to contribute to inefficiency of the cowpea farmers. The farmers are technically efficient but allocative and economic inefficient in the cowpea production. There is a need to invest in resources that will ensure that there is an increase in production and sustainability. The farmers have the potential and ability to scale up their production levels and earn higher income from their production. The farmers prior to the study were using the indigenous knowledge of planting cowpeas leading to low production. The study recommends the following measures to improve efficiency in cowpea production in the study area;

- There is need to encourage young people and graduates to be more involved in farming, this is to ensure agricultural production improves because most of the farmers are old and unable to learn new ways of improving the production in agriculture. The age of the farmers negatively affects economic efficiency of the farmers' cowpea production., As the farmers grow older their effectiveness in the field gradually decreases.
- The primary level of education was found to positively influence the economic efficiency in cowpea production in the study area. There is need to provide primary education to the farmers for them to be able to measure and calculate the inputs they use and output they attain in order to improve their efficiency levels.
- The study further recommends that there should be continuous engagement of farmers with private and academic institutions on how best the farmers can improve their farming methods to be more efficient and effective in the agricultural sector, such as methods of planting cowpea especially measurements of the field when preparing to plant in rows to

enhance yield.

- Method of intercropping has an impact on cowpea yield, farmers who planted in rows yielded more cowpea than those that used mixed cropping or broadcasted the seed when they planted. Therefore, there is need to educate farmers on planting in rows to increase yield and improve efficiency.
- Ownership of land and the size of land that farmers cultivate cowpea is significant for allocative and economic efficiency. This means that they both have an impact on the agricultural crops that farmers choose to cultivate in their fields. There is a need to ensure that farmers own the land they practice agriculture on.

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ANNEXTURE A: QUESTIONNAIRE

University of Limpopo

Faculty of Science and Agriculture

School of Agricultural and Environmental Sciences

Department of Agricultural Economics and Animal Production

A survey on Determinants of Production Efficiency among Smallholder Cowpea Farmers in Limpopo Province

Please read the following statement carefully before completing the questionnaire.

The purpose of this questionnaire is to gather information on cowpea producers in the Limpopo Province. The information that will be provided is meant to address the inefficiency challenges in the production of cowpea in Limpopo Province. The project is a sub-project of The Water Research Commission. The information provided will be kept confidential and will only be used for the purpose of this research. The questionnaire is to be completed by farmers with the help of the enumerator. It is meant to generate information on Household characteristics of farmers, socio-economic characteristics, information on land ownership, agricultural crops production, Input usage and costs of cowpea production, Revenue and market, Farm Management and constraints. Please sign below on the space provided.

I agree to part take in this survey and I am aware that I do it on my free will.

Name: ______________________

Signature:______________________

Date: Section A – C: ______________________ Section D – F: ______________________

Enumerator: __________________

District: ______________________ Municipality: _________________

Place: ______________________

Section A: Socio-economic characteristics of farmers

1. Gender of farmer:		1= Female		2=Male	
2. Identity number:					
3. Age of farmer:					
4. What is the size of your household?		Total no:	1=Female	2=Male	
		Adults			
		Children			
5. Marital status:	1=Never Married	2= Married	3= Widowed	4= Divorced	5= Separated
6. What is your highest educational level?					
7. Years of Schooling :					
8. What is the primary economic activity of the household head?		1= full - time Farmer		2= part - time farmer	
		3=Self employed		4= part – time worker	
		5 = Private Sector employee		6 = Government employee	

	7 =Other, Specify:			
9. What is the primary source of household income?	1= farming	2= Pension	3=Salary	4= wage
	5= Social grants	5= Others, Specify:		
10. How many years have you been involved in farming?				

Section B: Information of Land Ownership

11. Do you have title deeds for your land ? *(Hint : Do you have ownership over your land)*	1= Yes 2=No		
12. If Yes, How long have you owned the land ?			
13. If No, Why don't you own the land ?			
14. What is the status of your ownership?	1 = Inherited	2= Leased	3= Communal
	4 = Renting	5= Granted by the chief	
	7 = Other, Specify:		
15. What is the size of your farm? (hectares)			
16. Did you register your land with the Dept. Of Agriculture ?	1= Yes 2=No		

Section C: Agricultural crops production

17. What are the crops that you produce annually?	1= Maize	2= Cowpea	3= Groundnuts	4= Sweet Sorghum
	5=Pumpkin	6= Potatoes	7= beans(Boncisi)	8= Butternuts
	9= Other, Specify			
18 . Which crops do you sell ?	1……………………4……………………7……………………………			
	2……………………5……………………8……………………………..			
	3……………………6……………………9……………………………			
19. Do you intercrop these crops ?	1= Yes	2= No		
20. Which method of intercropping do you use?	1= mono-cropping	2= broadcasting	3= Mixed cropping	
	5 = Others, Specify :			
21. What is your purpose of growing cowpea?	1=Household consumption	2= income generation		
	3= Livestock feed	4=Manure	5= soil covering	
	6= Other, Specify			
22. Estimation of you agricultural income(For crops sold) : R				

Section D: Input usage and costs of cowpea production

23. Do you produce cowpea?		1= Yes	2=No	
24. If yes, Which Cowpea Variety planted :				
25. How many hectares of your farm do you grow cowpea?				
26. Do you intercrop cowpea with other crops ?		1= Yes	2=No	
27. Which crop do you intercrop cowpea with ?				
28. Which method of intercropping do you use ?	1= broadcasting	2= strip intercropping	3= mono-cropping	
	4= Mixed cropping	5 = Others, Specify :		
29. If yes, Do you use the same inputs to produce these crops?		1=Yes	2=No	
30. How do you irrigate your crops?		1 = Rainfall	2 = Borehole	3= Dam
		4 = Tap water		
31. How much does a bag of cowpea cost ?		R		
32. How many bags of cowpea did you plant on your field ?		R		
33. Do you use agro –chemicals for cowpea production ?		1=Yes	2=No	
34. In the recent (2016) cowpea production have you used **Dual agro-chemical** in land preparation?		1 = Yes	2= No	
35. How much did Dual cost you ?		R		
36. How many litres do you buy per planting season ?				
37. In the recent (2016) cowpea production have you used **round – up agro - chemical** in land preparation?		1 = Yes	2= No	
38. How much did Round up cost you ?		R		

39. How many litres do you buy per planting season ?			
40. During land preparations, did you mix these agro chemicals (Dual and Round-up) with water ?	1=Yes	2=No	
41. If Yes to **Q.40** , how many litres of each ?	Water	Dual	Round – up
42. How many times did you spray the mixture in this recent planting session ?			
44. Is your Cowpea field affected by **Aphids** ?	1=Yes	2=No	
45. How do you control Aphids ?			
46. What agro – chemicals do you use to control Aphids ?			
47. How many litres of the agro chemical do you buy per planting season ?			
48. How much did the agro chemical cost you?			
49. How much of the agro chemical did you apply in this recent planting session?	Water	Agrochemical	
50.Do you work on the field by yourself ?	1= Yes	2=No	
51. If No, what is your source of labour ?	1 = Full – time workers 2= Family members 3 = part – time workers		
52. How many hours do they work per day /month?			
53. How much do full time workers earn per day/week/month?	R		
54. Do you apply other agro-chemicals?	1= Yes 2=No		

Section E: Revenue and market

55. How many bags of cowpea did you harvest in the recent harvest season?			
56. Did you sell cowpea in the recent production?	1= Yes	2=No	
57. If No to **Q.56**, why didn`t you sell?			
58. If yes to **Q.56**, How many bags of cowpea were sold in the previous production?			
59. How much income did you realize in the previous cowpea production? R			
60. Where was the harvested cowpea sold?	1= Local market	2= Town	4= provincial market
	4 = Streets around the Village	5= Other, Specify:	
61. How many kilometres did you travel to the market?			
62. How do you transport your cowpea to your market ?	1= Own transport	2= rent transport	3= walk
	4= Others, Specify:		

Section F: Farm Management and constraints

63. Do you have access to credit? 1 = Yes 2=No	
64 If Yes to **Q.63** Who provides credit?	1= Commercial Banks 2= cooperatives 3= family members 4= Illegal Money lander 5= Government institutions 6= Others, Specify:

65. Do you have access to extension services? 1 = Yes 2=No				
66. If Yes to **Q.65** Who provides extension services	1= Government extension officers			
	2= Private Organization officers			
	3=University of Limpopo			
	4= Others, Specify:			
67. If Yes to **Q.65** What kind of extension service?	1= Cowpea planting techniques			2= weeds control
	3= Cowpea Marketing			4= Cowpea cooking skills
	5= Production efficiency			6=Record keeping
	7= Farm management			8 = Others, Specify
68. If Yes to **Q.65**, how often do you get the extension service	6 = Other, Specify:			
69. Do you think you producing at minimum cost?	1= Yes 2=No			
70. How do you purchase inputs for the production?	1= purchase in Bulk		2= purchase one input at a time	
	3= Purchase inputs on discounts			6 = Other, Specify:
71. Has the recent drought in South Africa affect your crop production?	1= Yes	2= No		
72. Describe the effect of the recent drought (2015/2016) had on your agricultural production ……… ………………………				

…… ……………………….   …… ………………………   …… ……………………….   …… ……………………….
73. What are the lessons you've learnt about Cowpea?   …… ………………………   …… …………………….....   …… ………………………   …… ………………………   …… ………………………

74. Would you recommend to other farmers that they prioritize Cowpea? 1=Yes 2=No

75. If Yes to **Q.74,** What are the benefits of cowpea have you recently realized?

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76. In your previous planting seasons, did you use the broadcasting method to plant cowpea? 1=Yes 2=No

77. Which one was the highest yield? 1 = current 2= previous

78. How much was the yield in the previous season?

79. Will you still continue to broadcast cowpea in the coming planting seasons? 1=Yes 2=No

80. explain your answer in Q.79 …… …… …… …… ……
81. What are the reasons of you producing inefficiently? …… ……….. ………..

…….. ………..
82. What are do you suggest should be done to reduce production inefficiency? …….. …….. ……… ……… ………
83. What do you suggest should be done to improve the production of cowpeas? …….. ………

………
…………………………

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…………………………

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…………………………

THANK YOU SO MUCH FOR YOUR TIME & PARTICIPATION!

ANNEXTURE B: EFFICIENCY RESULTS

Technical Efficiency Results

TE |	*Coef.*	*Std. Err.*	*t*	*P>|t|*	*[95% Conf. Interval]*
2.X_1	-.001354	.000643	2.11	0,041	-.0491236 .1823755
X_2	-.0107634	.0061515	-1.75	0.088	-.023196 .0016693
X_3	-.0019781	.0095766	-0.21	0.837	-.0213331 .0173769
X_4					
2	.0567376	.180532	0.31	0.755	-.3081312 .4216064
3	-.0161282	.1896075	-0.09	0.933	-.3993393 .3670828
5	.0393236	.2085324	0.19	0.851	-.382136 .4607832
X_5					
2	-.1705851	.0743186	-2.30	0.027	-.3207887 .0203816
3	-.0641412	.0955494	-0.67	0.506	-.2572538 .1289713
4	.671994	.	.	.	.
X_6	-.013103	.0103592	-1.26	0.213	-.0340397 .0078337

X_7					
2	-.108533	.0659293	-1.65	0.108	-.2417811 .0247151
3	0	(omitted)			
X_8					
2	.4370177	.142945	3.06	0.004	.148115 .7259203
3	0	(omitted)			
4	-.2808479	.1232637	-2.28	0.028	-.529973 -.0317227
5	.6898587	.	.	.	.
5.X_9	.1335735	.0785524	1.70	0.008	-.0812758 .3078296
X_{11}	-.0001258	.0000748	-1.68	0.100	-.0002771 .0000254
X_{12}	.0001354	.0000643	2.11	0.041	5.50e-06 .0002653
X_{13}					
2	.2866904	.	.	.	.
3	-.1842667	.0753895	-2.44	0.019	-.3366345 .0318989
3.X_{15}	.2865584	.0822599	3.48	0.001	.1203049 .4528118
X_{19}					
2	.3786064	.1074765	3.52	0.001	.1613882 .5958245
3	.1878235	.0842613	2.23	0.031	.0175251 .3581219

_cons	.8238661	.3058172	2.69	0.010	.2057865 1.441946
/sigma	. 0699328	.0126221			.1580669 .2353436
	No of obs	*LR chi2(20)*	*Prob > chi2*	*Log likelihood*	*Pseudo R2*
	60	*59.26*	*0.0000*	*14.462809*	*1.9534*

0: Left-censored observations

19: Uncensored observations

41: Right-censored observations at TE >= 1

Allocative Efficiency Results

AE |	*Coef.*	*Std. Err.*	*t*	*P>|t|*	*[95% Conf. Interval]*
X_{10}	*.0001436*	*.0001215*	*2.05*	*0.047*	-.0491236 .1823755
X_{11}	.0008834	.0002286	2.38	0.023	-.0000378 .0000771
X_{12}	-.000247	.0000798	-0.24	0.010	-.1707212 .1340237
X_{13}	.0005865	.0005183	2.09	0.030	-.0007884 .0010902
X_{18}	-.0008484	.0013564	-0.63	0.534	-.0035679 .0018711
X_{19}	.0000696	.0002741	0.25	0.801	-.00048 .0006191
_cons	.6285865	.1535133	4.09	0.000	.3208108 .9363622
sigma	.1967053	|.0192722			.1580669 .2353436
	No of obs	*LR chi2(20)*	*Prob > chi2*	*Log likelihood*	*Pseudo R2*
	60	2.68	0.8484	*4.7142979*	-0.3961

0: Left-censored observations

55: Uncensored observations

5: Right-censored observations at AE >= 1

Economic Efficiency Results

EE	*Coef.*	*Std. Err.*	*t*	*P>t*	*[95% Conf. Interval]*
2.X_1	.0165904	.0535821	0.31	0.759	-.0923014 .1254822
X_2	.021559	.005873	3.67	0.001	.0096236 .0334945
X_3	-.0007971	.0114711	-0.07	0.945	-.0241093 .022515
X_4					
2	.0520185	.1867705	0.28	0.782	-.3275448 .4315818
3	.1054049	.191852	0.55	0.586	-.2844853 .4952951
5	.0542433	.1770466	0.31	0.761	-.3055587 .4140454
X_5					
2	.104	.0850229	1.22	0.230	-.0687872 .2767873
3	.0954138	.1163203	0.82	0.418	-.1409775 .3318052
4	.6266844	.2664316	2.35	0.025	.0852303 1.168139
X6	-.0198261	.0129285	-1.53	0.134	-.0460999 .0064478
X7					
2	.5010135	.091115	5.50	0.000	.3158456 .6861815
3	0 (omitted)				
X8					

2	-.2414884	.1037099	-2.33	0.026	-.4522523 -.0307245
3	0 (omitted)				
4	-.1440202	.0922422	-1.56	0.128	-.3314788 .0434385
5	.5983408	.2514498	2.38	0.023	.0873333 1.109348
5.X9	-.1335735	.0785524	-1.70	0.098	-.2932111 .0260641
X10	-1.06e-06	1.39e-06	-0.76	0.452	-3.88e-06 1.77e-06
X11	.0000241	.0000281	0.86	0.398	-.000033 .0000812
X12	-.0000343	.0000501	-0.69	0.498	-.0001361 .0000674
X13					
2	.1024072	.1164747	0.88	0.385	-.1342978 .3391123
3	-.0790329	.0562847	-1.40	0.169	-.1934171 .0353513
X14					
2	-.0697316	.0749036	-0.93	0.358	-.2219542 .0824909
3	.0619349	.0698371	0.89	0.381	-.0799911 .2038609
3.X15	-.0666615	.081426	-0.82	0.419	-.232139 .098816
X17	-.0007047	.000439	-1.61	0.118	-.0015968 .0001874
X18	-.000234	.0003158	-0.74	0.464	-.0008758 .0004077
X19	.0001291	.0013912	0.09	0.927	-.0026982 .0029563
_cons	-.3207117	.3924299	-0.82	0.419	-1.118225 .4768017
/sigma	.1255088	.012246			.1006221 .1503956
	No of obs	*LR chi2(20)*	*Prob > chi2*	*Log likelihood*	*Pseudo R2*
	60	47.39	0.0063	30.603949	-3.4309

0: left-censored observations

55: Uncensored observations

5: Right-censored observations at EE >= 1

Efficiency Scores

TE	AE	EE
1.000	0.617	0,617
1.000	0.792	0,792
1.000	0.613	0,613
1.000	0.692	0,692
0.896	0.793	0,710
1.000	0.510	0,510
1.000	1.000	1,000
1.000	0.474	0,474
1.000	0.433	0,433
0.750	0.942	0,706
0.787	0.907	0,713
1.000	0.530	0,530
1.000	0.531	0,531
1.000	0.477	0,477
1.000	0.520	0,520
1.000	0.468	0,468
1.000	0.540	0,540
0.964	0.429	0,413
1.000	0.593	0,593
0.875	0.808	0,707

1.000	0.766	0,766
0.875	0.806	0,705
1.000	0.513	0,513
1.000	1.000	1,000
1.000	0.706	0,706
1.000	0.707	0,707
0.940	0.407	0,382
1.000	0.706	0,706
0.898	0.439	0,394
0.886	0.456	0,404
1.000	0.596	0,596
0.883	0.442	0,390
1.000	0.525	0,525
1.000	0.506	0,506
1.000	0.706	0,706
0.917	0.775	0,710
1.000	0.510	0,510
1.000	0.992	0,992
1.000	0.474	0,474
1.000	1.000	1,000
0.771	0.916	0,706
0.755	0.942	0,711
1.000	0.530	0,530
1.000	0.515	0,515
1.000	0.455	0,455
0.898	0.443	0,397
1.000	0.593	0,593
0.875	0.808	0,707

1.000	0.762	0,762
0.854	0.825	0,704
1.000	0.511	0,511
1.000	1.000	1,000
1.000	0.706	0,706
1.000	0.707	0,707
0.940	0.407	0,382
1.000	0.706	0,706
0.883	0.442	0,390
1.000	1.000	1,000
1.000	0.706	0,706
0.883	0.442	0,390