ECONOMICS OF IRISH POTATO PRODUCTION IN PLATEAU STATE, NIGERIA

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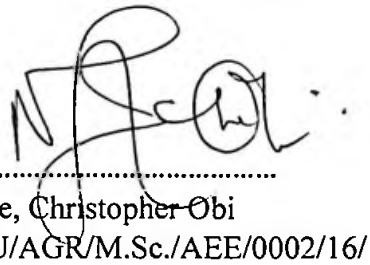
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MARCH, 2020

DECLARATION

I hereby declare that this dissertation has been written by me Uche, Christopher Obi and it is a report of my research work. It has not been presented in any previous application for Master of Science degree in Agricultural Economics. All quotations are indicated and sources of information specifically acknowledged by means of references.



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08-02-2021

.....

Date

CERTIFICATION

This Dissertation, "Economics of Irish Potato Production in Plateau State, Nigeria", meets the regulations governing the award of Master of Science (M.Sc.) degree in Agricultural Economics of the School of Postgraduate Studies, Nasarawa State University, Keffi and it is approved for its contribution to knowledge.

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DEDICATION

This research work is dedicated to Almighty God for granting me success in my studies.

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ABSTRACT

The study examined the economics of Irish potato production in Plateau State, Nigeria. A multistage sampling technique was used to select 180 respondents for the study. Data were analyzed using descriptive statistics and Cobb-Douglas functional form of the stochastic frontier model. The results revealed that the mean age of the respondents was 44 years. Majority of the respondents were married and most had formal education with average household size of eight persons. The profitability analysis shows a gross margin of ₦95,986.86 per hectare with return on naira invested as 29 kobo. The Maximum Likelihood Estimates of production function used in the study shows that farm size and seed positively and significantly influenced output of Irish potato under the Cobb-Douglas model and that the mean technical efficiency estimates was 68%. The inefficiency estimates shows that education and household size decreased inefficiency, while farming experience increased it. The study further found that high costs of inputs, inadequate credit facilities, pests and diseases, lack of security are the major constraints to Irish production in the study area. Based on the results, the study recommends that government should increase extension contacts to train farmers on how to reduce technical inefficiency and ultimately, increase profitability in the study area. The study further recommends an increase in farm size under Irish potato cultivation and provision of adequate security to increase farmers' productivity.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The Irish potato (*Solanum tuberosum*) is said to be one of the most important root and tuber crops around the World. In Nigeria, tubers such as yam and cassava take pre-eminence over potato due to higher productivity and immense relevance. Even then, Irish potato still remains a tuber of great importance in Nigeria. Irish potato is the World's fourth largest food crop after wheat, rice, and maize (Jwanya, Dawang, Mashat, and Gojing, 2014).

Developing countries have witnessed an expansion in the cultivation of potatoes mainly due to its nutritive content and its ease of cultivation which makes it a valuable food security and cash crop for millions of farmers (FAO, 2009). Developing countries are now the world's biggest producers – and importers – of potatoes and potato products. In developing countries, Irish potato is ranked first in food energy production per hectare per day, significantly above cassava and cereals (Zemba, Wuyep, Adebayo, and Jahknwa, 2013). It thrives best in cool climates and therefore requires a cool growing season with a moderate and well-distributed rainfall of about 800mm during growing seasons with no prolonged dry weather. It could be grown under rain-fed condition or irrigated, but waterlogged areas are unsuitable. Temperatures higher than 27^0C are unfavourable for the production of economic size tubers. Observations have shown that temperature ranges of 21^0C – 26^0C is required for sprouting of the tubers (Ahmed, 1980).

Irish potato is believed to have originated from the highland of Bolivia in South America (Martin and Leonard, 1949; Ifenkwe and Okonkwo, 1983). The spread of the crop outside

its centre of origin was mainly by deliberate introduction. The crop moved out of South America to Spain in 1570; to England in 1585; then to Ireland by Spanish explorers from 1963. The crop was grown on a large scale in Ireland and became so popular such that it is not surprising that it acquired the misnomer of "Irish Potato".

Irish potato was introduced into Nigeria early in the 20th Century by European miners in Jos Plateau. Jos Plateau has high altitude and thus, cool climate, which is favourable for the development of the crop. About 95% of Irish potato produced in Nigeria comes from Jos Plateau which has near temperate climatic conditions that favour Irish potato production (NRCRI, 2005). According to Okonkwo *et al.* (1995), Irish potato can be grown on the Obudu Highlands, Mambilla Plateau and Biu Plateau in Cross Rivers, Taraba and Borno State, respectively. Research also revealed that during the cold harmattan periods of November to February, Irish Potato can also be grown under irrigation in most Northern States of Nigeria (NRCRI, 2005).

Irish potato is grown for food as well as cash crop. It is a major source of income among the rural farmers during the rainy and dry season in the producing areas. Its production and marketing have become an integral part of the rural economy in the highland zones of Plateau State (Mohammed, 2009). Recent research still stipulates that the Jos Plateau alone accounts for up to 95% of the total Irish potato produced in Nigeria (Zemba *et al.*, 2013; Wuyep *et al.*, 2015; Jwanya *et al.*, 2014).

Irish potato is an important staple food as well as raw materials for industries. In order to meet the demand for industrial and human consumption, the yield per hectare needs to be improved. Such imminent improvement could be achieved through efficient management and monitoring of agro-climatic parameters, among others (Zemba *et al.*, 2013).

Consumption of Irish potato (fresh and processed) in Nigeria rose by 73% from 2.68kg/capita/year in 2000 to 4.63kg/capita/year in 2013 due to its value as a complementary dish in the Fast-moving Consumer Goods (FMCG) industry (International Potato Center, 2017). Nigeria demand for Irish potatoes especially in rapidly growing urban areas has been rising. Since year 2000, imports of raw and processed Irish potatoes have risen by 345% from 9000 tonnes to 40000 (Ugonna *et al.*, 2013)

Production and consumption of Irish potato has been increasing since its introduction to Africa (International Potato Center, 2008; FAO, 2008). There has been appreciable increase in the land area and output of Irish Potato in especially developing countries around the World. This increase could be attributed to advances in agricultural technology such as the introduction and provision of extension services as well as way of diversifying sources of livelihood (Wuyep *et al.*, 2015). Irish potato production around the world exceeded 320 million tons by the end of 2008. In 2017, global production stood at 388.2 million tonnes (FAOSTAT, 2019). The harvested area was 19.3 million hectares while potato yield was about 20 thousand kg/ha (FAOSTAT, 2019). China alone produced about 99.2 million tons in 2017, followed by India 48.6 million tonsof the world production, Russia 29.6 million tons, Ukraine 22.2 million tons and USA 20 million tons (FAOSTAT, 2019).

In Nigeria, the harvested area of Irish potato is 345.2 thousand hectares. Production in Nigeria is as high as 1,284,368 tons while yield is 3,720.1 kg/ha (FAOSTAT, 2019). More than 85% of the potato production in Nigeria is carried out by smallholder farmers who own small farms and carry out their operations manually with traditional farm tools,

like hoes and machetes. The land is cleared and the thrash burnt. Ridges or flats are made depending on whether it is rain-fed or irrigated potato production. Only about 36% of farmers use tractors (Okonkwo *et al.*, 2009). The potato is a very profitable crop in Nigeria. A number of studies (Zaknayiba and Mamman, 2016; Magit, 2015; Sani *et al.*, 2015; Jwanya *et al.*, 2014) have given credence to the potato as a profitability cash crop in the country. Typically, farm gate prices differ from prices in other areas and most often prices are affected by distance from production and the scarce value of the product in the face of huge demand.

Optimal productivity is the efficient utilization of resources used in production process. In this context, farm productivity is synonymous with production efficiency. Efficiency, therefore, is an important factor in productivity growth. In measuring technical efficiency, there are different methodologies and strategies that have been proposed and considerable controversy has surrounded the choice and merits of a specific methodology and the impact of such choice on the ensuing analysis (Olesen *et al.*, 1996; Coelli and Perelman 1999). Wadud and White (2000) indicated that in most empirical studies the selection of the methodology used to measure Technical Efficiency is arbitrary and based on the objective of the study, the data available and the personal preference of the researcher. Using a simulation analysis comparing the outcomes from parametric and non-parametric techniques, Resti (2000) concludes that there is no clear advantage of one method over the other. However, empirical studies using agricultural data have shown that the selection of a specific methodology can seriously affect the estimated Technical Efficiency scores (Kalaitzandonakes and Dunn, 1995; Sharma *et al.*, 1999; Wadud and White, 2000; Solis, 2005).

1.2 Statement of The Problem

The Irish potato is becoming a much-desired food security crop in contemporary Nigeria, but the production level cannot meet up with demand estimated to be about 10,000,000 tons per annum (Dominic and Ogheneruemu, 2019). In 2018, Nigeria produced 1,363,358 tons of Irish potato which is a mere 5% of the total output of 26,041,721tons produced in Africa (FAOSTAT, 2019). It has been observed that the level of national output of Irish potato in Nigeria is attributed to low productivity (Ojo, 2005). The productivity has remained low with yield per hectare averaging 3.7tons compared with 13.7tons and 20.1 tons in Africa and the world respectively (FAOSTAT, 2019). This low productivity is believed to be caused largely by technical inefficiency (Jwanya *et al.*, 2014).Irish potato is emerging as one of the most important tubers in Nigeria, as well as most of the developing world. There's empirical evidence that agricultural resources are not efficiently utilized in developing economies (Udemezue, 2019). According to (Udemezue, 2019), Nigeria, potato yield is 3,720.1kg/ha over a land area of 345,246ha which is far below the world average of 20,110.8kg/ha. This is an obvious evidence of the inefficiency that prevails in the production system. It also shows that at the current resource levels, without changes in input resources, there is a possibility of increasing productivity by a significant proportion if technical efficiency is increased. The much desired rapid growth in agriculture that will engender broad based economic growth cannot be achieved without sound use of science and technology, embodied in efficient and cost effective use of inputs in Irish potato production.

Hence, it is essential to assess how the existing inputs are being used, and what possibilities exist for improving efficiency of Irish potato production in Nigeria. Based

on the forgoing, the research will seek to provide answers to the following research questions:

i. What are the socioeconomic characteristics of the respondents?

ii. What is the profitability of Irish potato production in the study area?

iii. What is the nature of relationship between inputs and output in potato production?

iv. What is the level of technical efficiency of Irish potato production using Cobb-Douglas model?

v. What are the determinants of technical inefficiency in potato production using Cobb-Douglas model?

vi. What are the constraints to Irish potato production?

1.3 Research Objectives

The general objective of this study is to conduct an economic analysis of Irish potato production in Plateau State, Nigeria. The specific objectives are to:

i. describe the socioeconomic characteristics of the respondents;

ii. estimate the profitability of Irish potato production in the study area;

iii. examine relationship between inputs and output in Irish potato production

iv. estimate the technical efficiency of Irish potato production in the study area

v. examine the determinants of technical inefficiency in Irish potato production,

vi. identify the constraints to Irish potato production.

1.4 Significance of the Study

Agribusiness plays a crucial role in rural development and income improvement in Nigeria so it is important to conduct empirical research that will generate knowledge on economics of potato production. This study will therefore, play a significant role in

providing useful information concerning technical inefficiencies in Irish potato production with a view to increasing productivity among farmers. It will be useful in identifying those factors which are associated with inefficiencies in Irish potato production. According to Udemezue (2019), there's evidence that agricultural resources are not efficiently utilized by potato farmers in developing economies. Therefore, study of economics of Irish potato production will be useful to potato farmers experiencing low productivity which is believed to be caused, largely by technical inefficient use of agricultural resources. This study is expected to provide useful benchmark information to new farmers on resource productivity and profitability of Irish potato production. And for existing farmers, the study will provide information that will enable them boost productivity, and consequently, profitability.The study will further contribute to literature on economics of Irish potato production and technical efficiency analysis in Nigeria as no known study currently exist on technical efficiency estimation using the Cobb-Douglas model.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Framework

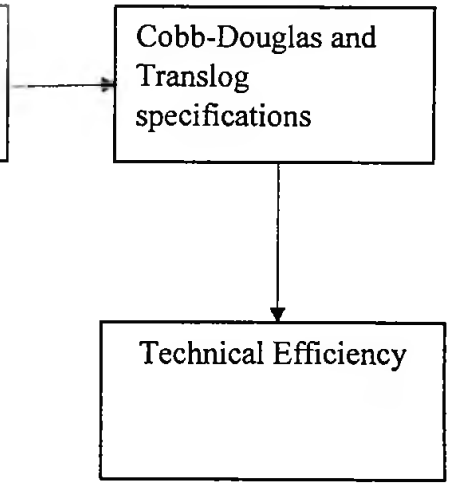
The pioneering work by Farrell in 1957 provided the definition and conceptual framework for this research. The conceptual framework of the study explains that farmers' socioeconomic characteristics interacting with input variables (Fixed + Variable) and Skills, behaviours, attitudes, knowledge base, accurate timing as well as available technology, infrastructure and production techniques will lead to optimum utilization of available resources which will in turn lead to technical efficiency in potato production (Hassan, 2004). Summation of technical efficiency in potato production and random shocks will show the Optimum Production Levels of potato. The conceptual framework explains that with all these factors put together there is the possibility of reaching the optimum production level of potato production within the capacity of the available technologies at the current disposal of the farmer. The classical theory of production argues that the optimum production level of potato production is reduced by random shocks. These shocks are beyond the control of the farmer and can occur from factors outside the farmers grasps. (Asefa, 2011) These shocks are however not as a result of technical inefficiency. They are simply unexplained phenomena. Consequently, the maximum production level of a farm firm is determined by the technology and resources under it's control and in part by the environment outside it's control.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Framework

The pioneering work by Farrell in [illegible] framework for this research. The concept [illegible] farmers' socioeconomic characteristics [illegible] Variable) and Skills, behaviours, attitudes [illegible] available technology, infrastructure [illegible] utilization of available resources wi[illegible] production (Hassan, 2004). Sur[illegible] random shocks will show the [illegible] framework explains the [illegible] reaching the optimum [illegible] available techno[illegible] production a[illegible] random [illegible] factors [illegible] of [illegible]



Source: Author's construct, 2019

Figure 2.1: Interaction between Physical Resources, Intangible Resources, Environmental Factors and Technical efficiency.

2.1.1 Efficiency

Case *et al.* (2009) conceptualized efficiency as the condition in which the economy is producing what people want at least possible cost. This means that each input is producing the maximum level of output per unit such that per capita productivity is achieved to the maximum for all production cycles. In this classical efficiency scenario, a firm (or faming unit) produces the greatest possible quantity of output for the least amount of money.

Farrell (1957) pointed out that manager or the farmer is thus concerned with producing higher levels of output at the lowest possible cost. Therefore, the firms make effort to either reduce the cost of a certain level of output or to increase the output with a certain level of costs. These two optimization problems provide the same rule for the allocation of inputs and selection of technology. Because there are alternative means of achieving the production goals, the production theory gives the theoretical and empirical framework which helps in best selection among alternatives for anyone or a combination of the farmer's objectives to be achieved. Agricultural productivity is a measure of efficiency since the aggregate productivity of an economic system is proportional to the efficiency of production of the components within the systems (Olayide and Heady, 1982).

Further, potential resource productivity means getting the maximum output from the minimum possible set of inputs. Thus, optimal productivity of resources demands an efficient usage of resources in the production process. Agricultural productivity can therefore be defined as a measure of efficiency with which the agricultural system utilizes land, labour, capital and other resources.

When firms operate under uncertainty, fluctuations in output are mainly due to fluctuations in inputs, technical inefficiency and random shocks. The fluctuation due to

variation in inputs can be captured through a production function specification. The variation in output due to technical inefficiency and random shocks can be captured and decomposed through the stochastic production frontier approach (parametric approach). The existence of inefficiency in production comes from inefficient use of scarce resources (Abedullah and Bashir, 2006).

In the sense of production, the agricultural system can be seen as a firm. Therefore, a firm is poised between two markets. It is a demander in factor markets. It buys the inputs required for production in factor markets (markets that supply inputs for firms). It is a supplier in market for goods and services. It has to adjust its production to satisfy the demand curve of its customers at profit. It is assumed that the firm or the owner of the firm always strives to produce efficiently, or at lowest cost. He will always attempt to produce the maximum level of output for a given dose of inputs avoiding waste whenever possible. The production function is the relationship between the maximum amount of output that can be produced and the inputs required to make that output. Put in other way, the function gives for each set of inputs, the maximum amount of output of a product that can be produced. It is defined for a given state of technical knowledge (if technical knowledge changes, the amount of output will change) (Dorfman, 2016).

The efficiency of a farm/production unit can be measured in terms of allocative efficiency (reflecting the ability of a farm to use inputs in optimal proportions, given their respective prices) and technical efficiency (TE). Technical Efficiency is the ratio between actual and potential output of a production unit (Shanmugam and Venkataramani, 2006). The efficiency of a farm (production unit) can be measured either with respect to its normatively desired performance or with the performance of another farm. The

"production frontier" serves as one such standard in the case of Technical Efficiency. Technical Efficiency can be defined as the ability and willingness of a production unit to obtain the maximum possible output with a specified endowment of inputs (represented by a frontier production function), given the surrounding technology and environmental conditions (Kalirajan and Shand, 1994). Technical efficiency measures are calculated relative to the production function of the fully efficient farm or a unit that is represented by a frontier function (Battese and Coelli, 1988). Since in actual practice this frontier value is not known, it must be estimated from a sample of observed yield of each farm, and each farm's performance is compared with the estimated frontier. The conceptual framework of the study is presented in figure 2.1. Inputs such as farm size, seed, agrochemicals, fertilizer and labour are interacting with socioeconomic factors, managerial skills and available technology to affect Irish potato output. This means that changes in the levels of inputs as well as other factors will result in changes in output. To empirically measure the productivity and technical efficiency of the farmers, the stochastic production frontier was estimated using Cobb-Douglas and Translog production functions.

2.1.2 Stochastic Frontier Production Function

As advanced by Coelli (1996), the stochastic frontier production function was independently proposed by Meeusen and Broeck (1977) and Aigner, Lovell and Schmidt (1977). The original specification involved production function with composite error terms accounting for random effect as well as technical inefficiency effect both of which could cause production output deviation from frontier. The frontier production function can be defined as the maximum feasible or potential output that can be produced by a

production unit such as farm, given level of inputs and technology. The actual production function (corresponding to the production unit's actual output) can be written as:

$Y_i = X_i\lambda + C\hat{i}$ $(i=1, 2 \ldots, N)$ i

Where, Y_i = is the output of the i^{th} farm; Xi = is the K × 1 vector of the inputs used in i^{th} farm; λ= is a vector of parameter to be estimated; $C\hat{i}$ (composite error term) = *(Vi- Ui)*; V_i = random effect variables which are assumed to be [iid. N (O, σv^2)]. The random effect variable, V_i, captured aggregate effects of unobserved factors on production, which are generally exogenous and beyond the control of the farmer; U_i = non-negative random variables which are assumed to account for technical inefficiency in production, (captured output deviation from the frontier caused by factors under the control of the farmers, which are generally socioeconomic in nature) are independently distributed as truncation at zero of the N (U_i, σu^2).

Where, $U_i = Z_i\delta + e$.....ii

Z_i = is the P× 1 vector of variables (mainly farmers' socioeconomic factors) which may influence the efficiency of the farm; δ = is a vector of unknown parameter to be estimated and e is the error term.

The frontier or the potential output is defined as the maximum output obtained without inefficiency effect on the production given the input vector, Xi. This can be specified as follows:

$Y^* = \exp(X_i\lambda + Vi)$ iii

Hence, the technical efficiency, TE, of the i^{th} farm can be defined as the ratio of the observed output to the potential or frontier output, given the available technology. This can be expressed as follow:

$TEi = Y/Y^* = \exp(X_i\lambda + V_i - U_i)/\exp(X_i\lambda + V_i) = esp(U_i)$.....iv

Given equation iii, the technical efficiency scores range from zero to 1 and inversely related to the inefficiency effect (Coelli and Battese, 1996).

Aigner *et al.* (1977) suggested the use of likelihood function to allow for two variance parameters namely Sigma squared (σ2) and gamma (γ) which have statistical application. They are defined as follows:

$\sigma_T^2 = \sigma_V^2 + \sigma_U^2$; $\gamma = \sigma_U^2/\sigma_T^2$.....v

The value of σ^2 measures goodness of fit to the data. The γ value lies between zero to 1, where the value of zero indicate all deviation from the frontier is due to noise effect and the value of 1 is an indicative that all deviation from frontier are due to inefficiency effect.

2.1.3 Gross Margin Analysis

Gross Margin Analysis, according to Olukosi and Erhabor (1988), is a useful tool in situations where fixed capital is a negligible portion of the farm enterprise where the farmers are involved in small scale and subsistence cultivation. A gross margin refers to the total income derived from an enterprise less the variable costs incurred in the enterprise. The Gross Margin model is of the form:

GM = GI – TVC.

Where:

GM = Gross Margin

GI = Gross Farm income. This is the total physical product multiplied by the unit price of the product at the prevailing price.

TVC = Total Variable Cost.

Similarly, the Gross farm income was determined as:

$GI = \Sigma Y_i * pY_i$

Where:

Y_i = Output (kg)

pY_i =Average price (₦)

2.2 Theoretical Framework

This study was guided by the theory of production. The theory attempts to explain the choices a farmer makes when allocating resources in order to get specific outputs within a production system. The theory also explains technical efficiency in production. The study relied on assumptions and principles of the theory.

2.2.1 Theory of Production

The production theory attempts to explain the principles by which a firm (farming unit) decides how much of each commodity that in its output will be produced, and how much of each kind of labour, raw material, fixed capital good, that it employs (its inputs or factors of production) will be used (Dorfam, 2016). Production function defines the relationship between inputs and the maximum amount that can be produced within a given period of time with a given level of technology. The theory assumes that whatever input or input combinations are included in a particular function, the output resulting

from their utilization is at the maximum level. This is the concept of Technically Efficient Production. The measurement of efficiency is based on the ability to estimate a production frontier and then specific producer's performance is measured with respect to that frontier. Efficiency is a central issue in Production economics, helping us as guide for allocation of resources (Farrel, 1957). The short-run production function shows the maximum quantity of good or service that can be produced by a set of inputs, assuming the amount of at least one of the inputs used remains unchanged. The long-run production function shows the maximum quantity of good or service that can be produced by a set of inputs, assuming the firm is free to vary the amount of all the inputs being used (Keat and Young, 2006). Basically, specification of production function under stochastic frontier distinguishes the error term associated with the production function into statistical noise and inefficiency components. It is assumed that both errors influence deviation in output from the optimum level. Figure 2.2 previews the graphical illustration of stochastic frontier analysis. In this thesis, I utilized two of the most classical functional forms for empirical analysis, namely Cobb-Douglas production function, originally developed by Cobb and Douglas (1928) and Translog production function as proposed by Christiansen *et al.* (1973).

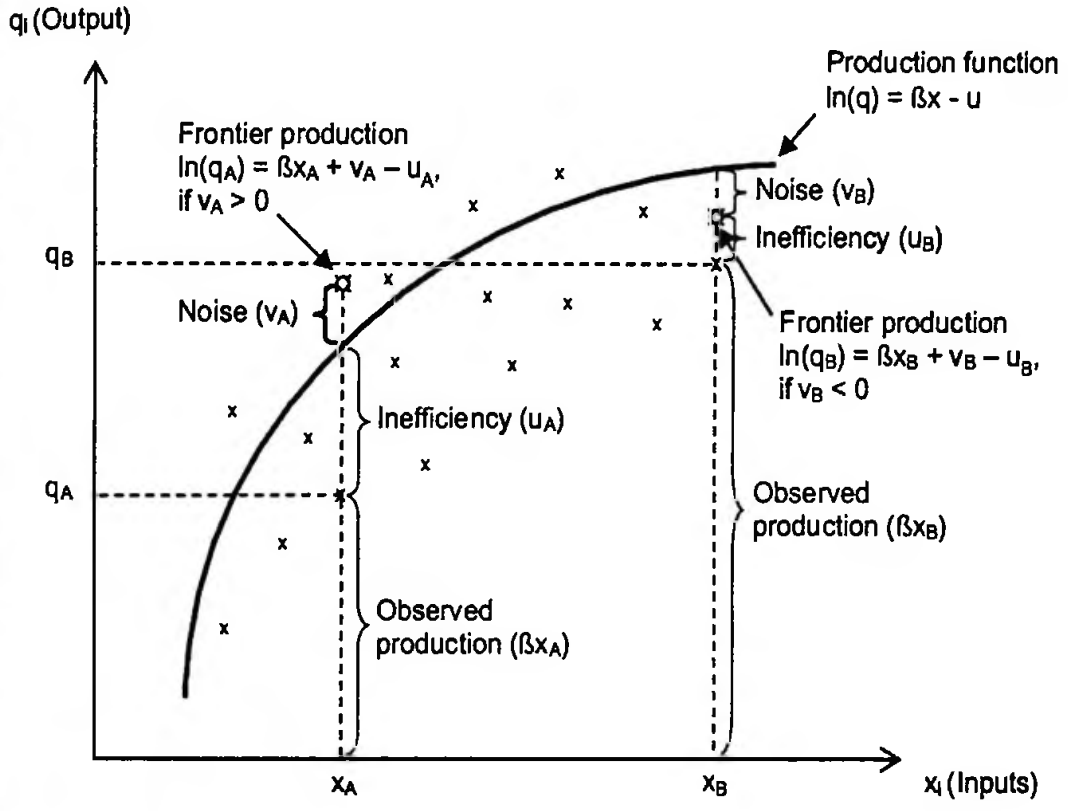


Figure 2.2: Graphical representation of stochastic frontier analysis.

Source: Neumann et.al (2010)

2.3 Empirical Review

2.3.1 Profitability of Irish Potato production

Profitability is usually measured by the amount of profit the company produces annually. Drucker (1955) states that profit is not the main reason why business is established, he believes that avoidance of loss is instead the guiding principle. The environment of business has changed since Drucker wrote his ideas, though many of them still apply today. But profit has become more and more important for farmers. Technical efficiency is derived from production function which is possible to achieve while realizing sub

optimal profit. Thus, a technical efficient farmer can be kicked out of the market due to failure to achieve profit (Assa *et al.,* 2012).

Hudu, (2018) in his study, he used Gross margin model and reported that the crop was found to be profitable with a mean income of ₦48,400 per hectare and returns on investment (ROI) of N1.34. However, the study did not consider technical efficiency in the production process and this study will fill the gap.

Fomyol, (2017) analysed data collected from 90 Irrigated potato farmers and 90 rain fed potato farmers using gross margin analysis. He reported an average total cost of ₦70.070 and ₦66.140 with profit of ₦129,400 and ₦98100 for rain fed and irrigated farm respectively.

Bajracharya and Sapkota (2017) conducted an analysis of profitability and productivity of potato in Nepal. They used gross margin analysis and reported a benefit cost ratio of 1.44 yielding benefits that was 44% greater than costs. The return to scale was 0.842, indicating decreasing returns to scale. The study reported an average potato production of 4598kg/hectare which was lower than national average in Nepal, and they attributed the low productivity to disease infestation.

Zaknayiba and Mamman (2016) employed gross margin analysis and net farm inome to analyse the profitability of Irish potato production in Bokkos local Government Area of Plateau state and reported that total cost of Irish potato production per hectare, average gross returns per hectare, net farm income obtained per hectare and returns per Naira invested were ₦224,558.8, ₦540,235.4, ₦315,676.6 and ₦2.4 respectively. 90% of their respondents had one form of education and 60% of the farmers had more than 10 years

farming experience, but the study did not relate these socioeconomics characteristics to efficiency. In their study while analysing the economics of Irish potato production under irrigation system in Katsina State, Sani *et al.* (2015) applied Net Farm Income analysis. They divided the study into three categories based on farm sizes. The study reported that Irish potato production in the study area was profitable with mean Net Farm Income of N5798.83, ₦21555.35 and ₦65399.48 for 0.2-0.4ha, 0.5-0.7ha and 0.8-1ha respectively. The result further reveals that manure and fuel contributed toward the output for 0.2-0.4ha, manure, fuel, water and labour contributed for 0.5-0.7ha and manure, water and labour for 0.8-1ha. The study considered only irrigation cultivated Irish potato farms and this study is concerned with the more prominent production system for local farmers which is rain-fed cultivation.

Jwanya *et al.* (2014) conducted an economic analysis of irrigated Irish potato production in Plateau State relied on Gross Margin Analysis, Benefit–Cost Analysis and Sensitivity Analysis in data analysis. Results revealed that costs of seeds, labour and chemical fertilizers made up the highest (89.40%) portion of the average total variable cost of production. Results also revealed that irrigated Irish potato production in Plateau State is a profitably lucrative enterprise with a robust economic viability as shown by values of Gross Margin (N655,637.88), benefit–Cost Ratio (2.64) and Sensitivity Analysis ratio (2.16). Average Gross farm income per hectare of the farmers was N903,918.66. Efficiency gains was not part of the study and efficiency gains from the current study could translate into better competitive position for the farmers transforming their impact on market share into higher profitability.

Assa *et al.* (2012) in their study measured the profit efficiency of sample Irish potato farms and used it to explore determinants of profit inefficiency in Dedza district of Malawi. They employed flexible translog profit function in one stage estimation of profit efficiency in central Malawi and reported that profit efficiency estimates ranged from 31% to 99% with a mean of 74%. The minimum efficiency of 31% showed gross underutilization of resources and loss of income while the best economically efficient farmer operated almost on the frontier. The diagnostic statistics of the translog profit function showed a total variance of 0.23, being statistically significant at 1% risk level. There was no consideration of Cobb-Douglas model in the profit efficiency study which this study did.

Ojo (2005) conducted an economic analysis of Irish potato production in Plateau State applying Net Farm Income analysis and reported that the average NFI for the sole potato enterprise was N41,615. The breakdown for Bokkos, Mangu and Barkin Ladi areas were N35,408, N37,458 and N51,978 respectively. However, average gross margin for potato/maize enterprise in the state was N39,274, while those of the three LGAs were N27,153, N47,050 and N43,620 respectively. Only that of Bokkos was lower than the state average. This can be attributed to the high total labour cost when compared to that of the state. Ojo (2005) calculated profitability based on Net Farm Income. My study used Gross Margin Analysis instead. Gross margin analysis is a simple, practical and powerful tool where fixed capital is negligible for small scale farmers who practice small scale subsistence agriculture. The results are easy for researchers and farmers to understand.

2.3.2 Determinants of Technical Efficiency in Irish potato production

Bakhsh and Ahmad (2006) observed that the potato farmers had a mean technical efficiency score of 84 percent. They noted that an increase of 16% in technical efficiency would raise yield by 19.1%. Technical efficiency in potato production was measured employing the Cobb-Douglas stochastic production frontier approach. The study further reported that by shifting the average farmer to the production frontier, the average yield would increase from 8.33 tons per acre to 9.92 tons per acre using the available resources. This study will be done in a different geographical zone.

Chepkwony *et al.* (2016) employed stochastic frontiers regression in Cobb-Douglas functional form results showed that the mean technical efficiency index was 78.9% of efficiency of production and consequently inefficiency of 21.1%. This meant that farmers had 21.1% scope of increasing the potato production by using current technology. The inefficiency parameter estimate indicated three socio-economic and institutional factors namely, education level, access to extension services, and access to credit, as having significant effect on technical efficiency. The geographical difference and specificity of how each determinant contributes to T.E are improvement areas the current study will focus upon.

Deressa *et al.* (2017) employed a Cobb Douglas production functional form to analyse technical efficiency level in potato production in the study area. From the results age was identified as one of the most important socioeconomic variables that determined farmers' experience of management of their agricultural production. The mean age of the sample household heads was 42 years. Analysis of the survey data revealed efficiency indices obtained vary from one potato farmer to another in a range from 0.64 to 0.97; with an

average of 0.86. This result meant that an average of 14% of potato output was lost due to the specific inefficiencies pertaining to farms. The study identified that seed, labour and chemical were positively related to potato output.

Studying the technical efficiency of smallholder potato was carried out in Rwanda, Paul (2011) estimated the technical efficiency by relying on stochastic frontier production approach. Results indicated that 71 percent variation in the output of Irish potato production was attributed to technical inefficiency with a mean of 60.5 percent technical efficiency. It is shown that area under potato, seed and family labour and fertilizers contributed positively towards the improvement of efficiency. The analysis also reveals that, farming experience, household size, gender, marital status, farm size, extension services are socio-economic factors influencing the farmers' technical efficiency. On the other hand, socioeconomic factors including education, access to credit and firm size brought negative impacts in affecting the efficiency level of farmers.

Magit (2015), comparatively analysing the economics of irrigated and rain-fed Irish potato (*Solanum tuberosum*) farming in Plateau State, Nigeria employed gross margin analysis and the Cobb-Douglas Stochastic frontier models. The average level of efficiencies estimated for the two categories of farmers were 69% and 88% for technical, 66% and 79% for allocative and 45% and 70% for economic respectively. The socio-economic factors that had significant bearings on technical, allocative and economic inefficiencies were age, education, household size, extension visits, and membership of cooperative society. The factors that were significant at 1% level of probability were age, education and extension visits. Household size and membership of cooperative society were significant at 5% level of probability for irrigated and rain-fed Irish potato farming.

Some of the main constraints identified were inadequate farm size; poor and inadequate network of rural roads; poor and inadequate storage facilities; and high cost of seeds.

Shanmugam and Venkataramani (2006) used both Cobb-Douglas and Translog models to analyse the response of certain socioeconomic determinants in technical efficiency. Coefficients of literacy were positive and significant at 5 per cent level; the coefficient of rural electrification was negative and significant at 5 per cent which the researcher found surprising; and road infrastructure had a positive effect on technical efficiency, at 10 per cent level of significance. The result for electrification was adduced to reflect the imperfect nature of the variable. In the exact sense, this variable represents the percentage of villages electrified within a district. It did not say anything, however, about how this infrastructure might be used in agricultural production. The study further observed that there were differences in the determinants of technical efficiency across districts. In semi-arid districts, Individual Medical Readiness (IMR) and road infrastructure showed significant effects, in the expected direction, on technical efficiency. In these same districts, larger land holding sizes were observed to improve efficiency. In sub-humid districts, the coefficient on literacy is positive and significant at 10 per cent level and road has a significantly positive effect at 1 per cent level. His study paid little attention to analysing how human capacity that can have influence on Technical Efficiency, instead it focused on infrastructure and amenities.

Bogale and Bogale (2005) reported that since individual and overall significance tests of the coefficients of the inefficiency variables for the farms under traditional irrigation schemes were not significantly different from zero they concluded that there was no inefficiency effect. For farmers under the modern schemes, individual tests for three

variables (irrigation experience, livestock and commodity rate of production) were significant. Though individual tests of coefficients of most of the inefficiency variables were not significant, the generalized likelihood ratio test of the overall significance of the coefficients was highly significant indicating the joint effect of these variables on the inefficiency. A breakdown of the variables showed that the efficiency level of farmers and education level of household head was negative which was unusual. Credit had a positive relation with the level of technical efficiency though it is not statistically significant. Commodity rate of production had a significant negative effect on the level of technical efficiency. The result of this study indicated that livestock ownership negatively affected the level of technical efficiency at 10% level of significance. Further, there is a negative relationship between family size and technical efficiency though it was not statistically significant. The study focused only on irrigated potato production Assa *et al.* (2012) used Translog model in their study and found out that potato cultivated area to conclude that fertilizer and agrochemicals, purchased seeds, hired labour and irrigation water use were the major determinants of potato production. Farm specific efficiency factors such as level of education, irrigation system, distance from the main channel (head and tail) and distance from the village to city, were significant factors that accounted for variation in efficiency among the farms. The overall mean technical efficiency level was 81.2 percent indicating the high potential to increase potato production in the area. Results of the study suggested that by improving level of education, irrigation and physical infrastructure technical efficiency problem could be handled to a great extent with available resources and technology. The weakness of this study is that it relied more on the determinants of technical efficiency using farm level

coefficients and ignoring salient socioeconomic variables that could lead to technical inefficiency.

Assa (2012) employed Translog stochastic production frontier model to predict farm level technical efficiency using Maximum Likelihood Method. Results from the study revealed that individual farm level technical efficiency was about 83%. The result further showed that non-farm employment, education, farm experience, degree of specialization and weeding were positively related to technical efficiency and significant at 1%. Age and household size were negatively related to technical efficiency and significant at 5% and 10%, respectively. There was no significant relationship between technical efficiency and extension visits and credit access. Furthermore, the value of the γ-estimate was significantly different from one, indicating that random shocks played a significant role in explaining the variation in potato production. This study adopted Translog model in measuring the technical efficiency which may not provide accurate measure of TE and is not compared to an alternative technique.

Tiruneh *et al.* (2017) state that the maximum likelihood estimates for the inefficiency parameter showed that most rain-fed and irrigated potato farmers in the study area were not efficient. The mean technical efficiency (TE) was found to be 81% and 68%, and about 4057 and 6185 kg of potato tubers per hectare were lost due to inefficiency factors for and/or from rain-fed and irrigated potato farmers, respectively. Variables such as education, soil condition and seed tuber size affected TE of both rain-fed and irrigated potato farmers, while age of the household head affected irrigated potato farmers' TE positively and significantly indicating that experience through age matters in irrigated potato production. The finding implies that there is an opportunity to improve technical

efficiency among the rain-fed and irrigated potato farmers by 19 and 32%, respectively. Improving potato productivity needs owing cares of technical efficiency and farm and household socioeconomic characteristics that influenced technical efficiency in smallholder potato production. However, the study did not assess the result using the Cobb-Douglas functional form and this weakness will be taken into account by this study.

As reported by Bhatt and Bhat (2014), studying the technical efficiency and farm size productivity at micro level with evidence from India employed Non-parametric Data Envelopment Analysis, average technical efficiency was worked out to be 48%. Most of the farms were operating at low level of technical efficiency. There was also wide dispersion in technical efficiency across farm categories. Farm size and productivity efficiency relationship were found to be non-linear, with efficiency first falling and then rising with size. Large farms were observed to have higher net farm income per acre and were more technically efficient compared to small farm size categories. The study further delineated the socio-economic, institutional and farm factors of technical efficiency using Two-limit Tobit Regression Model. The results showed that occupation, farm experience, household size, farm size, membership and seed type were important determinants of technical efficiency across farm sizes. The weakness of this study is that it considered technical efficiency on a large farm versus small farm basis rather than using a standard unitary measurement such as hectarage. This weakness will be attended to by the currents study.

2.3.3 Constraints to Irish Potato production

Gambo *et al.* (2017) identified land tenure system as a factor that discouraged large scale production of Irish potato. Also, mechanization was difficult due to fragmentation of farm lands. Fertilizers, improved seeds and pesticides were in short supply. Furthermore, infestation, inadequate farm labour, bad roads and inadequate credit facilities were identified as key constraints to potato production.

Arneja *et al.* (2009) in their study, "Constraints In Potato Cultivation Faced By The Potato Growers" in India identified non-availability of credit, non-availability of varieties resistant to diseases, non-availability of fertilizer and lack in knowledge of dose, time and method of weedicide application as the major constraints. They also identified unfavourable government policies, lack of technical knowledge about potato growing and awareness about marketing trends respectively, problem of no minimum support price fixed by government for their produce as key constraints to potato production.

Muhinyuza *et al.* (2012) identified major potato production constraints to include lack of access to credit, lack of high yielding cultivars, insufficient clean planting materials, late blight, dormancy period, low market price, soil degradation, inaccessibility to fertilizers and fungicides. Serious crop damage occurs due to late blight, bacterial wilt and viruses while insect pests are considered to cause less damage in the study areas.

Uddin *et al.* (2015) identified the constraints to include high initial investment, lack of government procurement, storing cost at cold storages and low market price of potato.

They further identified lack of information and high prices of pesticides as major constraints to potato production.

CHAPTER THREE

METHODOLOGY

3.1 Description of Study area

This study was conducted in Plateau State, Nigeria. Located in the middle belt of Nigeria, it is the twelfth largest state in the country. Created on February 3, 1976, Plateau State covers a land area of approximately 30,913km^2 and has a population of 3.2 million inhabitants. It is located between latitude 08° 24^{1}N and longitude 008° 32^1 and 010° 38^1 east.

The State Comprises Seventeen Local Government Areas. It is bounded in the North East with Bauchi State and in the South West with Nasarawa State. The State is mainly an upland zone, rising above 250 metres above the sea level. The State enjoys tropical climate with two distinct seasons. These are the rainy season (April – October) and the dry season (November – March). Tropical forest exists in the South, while Guinea Savannah Occupies the northern peripheries. The main cash crops grown in the area aside Irish Potato include maize, yam, rice, cassava, guinea corn, apples, grapes, wheat, barley and many other exotic crops. (Gambo *et al.*, 2017 and Jwanya *et al.*, 2014). Plateau State has a near temperate climate with an average temperature of between 13 and 22°C. The warmest temperatures usually occur in the dry season months of March and April while the coldest weather is between December and February. The mean annual rainfall varies from 131.75cm in the Southern part to 146cm on the Plateau and the highest rainfall is recorded between the months of July and August. The Gross Domestic Product (GDP) is $5.15 billion and per capita income of $1,587 (National Bureau of Statistics, 2020).



Fig. 1 Map of Nigeria Showing Plateau State
Source: http://www.wjgnet.com/19498462/full/v4/i1/327.htm

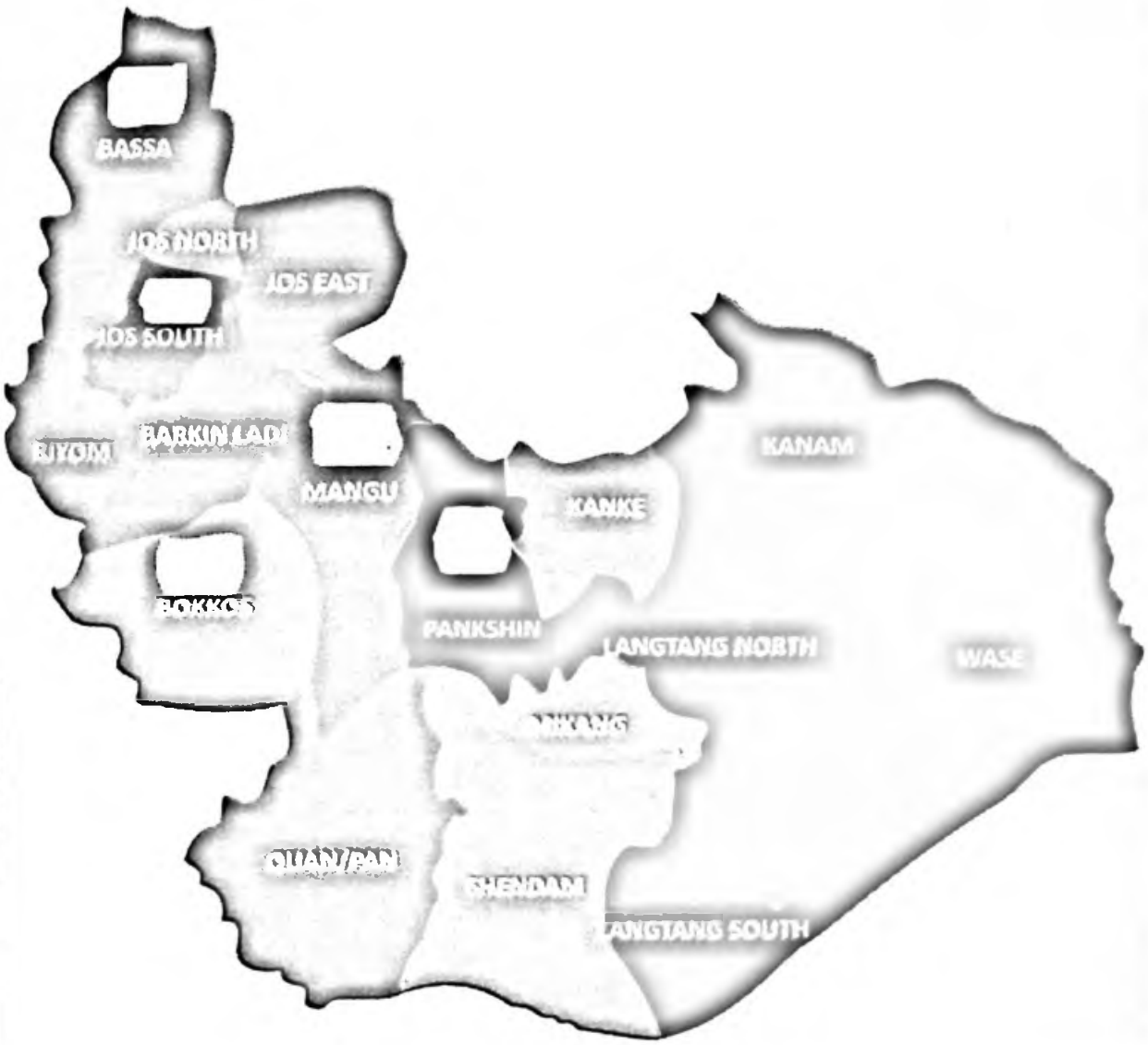


Fig. 2 Map of Plateau State highlighting five local governments

Source: http:/www.plateaustate.gov.ng

3.2 Sampling Technique and Sampling Size

The target population for this study were Irish potato farmers in the whole of Plateau State. A multi-stage sampling technique was employed for the selection of respondents.

Stage 1: In the first stage, five (5) Local Government Areas were purposively sampled out of the seventeen in Plateau State based on their level of potato production. The LGAs are Bokkos, Mangu, Jos South, Pankshin and Bassa.

Stage 2: In the second stage, 2 communities with the highest potato production levels were purposively sampled from each LGA.

Stage 3: In the final stage, simple random sampling technique using balloting method was used to select 180 respondents from the sampling frame derived from list of potato farmers in each of the selected Local Government Area as obtained from Plateau Agricultural Development Programme (Table 3.1). Sample size for the study was determined using Cochran equation given

as:

$$n_0 = \frac{Z^2pq}{e^2}$$

Where: n_0 is the sample size

- e is the desired level of precision (the margin of error). This study used 7% margin of error at 95% confidence level.
- p is the (estimated) proportion of the population which has the attribute in question. This study used a p value of 0.5
- q is 1 – p.

The z-value is found in a Z table.
A total of 180 respondents were determined which is about 15% of the sampling frame.

Table 3.1: Sampling frame of Irish Potato farmers in the study area

Local Government	Villages	Sampling frame	Random selection (15%)
Mangu	Kerang	120	18
	Panyam	125	19
Pankshin	Mile 8	120	18
	Bwarak	115	17
Bassa	Miango	120	18
	Rukuba	120	18
Bokkos	Maikatako	130	20
	Mbar	120	18
Jos south	Kuru	115	17
	Vwang	115	17
Total		1200	180

Source: Field Survey, 2019

3.3 Data Collection

Primary data were collected using a structured questionnaire procedure. Data collected include socioeconomic data, data on farmers' inputs and outputs. The inputs included seed, herbicides, fertilizer and pesticides. The data on inputs indicated quantities and costs of inputs used for production while outputs were measured in kilogram per hectare.

3.4 Measurement of variables

Age: Age of the respondent was measured by the number of years the individual has lived. Typically, young people are more energetic than the old people, they are less risk-averse and have greater measure of innovativeness (Nnadi and Akwiwu, 2008).

Level of Education: This is measured in proxy by number of years a respondent has spent schooling. Education enhances more informed participation in agricultural enterprises as well as equip individuals with the necessary knowledge as to how to allocate their scarce resources to achieve optimal output. Akudugu (2012)indicated positive relationship between education and adoption of agricultural technology.

Farm size: This usually determines farmers' choices whether to subsist or engage in market-oriented production. In order to participate in large scale agricultural enterprise, farmers need more farm size for production. Farm size level was expected to significantly affect the participation of farmers in agricultural enterprises. Nnadi and Akwiwu (2008) indicated that the high rate of people's participation in rural agriculture in the Imo State was attributed to the availability of farm lands and also the dependence on land for existence. Farm size was measured in hectares.

Farming experience: It was measured in years. While farming experience helps a farmer to gain enough knowledge and expertise in undertaking certain farming activities, it takes

quite a long period of farming to be able to gather this experience. Akudugu (2012) indicated experience on farm activities has a positive and significant relation with farming and adoption. This was measured in years.

Access to credit: Access to credit/loan usually is expected to have positive effect on efficiency. Accessing credit is positively related to a farm firm's efficiency because credit forms an important part of the agricultural enterprises in line with the findings of Asante *et al.* (2011). Lack of credit facilities hinders the plans and activities of the farmer and puts him in a difficult situation. Akudugu (2012) also indicated that lack or inadequate access to credit is a crucial militating factor against farmers in financing their farm operations and is one of the major underlying factors of low agricultural productivity. This was measured in amount (Naira) of credit obtained.

Household size: Household size is a determinant of inefficiency because a large household has the capacity to overcome labour requirements during the introduction of new technology (Mignouna *et al.*, 2011). Household size was measured in number of persons in the household.

Labour: This was measured in mandays. Six hours of work constituted one man day for men, 8 hours for women and 12 hours for children (Baruwa and Omodara, 2019).

Farm Income: Farm income was included in the estimation and was expected to be positive. Abdul-Hakim and Che-Mat (2011) indicate that improving the household income of rural farmers could reduce poverty. This was measured by the amount of income (Naira) realized per year for Irish potato production

Input and Output Variables: Input variables such as seed and fertilizer were measured in kg while pesticide and herbicide were measured in litres. Output was measured in kg.

3.5 Analytical Technique

Descriptive and inferential statistics were utilized for the analysis of data collected. Objectives I and VI were achieved using simple descriptive statistics like mean, frequency and percentage. Objective II achieved using Gross Margin Analysis while objectives III, IV and V were achieved using a Cobb-Douglas stochastic frontier model..

3.5.1 Specification of Functional forms of the Model:

According to Battese (1992), the Cobb-Douglas functional form meets the requirement of being self-dual, allowing an examination of economic efficiency. Murthy (2002), argues that Cobb-Douglas production function merits the use for analysing the production process because it can handle multiple inputs in it's generalised form and does not introduce distortions of it's own even in the face of imperfections in the market, therefore, this study employed the Cobb-Douglas model in this study.

The Cobb-Douglas form of the stochastic frontier production function applied in this study is given thus:

$$LnY_i=\lambda 0 +\Sigma^{5}_{i=1} \lambda_i lnX_i + C\hat{i} \quad \text{.....vi}$$

Where; Y_i= output of potato in i^{th} farm (kg), X_1= Farm size (ha), X_2=Labour (Manday), X_3=Seed (Kg), X_4= Fertilizer (Kg), X_5= Pesticide (litre), Ln= Natural Logarithm, λ_0-λ_5 = Parameters to be estimated, $C\hat{i}$ = as defined in equation i

The inefficiency effect model is explicitly specified in its general form as follows:

$$U_i= \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \text{.....} \delta nZn + e\text{.....vii}$$

Where, Ui= inefficiency effect of i^{th} farm, Z_1= Age(in years),, Z_2= education(in years), Z_3= household size(in number of persons), Z_4 = Farming experience(in years), Z_5 =Extension visit (in number of visits) t, e=error term while δ_0 to δ_3 estimable parameters.

3.5.2 Gross Margin Analysis

The Gross Margin model is of the form:

$GM = GI - TVC.$

Where:

GM = Gross Margin of the Irish potato enterprise in naira per hectare

GI = Gross Farm income of the Irish potato enterprise in naira per hectare. This is the total physical product multiplied by the unit price of the product at the prevailing price.

TVC = Total Variable Cost of the Irish potato enterprise in naira per hectare (cost incurred on the variable inputs: seed, herbicides, pesticides, fertilizer, labour and transportation.)

Similarly, the Gross farm income was determined as:

$GI = \Sigma Y_i * pY_i$

Where:

Y_i = Output (kg) units of harvested Irish potato.

pY_i =Average price (₦) of harvested Irish potato.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socioeconomic characteristics of respondents

The socioeconomic characteristics of respondents are presented on Table 4.1. The socioeconomic characteristics of respondents are relevant in the investigation of the underlying factors that may lead to efficiency or inefficiency in production.

Age: The age of the respondents ranged from 18-68 years with a mean age of 44 years. About 36.7% of the respondents were between 40 and 50 years old being the modal class. This shows that the respondents were relatively young. Previous studies reported mean ages of 48 years by Obi-Egbedi and Midawa (2019). Hudu *et al.* (2018) reported 40 years, while Ojo (2005) reported 41 years.

Annual Income from Irish potato: The farmer with the least income earned ₦45,600, with the highest earner getting ₦4,924,800. The mean annual income of the respondents was ₦624,777.0. This means that the respondents were relatively stable income earners. Table 4.1 shows the frequency distribution of annual income divided into four classes while the mean income was calculated per respondent. Olalekan and Eyitayo (2015) reported that average arable crop farming household income was about ₦900, 000 per annum in Ekiti State Nigeria. Income equality is important in determining inefficiency. Todaro and Smith (2009) revealed that income inequality can lead to economic inefficiency. In this type of situation only a few of the crop farmers can efficiently determine the viability of the rural economy by their financial power. This implies that only the high-income earners in an economy can reach optimum levels of technical efficiency.

Table 4.1: Socioeconomic Characteristics of Respondents

Factor	Frequency	Percentage	Mean
Age			
18 – 28	10	5.6	44 years
29 – 39	60	33.3	
40 – 50	66	36.7	
51 and Above	44	24.4	
Total	180	100.0	
Annual Income (₦) from Irish potato			
250,000 and less	43	23.9	₦624,777.0
251,000 – 500,000	40	22.2	
500,100 – 750,000	48	26.7	
751,000 and Above	49	27.2	
Total	180	100.0	
Marital status			
Married	157	87.2	
Single	16	8.9	
Divorced	1	0.6	
Widowed	6	3.3	
Total	180	100.0	
Sex of respondents			
Male	120	66.7	
Female	60	33.3	
Total	180	100.0	
Farm Size			
Less than 1 hectare	92	51.1	1.5 ha
1 – 2 hectares	83	46.1	
2.1 hectares and above	5	2.8	
Total	180	100.0	
Extension visits			
No access to extension	39	21.7	
Access to extension	141	78.3	
Total	180	100.0	
Level of education			
No formal education	10	5.6	
Primary	27	15.0	
Secondary	69	38.3	
Tertiary	74	41.1	
Total	180	100.0	
Household size			
1 – 5	36	20.0	8 persons
6 – 10	119	66.1	
11 – 15	22	12.2	
Above 15 persons	3	1.7	
Total	180	100.0	
Farming experience			
1 – 10	85	47.2	16 years
11 – 20	49	27.2	
21 – 30	24	13.3	
Above 30	22	12.2	
Total	180	100.0	

Source: Field Survey, 2019

Marital status: Majority (87.2%) of the respondent were married while 8.9% of the respondents were single. About 0.6% were divorces and 3.3% of the respondents. As majority of the respondents had stable family units and a balanced social system, Matanmi *et al.* (2011) advanced that this could improve decision-making in technology adoption, production and domestic life. This is reasonable fact to suggest that marital status may have influence on the technical efficiency of the farmer.

Gender: Majority (66.7%) of the respondents were male while 33.3% were female. The result revealed that there were more men than women producing Irish potatoes in the study area. This depicts the typical case of dominance of men over women in agricultural settings. Similar findings were made by Zaknayiba and Mamma (2016) who reported that majority (70%) of Irish potato farmers in Bokkos were male which agrees with the findings of Adedoyin and Fapojuwo (2007) that men supplied large percentage of work force in Nigerian agricultural communities. Similar findings were also made by Hudu *et al.* (2018) who reported 62.5% male and Jwanya *et al.* (2014) who reported 84.17% male in their various studies thus agreeing that men dominate women in agriculture.

Farm size: Farm size range between 0.05 hectares and the 3 hectares with a mean of 1.5 hectares. The total land area cultivated by the respondents was 263.57 hectares and a little above half, (51.1%) of the farmers had less than 1-hectare of land. The implication of the finding is that the respondents were smallholders. Ogundari and Ojo (2007) previously affirmed that agriculture in Nigeria is characterized by smallholders typically ploughing 0.05 to 3.0 hectares of land area. Umar *et al.* (2017) observed that farm size was significant to technical efficiency. The mean farm size reported by Ojo (2005) was 3 hectares.

Extension contact: Majority (78.3%) of the respondents had access to extension while 21.7% had no access to extension services. This result is similar to the finding of Obi-Egbedi and Gulak (2019) who reported 75.4% access to extension. Greater extension contact implies increased exposure to the knowledge of technical skills and expertise on innovations that can improve technical efficiency. Asiabaka (2002) has advanced that extension can be viewed from three important dimensions, they are educational component, economic dimension and social dimension. Okwu and Ejembi (2001) have, however, reported that extension delivery in Nigeria is marked by a myriad of problems. The public agricultural development programme (ADP) has produced below its mandate with most farmers receiving one visit per annum or none at all.

Level of education: About 41.1% of the respondents had tertiary education certificates while 5% had no formal education. The result infers that the population has a fair level of formal education as most of the respondents had attained tertiary educational level. Ballara (1991); Ezeibe (2011) and Okoronkwo *et al.* (2009) have found strong correlation between productivity and a farmer's level of education. Typically, education provides an individual the capacity to understand and apply technical skills and adopt innovations as well as maximise the potentials of available technology.

Household size: The household size in the study area range from 3 to 18 members with a mean of 8 persons per household. There is significant correlation between household size and labour supply as most rural dwellers prefer to have large households that can provide labour for their farms. Oluwatayo *et al.* (2008) have asserted that larger household sizes provide the required family labour and reduce the cost utilized for hired labour. Nevertheless, Ike and Oboh (2009) have found correlation between large household size

and poverty. Mbanasor and Kalu (2008) and Bhatt and Bhat (2014) found household size significantly related to technical efficiency. Past findings show household sizes of 8 (Hudu *et al.*, 2019), 11 by Obi-Egbedi and Gulak (2018) while Ojo (2005) reported household size of 6.

Farming experience: The farmer with the least experience had 2 years while the maximum experience was 45 years. The average farming experience recorded in the study was 16 years. This means that there was high experience among the respondents about potato farming. The mean here is not significantly different from past studies, Obi-Egbedi and Gulak (2019) reported 18 years mean farming experience. Ojo (2005) also reported 18 years farming experience. Greater levels of farming experience can improve the farmers ability to make decisions and incorporate new technologies. Haruna (2010) found evidence that farming experience influences individual farmer's perception and understanding of the management requirements and consequently improved farm produce.

4.2 Profitability Analysis of Irish Potato Enterprise

The descriptive statistics of variables used in the study are presented in profitability Analysis Table 4.2. The amount of labour used range from 4.25-545.33 mandays with a mean of 24.1 man-days per hectare. Labour utilization for potato production revealed high variability. The average labour utilized has a coefficient of variation of 180%.

The quantity of seed used range from 100kg -10000kg with a mean seed rate for potato production in the area of 841.7kg/hectare which is below the recommended seed rate. The coefficient of variation was 140%. This infers variability among seed use of potato farmers. The quantities of herbicide and pesticide used were equal and ranged from 0-36 litres with a mean of 2.3 litres per hectare while fertilizer used range from 0-12,050kg with a mean of 616.2kg per hectare. Herbicide, pesticide and fertilizer use showed great variability among respondents with all of them recording zero usage by some respondents. The coefficient of variation was markedly higher than 100% which indicates significant variability among respondents. The land size range between 0.05 hectare and 3 hectares with a mean of 1.5 per hectare. This land area is lower than mean farm size reported by Hudu, *et al.* (2018) but higher than 0.7hectare reported by Jwanya, *et al.* (2014) for studies carried out in Plateau state. The output harvested range from 400kg-43200kg with a mean output of potato 3742.8kg per hectare. Although this output matches Nigeria's national output of 3,720.1kg per hectare (FAOSTAT, 2019), it is extremely low compared with the world average yield of 20,111 kg per hectare (FAOSTAT, 2019). A coefficient of variation of 130% for mean output per hectare shows highvariability of yield per hectare among respondents.

Profitability analysis of the potato enterprise shows the breakdown of costs and benefits derived from the enterprise by participants. The result of the profitability analysis presented in Table 4.2 shows that about 65% of the total variable cost was expended on seed at the cost of ₦215,264.78 per hectare. This cost was followed by the cost of fertilizer (a combination of NPK 15-15-15 and organic manure) with a mean cost of ₦54,087.38 per hectare and about 16.4% of the total variable cost (TVC). Further, labour constituted 12.4% of the TVC and had a mean cost of ₦41,004/ha. Mean cost of transportation was ₦13,331.01/ha and was worth 4% of the TVC. The total variable cost was ₦330,692.43/ha. The output per hectare was 3,742kg and average selling price of output was ₦114 per kg while the total revenue was ₦426,679.29. The gross margin of the potato enterprise was ₦95,986.86/hectare. The Return on Naira Invested (RNI) was ₦1.29. This infers that 29 kobo profit was made on every ₦1 invested. This means that the potato enterprise was relatively profitable. Incongruent to this finding, in a previous study, Jwanya *et al.* (2014) analysed the profitability of Irish potato production in Plateau State and found higher RNI of 2.64 with a gross margin of ₦655,637.88 per hectare. Yusuf and Wuyah (2015) found similar gross margin of ₦93,642.90 per hectare in the study carried out in Zaria, Kaduna State, Nigeria.

Table 4.2: Profitability Analysis of Irish Potato enterprise

Variable	Unit	Average quantity	Price/Unit	Cost/ha (N)	Percentages	Minimum	Maximum	Std. deviation	CV %
1. Variable Cost									
i. Seed	Kg	841.7	255.75	215,264.78	65.1	100	10,000	1,141.6	140
ii. Herbicide	Litres	2.29	1,436.78	3,290.22	1.0	0.0	36	4.6	200
iii. Pesticide	Litres	2.29	1,622.29	3,715.04	1.1	0.0	36	4.6	200
iv. Fertilizer	Kg	616.24	87.77	5,4087.38	16.4	0.0	12,050	1,368.4	220
v. Labour	Man-days	24.12	1,700	41,004	12.4	4.25	545.33	43.1	180
vi. Transportation	N	13,331.01	1	13,331.01	4	-	-	-	-
2. Total Variable Cost(TVC)= i+ii+iii+iv+v+vi	N/ha			330,692.43					
3. Revenue									
i. Output	Kg	3742.81	114	426,679.29		400	43,200	4,839.7	130
4. Gross Margin,TR-TVC	N/ha			95,989.86					
5. Returns per naira invested				1.29					
6. Land	Ha	1.5				0.05	3	7.4	493

Source: Field survey, 2019

Herbicide, pesticide and fertilizer use showed great variability among respondents with all of them recording zero usage by some respondents. The coefficient of variation was markedly higher than 100% which indicates significant variability among respondents. The land size range between 0.05 hectare and 3 hectares with a mean of 1.5 per hectare. This land area is lower than mean farm size reported by Hudu, *et al.* (2018) but higher than 0.7hectare reported by Jwanya, *et al.* (2014) for studies carried out in Plateau state. The output harvested range from 400kg-43200kg with a mean output of potato 3742.8kg per hectare. Although this output matches Nigeria's national output of 3,720.1kg per hectare (FAOSTAT, 2019), it is extremely low compared with the world average yield of 20,111 kg per hectare (FAOSTAT, 2019). A coefficient of variation of 130% for mean output per hectare shows high variability of yield per hectare among respondents.

Profitability analysis of the potato enterprise shows the breakdown of costs and benefits derived from the enterprise by participants. The result of the profitability analysis presented in Table 4.2 shows that about 65% of the total variable cost was expended on seed at the cost of ₦215,264.78 per hectare. This cost was followed by the cost of fertilizer (a combination of NPK 15-15-15 and organic manure) with a mean cost of ₦54,087.38 per hectare and about 16.4% of the total variable cost (TVC). Further, labour constituted 12.4% of the TVC and had a mean cost of ₦41,004/ha. Mean cost of transportation was ₦13,331.01/ha and was worth 4% of the TVC. The total variable cost was ₦330,692.43/ha. The output per hectare was 3,742kg and average selling price of output was ₦114 per kg while the total revenue was ₦426,679.29. The gross margin of the potato enterprise was ₦95,986.86/hectare. The Return on Naira Invested (RNI) was ₦1.29. This infers that 29 kobo profit was made on every ₦1 invested. This means that

the potato enterprise was relatively profitable. Incongruent to this finding, in a previous study, Jwanya *et al.* (2014) analysed the profitability of Irish potato production in Plateau State and found higher RNI of 2.64 with a gross margin of ₦655,637.88 per hectare. Yusuf and Wuyah (2015) found similar gross margin of ₦93,642.90 per hectare in the study carried out in Zaria, Kaduna State, Nigeria.

4.3 Input/Output Relationship in Irish Potato production

The maximum likelihood Estimates (MLE) of Cobb-Douglas production frontiers are presented in Table 4.3. It can be inferred that farm size (0.43) and seed (0.23) were statistically significant estimates of the Cobb-Douglas function at 1% and 5% respectively. This implies that 1% increase in farm size will lead to 0.43% increase in output of potato. On the other hand, 1% increase in seed would lead to 0.23% increase in the output of potato. The coefficients of labour and agrochemicals variables, though positively related to potato output, did not significantly influence potato output variation in the study area. The coefficient for fertilizer was negative and insignificant.

The elasticity estimate show that potato farmers were operating at increasing return to scale. This implies that if the combined inputs used in potato production increase by 1%, the output will increase by more than 1%. The findings bear similarity to the findings of Jwanya *et al.* (2014).

Table 4.3: Maximum likelihood estimate of Cobb-Douglas production frontier

Variable	Parameter	Coefficient	Std. Error	T-ratio
Constant	β_0	7.24***	0.83	8.72
Farm size	β_1	0.43***	0.13	3.35
Seed	β_2	0.23**	0.11	2.03
Agrochemical	β_3	0.04^{ns}	0.03	1.32
Fertilizer	β_4	-0.02^{ns}	0.05	-0.40
Labour	β_5	0.03^{ns}	0.06	0.50

*** – significant at 1%; ** – significant at 5%; * – significant at 10%; ^{ns} – not significant
Source: Field survey, 2019

4.4 Technical Efficiency among Irish Potato farmers

4.4.1 Efficiency Scores using Cobb-Douglas Frontier Model.

The efficiency scores obtained from Cobb-Douglas frontier model are presented in Table 4.4. The efficiency scores range between 36% and 99.7% with a mean score of 68% implying that potato farmers require about 32% cost saving technology to attain the status of the most efficient farmers given this model

The result revealed that substantial increases in productivity levels can be achieved by improving the technical efficiency of Irish potato farmers.

Table 4.4: Distribution of efficiency scores obtained using Cobb-Douglas frontier model

Efficiency range	Cobb-Douglas frontier	
	Frequency	Percentage
0.0 – 0.25	0	0
0.26 – 0.50	23	12.8
0.51 – 0.75	97	53.9
0.76 – 1.00	60	33.3
Total	180	100
Mean	0.68	
Minimum	0.36	
Maximum	1.00	

Source: Field survey, 2019

4.5 Factors influencing inefficiency of Irish potato production

The estimates of inefficiency effects using the Cobb-Douglas functional form are presented in Table 4.5. The coefficient of variance parameter show that σ^2 (sigma squared) was significantly different from zero while it was not significant for gamma (γ). The gamma (γ) value shows that 0.24% of the deviation from the potato output frontier were due to technical inefficiency. The sigma square which is significantly different from zero indicates a good fit and correctness of the distribution form assumed for the composite error term.

The result revealed that age was negative but not significant. Education was significant at 1% level and the negative sign of the coefficient indicated that education increased the efficiency of the potato production.

Table 4.5: Maximum likelihood estimate of inefficiency with Cobb-Douglas production frontier model

Common description		Cobb-Douglas Frontier		
Variable	**Parameter**	**Coefficient**	**Std. Error**	**T-ratio**
Constant	δ_0	1.61**	0.68	2.37
Age	δ_1	-0.17^{ns}	0.16	-0.01
Education	δ_2	-0.30***	0.10	-3.02
Household size	δ_3	-0.22*	0.13	-1.66
Farming experience	δ_4	0.26***	0.07	3.48
Extension	δ_5	-0.01^{ns}	0.08	1.55
Variance-parameter	σ^2	0.33***	0.04	9.03
Gamma	γ	0.0024^{ns}	0.01	0.16

*** – significant at 1%; ** – significant at 5%; * – significant at 10%. A positive sign on the coefficient means that the variable affects technical efficiency negatively.
Source: Field survey, 2019

This scenario for education implies that as farmers' education increases farmers technical inefficiency reduces. A farmer who has a higher level of education has the capacity to understand and adopt improved technology resulting in shifting upwards of his production frontier. In order words, farmers with greater years of schooling tend to be more efficient. Akudugu(2012) indicated positive relationship between education and participation in agriculture. Similarly, the household size was significant at 10% and reduced inefficiency of the farm firm. The implication of large household is that as the number of household increases, a pool of family labour becomes available. The coefficient for farming experience (0.26) was positive and was significant at 1%. This implies increased inefficiency suggesting that with more experience, the farmers became more inefficient. This contradicts Akudugu (2012) who indicated a negative relationship

between experience and inefficiency. Extension was not statistically significant under this study.

4.6 Constraints to Irish potato production

The constraints to respondents' potato production are presented in Table 4.6. The most important constraint identified by the respondents was high cost of inputs and it was ranked 1st. This was followed by inadequate credit facilities, ranked 2nd and selected by 93.9% of the respondents. The 3rd constraint was pest and diseases selected by 89.4% of the respondents. Lack of security on the farm (81.1%) was the 4th most important constraint identified by the respondents.

The 5th most important constraint was high cost of credits facilities. Credit facilities have continued to be high and hard to access to the agricultural sector. The sector was only able to access 4.02% of formal credits in Nigeria as at the third quarter of 2019 (Udegbunam, 2019). This low access to formal credits is even an improvement from what it was in 2008 where it was reported to be as low as 1% (CBN, 2008). Formal credits in Nigeria are characterized by collateral requirements and mostly two-digit interest rates both criteria are hard for farmers to meet given their resource and financial levels.

Table 4.6: Constraints to Irish Potato production in the area

Factor	Frequency*	Percentage*	Rank
High cost of inputs	174	96. 7	1st
Inadequate credit facilities	169	93.9	2nd
Pests and diseases	161	89.4	3rd
Lack of security on the farm	146	81.1	4th
High cost of credit facilities	140	77.8	5th
Poor prices of the potato	136	75.6	6th
Soil fertility problems	134	74.4	7th
Non availability of tractors	133	73.9	8th
Inadequate improved seeds	120	66.7	9th
Distance to the market	118	65.6	10th
Distance to the farm	115	63.9	11th
Inadequate knowledge about potato production	108	60.0	12th
Drought	106	58.9	13th
Inadequate labour	100	55.6	14th
Lack of extension visits	93	51.7	15th
Flood	81	45.0	16th

Source: Field Survey, 2019

* – Multiple response

Furthermore, poor prices of Irish potato (75.6%) was reported to be the 6th constraint. Farm gate prices are usually less than the final prices that middlemen sell the potatoes for industrial use and consumption by big consumable organizations like restaurants and hotels as well as high consuming eateries. Smallholder farmers often accept poor prices for their potato once the sales broker convinces them that their produce is low in quality (Oppong-Yeboah, 2015; Mangisoni, 2006). Poor prices can also be related to the fact that Irish potatoes are imported in very high quantity into Nigeria. Nda-Isaiah (2017) reported that Nigeria lost ₦76 billion every year to the importation of Irish potato.

These huge sums would have been used to improve the Irish potato industry in Nigeria providing better income for farmers and significant employment across the value chain. Shiferaw *et al.* (2006) also reported that smallholder farmers usually prefer farm gate

prices because they are immediate and will help the farmers not to incur extra cost on marketing and transportation.

Soil fertility problems (74.4%) was identified by respondents as the 7th constraint. Declining soil fertility has been a problem in Nigeria and is intensified by climate change and extreme weather conditions in the country. Nigeria is one of the countries with high declining soil fertility (FAO, 2001). There is no clean-cut Nigerian government policy on land planning act that protects rich farm lands from being converted into sites for other purposes (Teminski, 2012).

Non-availability of tractors (73.9%) was the 8th constraint identified by respondents. This is especially important because potato production is a labour-intensive operation and requires a lot of energy. There are about 35,000 units of tractors in Nigeria, the country's tractor density put at 0.27 hp/hectare is far below the Food and Agriculture Organisation (FAO)'s 1.5hp/hectare recommended tractor density especially in view of increasing population and the imperative to produce more food.

Inadequate improved seeds (66.7%) is the 9th constraint identified. Smallholder farmers' access to improved planting material is usually low. Aheisibwe *et al.* (2015) identified high cost of seeds, absence of clear seed delivery system and limited information as some of the barrier to smallholder farmers accessing improved Irish potato seeds.

Distance from the market was identified by 65.5% of the respondents and ranked 10th. This is a constraint as many smallholder farmers are not willing to incur extra cost transporting potato tubers to potential markets (Shiferaw *et al.*, 2006). Distance from the farm was identified as the 11th constraint and was selected by 63.9% of the respondents.

This is usually a constraint because fertile lands are found in more interior areas of locality.

Inadequate knowledge about potato production (60.0%) was the 12th constraint identified by respondents. This is often as a result of weak linkage between extension and smallholder potato farmers. The absence of knowledge of modern Irish potato production techniques is a limiting factor of the productivity potentials of potato production in the country. Adetimehin*et al.* (2018) reported a strong correlation between access to extension and knowledge of improve agriculture and increased farmers productivity.

Drought (58.9%) was the 13th constraint to potato production identified by respondents. Due to climate change and extreme variability in rainfall patterns the occurrence of flood was observable in the area and had the potential to impact on potato production. Eze (2018) found that agriculture is being currently constrained by the frequency of droughts in certain parts of the country.

Inadequate labour (55.6%) was the 14th most important constraint identified by respondents. As there is increasing migration of abled-bodied youths to urban centres getting farm labour was constrained and it had a telling effect on the output of respondents. Lack of extension visits (51.7%) was the 15th constraint to Irish potato production identified by the respondents. Yu and Mwangi, (2014) have hypothesized that agricultural extension has consistently played the role of economic diversification, increasing yield and income of farmers. The last constraint (45%) was flood and it was ranked 16th by the respondents. Bulus and Nimfa (2017) reported that frequent changes in climatic conditions, including floods, have a significant impact on Irish potato farming.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

An economic analysis of Irish potato production in Plateau State, Nigeria was conducted. A multistage sampling technique was employed to select 180 respondents for the study. Primary data were collected through a structured interview procedure. Descriptive and inferential statistics were employed to analyse the data collected. Data analysis tools included descriptive statistics, Gross Margin Analysis as well as the stochastic frontier model in Cobb-Douglas functional form.

The results revealed that the mean age of the respondents was 44 years and the population was fairly young. The mean annual income of the respondents was ₦624,777.0. Majority (87.2%) of the respondent were married while 8.9% of the respondents were single. The average size of landholding under Irish potato production was 1.5 hectares among the respondents. Majority (78.3%) of the respondents had access to extension while 21.7% had no access to extension services. The mean household size among respondents was 8 persons.

The mean output of potato in the area was 3,742.8kg per hectare. Labour utilization for potato production also revealed high variability. The mean labour utilized by respondents was 4.25 man-days per hectare while the maximum was as high as 545.33 man-days per hectare. About 65% of the total variable cost was expended on seed at the cost of ₦215,264.78/hectare. The gross margin of the potato enterprise was ₦95,986.86/hectare. The RNI was ₦1.29. This shows that Irish potato production is a lucrative business venture in Plateau State.

The technical efficiency mean was 68% using Cobb-Douglas frontier model meaning that potato farmers require about 32% cost saving technology to attain the status of the most efficient farmers. Overall, the results revealed that substantial increases in productivity levels can be achieved by improving the technical efficiency of Irish potato farmers. Farm size (0.43) and seed (0.23) were statistically significant in the production function. The inefficiency estimates revealed that education, household size and extension reduced inefficiency while farming experience increased inefficiency under the Cobb-Douglas model. Given the efficiency scores of the estimates, it can be stated that the farmers were technically inefficient.

5.2 Conclusion

Technical efficiency was below optimum and farmers would need cost saving technology to attain absolute efficiency. The profitability analysis however, revealed that Irish potato production is a profitable enterprise with high gross margin indicating that with improved efficiency, the profitability level would be higher in the study area.

5.3 Recommendations

i. The increase of area under Irish potato cultivation is recommended to allow for more efficient use of inputs such as labour, seed and fertilizer found to be inefficient from the study.

ii. Improved extension teaching and training methods can help farmers enhance their productive capacities and therefore raise their technical efficiency to the optimum levels. Frequency and quality of extension can improve technical and productive capacities of the farmers.

iii. High cost of inputs was identified as the principal constraint to Irish potato production in the study area. Therefore, the government and relevant agencies must develop better supply networks for the distribution and sales of high-quality inputs at subsidize rate.

iv. Inadequate credit facilities are constraints to the entire agricultural sector in Nigeria and not Irish potato production, therefore proper sensitization on special agricultural loan schemes of the CBN including AGSMEIS, CACS and Anchor Borrowers schemes should be given to smallholder farmers in order to enhance their expansion capacities and improve their production capacities.

v. Security constraint was a major concern in the study area. There is need for government to provide adequate security for farmers to reduce low productivity.

vi. The study recommends Cobb-Douglas as the best model to be used for technical efficiency estimation among Irish farmers in the study area.

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APPENDIX I

Department of Agricultural Economics and Extension
Faculty of Agriculture, Nasarawa State University Keffi,
Lafia- Shabu Campus

ar Respondent,

RESEARCH QUESTIONNAIRE.

is questionnaire will be used by a student (Uche, Christopher Obi, with Matriculation No: SU/AGR/MSc/AEM/0002/16/17) of the above address. His Research Topic is: **Comparison of bb Douglas and Translog frontier models in the analysis of Technical Efficiency in Irish tato production in Plateau state, Nigeria**. You are kindly requested to give him every operation necessary and fill the questionnaire as appropriate. Note that all information ovided will be treated with maximum confidentiality and will be used for academic research ly. Also note that all information required are for the 2018 cropping season.
ank you.

Questionnaire No: ----------

CTION A: SOCIO –ECONOMIC CHARACTERISTICS OF THE FARMERS

Local Government Area----------
Name of Village----------
Sex: (a) Male [ ] (b) Female [ ]
Age: How old are you?----------years
What is your Level of education? (Tick)
Non formal[ ] (b) Primary School Education[ ] (c) Secondary School Education[ ] (d) rtiary Education[ ] (e)others(specify please)----------
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Marital status:

a. married [ ] b. single [ ]
c. divorced [ ] d. widow [ ]
e. widower[ ] f. not married [ ]

Household size: How many people are in your household?----------
a. No of Adult Male [ ] b. No of Adult Female [ ] c. No of female children [ ]
d. No of male Children [ ]

What is your primary occupation?

a. farming [ ] b. trading [ ] c. civil servant [ ] d. fishing [ ] e. pensioner[ ]
f. hunting [ ] f. others(specify please)----------

Farming experience (How long have you been in Irish potato production?) ----------years

What other crops do you produce?

i. ---------- ii. ----------

iii. ---------- iv. ----------

v. ---------- vi. ----------

1. What is the size of your Irish potato farm Land?----------(ha)

2. What is the size of your total farm Land (Irish potato and others)----------
ıa)

3. How did you acquire your Irish potato farm land?

a. family land [ ] b. inheritance [ ] c. purchased [ ]

d. leased/rented [ ] e. community land [ ] f. gift [ ]

g. others (specify)----------

4. If purchased, what was the cost of the farm land?----------(N)

5. If rented, how much did you pay per annum?----------(N)

5. How did you get your Irish potato seeds?

a. PADP [ ] b. market [ ] c. gift [ ]

d. previous harvest [ ] e. others(specify)----------

7. If you paid for the Irish potato seeds, how much did you pay for the seeds used?----------
5)

3. What type of seeds did you use?

a. local variety[ ] b. improved variety[ ] c. both local & improved [ ]

). Do you belong to any farmers' cooperative association? (a) Yes [ ] (b) No [ ]

). If yes to question 19, for how long have you been a member?----------years

1. What benefit did you derive from the membership of the cooperative association?----------
---------- ----------

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2. Did any extension agent(s) visit your potato farm during the production period? (a)Yes [ ] b) No [ ]

3. If *yes* to no 22 above, how often did they visit in a year----------

4. if you were visited at no 23 above, what were the benefit(s) of the techniques learnt from the gent(s) to your potato farming?(Specify)----------

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ECTION B: INFORMATION ON INPUTS, OUTPUT AND SALES

5. Variable inputs

Seeds (Kg)

ble 1: Quantity of seeds used and their costs

ot number	Plot size (ha)	Quantity of potato seeds used(Kg)	Price of seeds used per Kg or *mudu* (N)

Herbicides (Kg/L)

ble 2: Quantity of herbicides used and their costs

	Type of herbicides	Quantity of herbicides used in litre	Price of herbicides used per litre (N)

. Pesticides

ble 3: Quantity of pesticides used their costs

	Type of pesticides	Quantity of pesticides used in litres	Price of pesticides used per litre (N)

. Fertilizers

ble 4: Quantity of fertilizers/manure used and their costs

N	Type of fertilizer	Quantity (Kg)	Price per Kg (N)
	In-organic(chemical fertilizer)		

	Urea		
	NPK		
	Others(specify please)		
	Organic (Manure)		

Labour

able 5: Information on family labour used on your potato farm

	Male adult			**Female adult**			**Children**		
	No of people engaged	No of days worked	No of hours worked/day	No of people engaged	No of days worked	No of hours worked/day	No of people engage	No of days worked	No of hours worked/day

able 6: Information about Hired Labour used on the potato farm

	Male adult				**Female adult**				**Children**			
	No of people engage	No of days worked	No of hours worked /day	Wage rate/ day	No of people engaged	No of days worked	No of hours worked /day	Wage rate/ day	No of people engaged	No of days worked	No of hours worked /day	Wage rate/day

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Table 7: Information on potato produced for the 2018 cropping season

S/N	Items	Quantity(Kg)- bag size should be indicated please(eg 25Kg, 50Kg, 100Kg etc)
i.	Total farm output	
ii.	Quantity consumed	
iii	Quantity donated/dashed out(gifts)	
iv.	Quantity left for planting	
v	Quantity sold after harvest	

Table 8: Information on potato sales

S/N	Items	Quantity sold in Kg or bag(indicate bag size pls)	Unit price per Kg or bag	Total income
i	potato			
ii	Others(specify)			

26. Total cost of transportation incurred :----------(N)

27. What type of farm equipment do you have?
(Allow for more than one answer where possible)
Wheel barrow [ ] Tractor [ ] Tricycle [ ] Simple Implements [ ] Oxen drawn plough [ ]

thers(specify)----------

8. If you did not have any at no 27, did you hire them for your farm activities? Yes[ ] No[ ]

9. If yes for number 28 above, at what cost did you hire them? ..... (N)

ECTION C: IRISH POTATO PRODUCTION CONSTRAINTS

). What were the major constraints of potato production? (Please, tick the problems ıcountered by you) in the table below,

N	Farmers' Constraints	Tick(√)
	Inadequate credit facilities	
	High cost of credit facilities	
i	High cost of inputs	
	Pests and diseases	
	Distance to the market	
	Poor prices of the potato	
i	High cost of transportation	
ii	Flood	
	Drought	
	Non availability of tractors	
	Inadequate labour	
i	Non availability of improved seeds	
ii	Inadequate improved seeds	
i	Lack of extension visits	
v	Lack of knowledge on potato production	
vi	Inadequate extension visits	
vii	Inadequate Knowledge about potato production	
viii	Lack of security on the farm	
x	Distance to the farm	
x	Soil fertility problems	
xi	Others(specify)	

1. Suggest some of the ways through which problems you ticked at no 30 above could be lved:----------

---

Thank you.

APPENDIX II

Raw data from the analyses

Socioeconomic characteristics

Sex

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	120	66.7	66.7	66.7
Female	60	33.3	33.3	100.0
Total	180	100.0	100.0	

Age

	Frequency	Percent	Valid Percent	Cumulative Percent
18 – 28	10	5.6	5.6	5.6
29 – 39	60	33.3	33.3	38.9
40 – 50	66	36.7	36.7	75.6
51 and Above	44	24.4	24.4	100.0
Total	180	100.0	100.0	

Mean = 44 years

LandSize

	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 1 hectare	92	51.1	51.1	51.1
1 - 2 hectares	83	46.1	46.1	97.2
2.1 hectares and above	5	2.8	2.8	100.0
Total	180	100.0	100.0	

Mean = 1.5 hectares

ExtVisits

	Frequency	Percent	Valid Percent	Cumulative Percent
No access to extension	39	21.7	21.7	21.7
Access to extension	141	78.3	78.3	100.0
Total	180	100.0	100.0	

School

	Frequency	Percent	Valid Percent	Cumulative Percent
No formal education	10	5.6	5.6	5.6
Primary	27	15.0	15.0	20.6
Secondary	69	38.3	38.3	58.9
Tertiary	74	41.1	41.1	100.0
Total	180	100.0	100.0	

HHSize

	Frequency	Percent	Valid Percent	Cumulative Percent
1 – 5	36	20.0	20.0	20.0

6 – 10	119	66.1	66.1	86.1
11 – 15	22	12.2	12.2	98.3
15 and Above	3	1.7	1.7	100.0
Total	180	100.0	100.0	

lean – 8 persons

FarmExp

arming experience (years)	Frequency	Percent	Valid Percent	Cumulative Percent
1 – 10	85	47.2	47.2	47.2
11 – 20	49	27.2	27.2	74.4
21 – 30	24	13.3	13.3	87.8
Above 30	22	12.2	12.2	100.0
Total	180	100.0	100.0	

lean = 16 years

AnuualIncome

nnual Income (₦)	Frequency	Percent	Valid Percent	Cumulative Percent
250,000 and less	43	23.9	23.9	23.9
251,000 - 500,000	40	22.2	22.2	46.1
500,100 - 750,000	48	26.7	26.7	72.8
751,000 and Above	49	27.2	27.2	100.0
Total	180	100.0	100.0	

ean – ₦624,777.0
d deviation – ₦551,720.1

Marital

	Frequency	Percent	Valid Percent	Cumulative Percent
married	157	87.2	87.2	87.2
single	16	8.9	8.9	96.1
divorced	1	.6	.6	96.7
widowed	6	3.3	3.3	100.0
Total	180	100.0	100.0	

Land Acquisition

	Frequency	Percent	Valid Percent	Cumulative Percent

Valid	family land	45	25.0	25.0	25.0
	Inherited	87	48.3	48.3	73.3
	purchased	25	13.9	13.9	87.2
	Leased/rented	19	10.6	10.6	97.8
	community land	2	1.1	1.1	98.9
	gift	2	1.1	1.1	100.0
	Total	180	100.0	100.0	

Constraints

(i) Inadequate credit facilities –	169	
(ii) High cost of credit facilities –	140	
(iii) High cost of inputs –	174	
(iv) Pests and diseases –	161	
(v) Distance to the market –		118
(vi) Poor prices of the potato –	136	
(vii)Flood –		81
(viii) Drought –		106
(ix) Non availability of tractors –	133	
(x) Inadequate labour –	100	
(xi) Non availability of improved seeds –	114	
(xii)Inadequate improved seeds –		120
(xiii) Lack of extension visits –		93
(xiv) lack of knowledge on potato production –		84
(xv) Inadequate knowledge about potato production –		108
(xvi) Lack of security on the farm –		146
(xvii) Distance to the farm –		115
(xviii) Soil fertility problems –		134

ew Estimates COBB-Douglas (10-12-2019)

e final mle estimates are :

	coefficient	standard-error	t-ratio
eta 0	0.72371011E+01	0.82965877E+00	0.87229851E+01
eta 1	0.42756319E+00	0.12780553E+00	0.33454201E+01
eta 2	0.23227040E+00	0.11435686E+00	0.20311016E+01
eta 3	0.40088134E-01	0.30300243E-01	0.13230301E+01
eta 4	-0.17864587E-01	0.45402575E-01	-0.39347078E+00
eta 5	0.32547586E-01	0.64983035E-01	0.50086282E+00

elta 0	0.16071777E+01	0.67672744E+00	0.23749261E+01
elta 1	-0.16733265E+00	0.15740684E+00	-0.10630583E+01
elta 2	-0.30070395E+00	0.99553991E-01	-0.30205112E+01
elta 3	-0.22280008E+00	0.13399238E+00	-0.16627817E+01
elta 4	0.25546654E+00	0.73322687E-01	0.34841404E+01
elta 5	-0.12965173E-01	0.83568556E-01	-0.15514415E+00
gma-squared	0.33297875E+00	0.36860233E-01	0.90335498E+01
amma	0.23925672E-02	0.14796194E-01	0.16170152E+00

iciency Estimates

chnical efficiency estimates :

firm	year	eff.-est.
1	1	0.64990864E+00
2	1	0.69901043E+00
3	1	0.77053886E+00
4	1	0.65146671E+00
5	1	0.79456060E+00
6	1	0.59051705E+00
7	1	0.61924466E+00
8	1	0.66453661E+00
9	1	0.96663798E+00
10	1	0.90702571E+00
11	1	0.79338734E+00
12	1	0.99664948E+00
13	1	0.67139304E+00
14	1	0.82080653E+00
15	1	0.97459683E+00
16	1	0.84121101E+00
17	1	0.58338025E+00

18	1	0.81321269E+00
19	1	0.80066571E+00
20	1	0.86551910E+00
21	1	0.64348693E+00
22	1	0.41311994E+00
23	1	0.70751202E+00
24	1	0.80229710E+00
25	1	0.90138279E+00
26	1	0.72141672E+00
27	1	0.80309588E+00
28	1	0.79410437E+00
29	1	0.49918052E+00
30	1	0.98469165E+00
31	1	0.46031728E+00
32	1	0.60066857E+00
33	1	0.90260344E+00
34	1	0.60825414E+00
35	1	0.52901168E+00
36	1	0.80229710E+00
37	1	0.79697396E+00
38	1	0.76463785E+00
39	1	0.55622719E+00
40	1	0.62314277E+00
41	1	0.88552644E+00
42	1	0.59426214E+00
43	1	0.87054491E+00
44	1	0.91590634E+00
45	1	0.83995013E+00
46	1	0.74792591E+00
47	1	0.99607468E+00

48	1	0.96615130E+00
49	1	0.40095753E+00
50	1	0.85276877E+00
51	1	0.76218623E+00
52	1	0.98336767E+00
53	1	0.93424601E+00
54	1	0.99446771E+00
55	1	0.95300330E+00
56	1	0.85167931E+00
57	1	0.92668222E+00
58	1	0.83861009E+00
59	1	0.71103706E+00
60	1	0.99181683E+00
61	1	0.82407778E+00
62	1	0.64337079E+00
63	1	0.97624580E+00
64	1	0.98866295E+00
65	1	0.88155943E+00
66	1	0.84036142E+00
67	1	0.71662500E+00
68	1	0.97752251E+00
69	1	0.86319569E+00
70	1	0.81137660E+00
71	1	0.86879745E+00
72	1	0.81622028E+00
73	1	0.65782980E+00
74	1	0.83465795E+00
75	1	0.57626492E+00
76	1	0.79940258E+00
77	1	0.71971105E+00

78	1	0.54260189E+00
79	1	0.67936905E+00
80	1	0.61895836E+00
81	1	0.59447179E+00
82	1	0.90365814E+00
83	1	0.56205442E+00
84	1	0.56869420E+00
85	1	0.50310110E+00
86	1	0.50370373E+00
87	1	0.65581884E+00
88	1	0.45908265E+00
89	1	0.74946851E+00
90	1	0.57674457E+00
91	1	0.62431031E+00
92	1	0.57639742E+00
93	1	0.61149215E+00
94	1	0.59702081E+00
95	1	0.62883201E+00
96	1	0.56003895E+00
97	1	0.62369089E+00
98	1	0.57137756E+00
99	1	0.56321866E+00
100	1	0.53013286E+00
101	1	0.58809772E+00
102	1	0.59490329E+00
103	1	0.66553091E+00
104	1	0.60303947E+00
105	1	0.59296029E+00
106	1	0.54293101E+00
107	1	0.67181983E+00

108	1	0.64660255E+00
109	1	0.54329779E+00
110	1	0.47233005E+00
111	1	0.48710012E+00
112	1	0.55637436E+00
113	1	0.54888388E+00
14	1	0.51203608E+00
15	1	0.62404580E+00
16	1	0.57334376E+00
17	1	0.46791300E+00
18	1	0.48605380E+00
19	1	0.57754050E+00
0	1	0.52048313E+00
1	1	0.51442786E+00
2	1	0.53883888E+00
3	1	0.52011123E+00
4	1	0.53400639E+00
5	1	0.49373206E+00
5	1	0.45905400E+00
7	1	0.60360413E+00
3	1	0.64380115E+00
9	1	0.71782828E+00
	1	0.60876446E+00
	1	0.35641940E+00
	1	0.56879570E+00
	1	0.59240588E+00
	1	0.92064978E+00
	1	0.46349135E+00
	1	0.89003906E+00
	1	0.53326580E+00



138	1	0.63295112E+00
139	1	0.56077954E+00
140	1	0.57218690E+00
141	1	0.50704202E+00
142	1	0.58712559E+00
143	1	0.46358392E+00
144	1	0.64039870E+00
145	1	0.47609430E+00
146	1	0.78394928E+00
147	1	0.80065723E+00
148	1	0.65794935E+00
149	1	0.67481108E+00
150	1	0.90566417E+00
151	1	0.90628604E+00
152	1	0.57598581E+00
153	1	0.69278416E+00
154	1	0.61830438E+00
155	1	0.92206795E+00
156	1	0.99521241E+00
157	1	0.50658650E+00
158	1	0.68393762E+00
159	1	0.47324615E+00
160	1	0.82181479E+00
161	1	0.66185205E+00
162	1	0.65636390E+00
163	1	0.67581881E+00
164	1	0.44264555E+00
165	1	0.86043476E+00
166	1	0.61965923E+00
167	1	0.47916529E+00

168	1	0.61459862E+00
169	1	0.49059358E+00
170	1	0.44009282E+00
171	1	0.50640939E+00
172	1	0.72145563E+00
173	1	0.58782764E+00
174	1	0.69627052E+00
175	1	0.61602796E+00
176	1	0.60097042E+00
177	1	0.55504096E+00
178	1	0.72687803E+00
179	1	0.68176239E+00
180	1	0.46374413E+00

mean efficiency = 0.68220850E+00

Tanslog

The final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.30033964E+01	0.17852481E+01	0.16823411E+01
beta 1	-0.25330049E+01	0.96981458E+00	-0.26118445E+01
beta 2	-0.62233718E+00	0.88854730E+00	-0.70039848E+00
beta 3	-0.48538159E+00	0.40400093E+00	-0.12014368E+01
beta 4	0.10988370E+01	0.53066855E+00	0.20706653E+01
beta 5	-0.17377245E+01	0.94452356E+00	-0.18397894E+01
beta 6	-0.83342026E+00	0.29551824E+00	-0.28201990E+01
beta 7	0.40603353E+00	0.22492507E+00	0.18051946E+01
beta 8	-0.60252034E-01	0.71566699E-01	-0.84190041E+00

beta 9	-0.20551318E-01	0.30467137E-01	-0.67454051E+00
beta10	-0.45033165E-02	0.10634302E+00	-0.42347083E-01
beta11	0.18219956E+00	0.16464657E+00	0.11066101E+01
beta12	-0.27147535E-01	0.66638569E-01	-0.40738472E+00
beta13	0.31234780E+00	0.12166035E+00	0.25673754E+01
beta14	-0.17843059E+00	0.19199934E+00	-0.92932918E+00
beta15	0.56105164E-01	0.51827799E-01	0.10825303E+01
beta16	-0.33088368E+00	0.10522916E+00	-0.31444107E+01
beta17	0.42106639E-01	0.14742551E+00	0.28561298E+00
beta18	0.12270234E-01	0.32510093E-01	0.37742845E+00
beta19	0.35489004E-01	0.52024885E-01	0.68215440E+00
beta20	0.13829137E+01	0.64162292E+00	0.21553371E+01
delta 0	-0.56156825E+00	0.11231045E+01	-0.50001426E+00
delta 1	0.16107854E+00	0.69814209E+00	0.23072457E+00
delta 2	0.63532561E+00	0.11250963E+01	0.56468554E+00
delta 3	-0.53773132E+00	0.99125471E+00	-0.54247543E+00
delta 4	0.12060897E+01	0.10245077E+01	0.11772383E+01
delta 5	0.51835737E+00	0.97349852E+00	0.53246858E+00
delta 6	-0.83808724E-01	0.57629496E+00	-0.14542679E+00
delta 7	-0.12350281E+01	0.53930404E+00	-0.22900405E+01
delta 8	0.18797427E+00	0.36478549E+00	0.51530084E+00
delta 9	0.46819095E-01	0.17464732E+00	0.26807795E+00
delta10	-0.56152904E+00	0.33046623E+00	-0.16992025E+01
delta11	0.58017538E+00	0.50245284E+00	0.11546862E+01
delta12	-0.27235035E+00	0.58362108E+00	-0.46665612E+00
delta13	-0.42323414E+00	0.29113128E+00	-0.14537570E+01
delta14	0.67673851E-01	0.33711383E+00	0.20074481E+00
delta15	-0.41016270E-01	0.43438406E+00	-0.94423977E-01
delta16	0.90624571E-02	0.13407915E+00	0.67590356E-01
delta17	-0.21591032E+00	0.20838878E+00	-0.10360938E+01

delta18	-0.22064508E+00	0.19346272E+00	-0.11405044E+01
delta19	0.47352486E+00	0.40966483E+00	0.11558836E+01
delta20	0.26794238E+00	0.12569605E+00	0.21316690E+01
sigma-squared	0.32078098E+00	0.58778766E-01	0.54574296E+01
gamma	0.40902009E+00	0.11823876E+00	0.34592726E+01

log likelihood function = -0.13798069E+03

Technical efficiency estimates :

firm	year	eff.-est.
1	1	0.96027138E+00
2	1	0.59897552E+00
3	1	0.40551604E+00
4	1	0.66853394E+00
5	1	0.71123102E+00
6	1	0.63823374E+00
7	1	0.48115094E+00
8	1	0.51061657E+00
9	1	0.87155531E+00
10	1	0.59326009E+00
11	1	0.63943730E+00
12	1	0.90283444E+00
13	1	0.89418829E+00
14	1	0.76158315E+00
15	1	0.60362549E+00
16	1	0.67426257E+00
17	1	0.46128971E+00
18	1	0.53755193E+00
19	1	0.72681654E+00

20	1	0.75579246E+00
21	1	0.58801596E+00
22	1	0.38893963E+00
23	1	0.67237875E+00
24	1	0.71921866E+00
25	1	0.81809677E+00
26	1	0.58527050E+00
27	1	0.75695260E+00
28	1	0.64609743E+00
29	1	0.64018709E+00
30	1	0.89435280E+00
31	1	0.61372646E+00
32	1	0.66212578E+00
33	1	0.60361859E+00
34	1	0.61080234E+00
35	1	0.77277805E+00
36	1	0.71921866E+00
37	1	0.72993686E+00
38	1	0.86628925E+00
39	1	0.63371809E+00
40	1	0.41918663E+00
41	1	0.80768377E+00
42	1	0.69538580E+00
43	1	0.85475564E+00
44	1	0.82423674E+00
45	1	0.73135139E+00
46	1	0.57417298E+00
47	1	0.76999383E+00
48	1	0.86899190E+00
49	1	0.42546170E+00

50	1	0.72925030E+00
51	1	0.74970437E+00
52	1	0.88745832E+00
53	1	0.86334718E+00
54	1	0.92619200E+00
55	1	0.82357073E+00
56	1	0.89451267E+00
57	1	0.77538663E+00
58	1	0.44857137E+00
59	1	0.59320283E+00
60	1	0.87031167E+00
61	1	0.84682951E+00
62	1	0.89356133E+00
63	1	0.83741281E+00
64	1	0.91188892E+00
65	1	0.59242679E+00
66	1	0.85773906E+00
67	1	0.42046106E+00
68	1	0.88776665E+00
69	1	0.47366035E+00
70	1	0.83298511E+00
71	1	0.92299837E+00
72	1	0.77255665E+00
73	1	0.62474924E+00
74	1	0.78017115E+00
75	1	0.74602962E+00
76	1	0.69976084E+00
77	1	0.51772305E+00
78	1	0.31744059E+00
79	1	0.67380732E+00

80	1	0.44232892E+00
81	1	0.54337324E+00
82	1	0.72431348E+00
83	1	0.39130652E+00
84	1	0.36004276E+00
85	1	0.48383342E+00
86	1	0.36346856E+00
87	1	0.47891692E+00
88	1	0.30967709E+00
89	1	0.73136393E+00
90	1	0.48911073E+00
91	1	0.63175765E+00
92	1	0.60073289E+00
93	1	0.37476372E+00
94	1	0.38506878E+00
95	1	0.63810316E+00
96	1	0.61009304E+00
97	1	0.50891118E+00
98	1	0.53783824E+00
99	1	0.57538750E+00
100	1	0.69037734E+00
101	1	0.61075576E+00
102	1	0.46801654E+00
103	1	0.57932567E+00
104	1	0.35829459E+00
105	1	0.39023792E+00
106	1	0.30799012E+00
107	1	0.32116100E+00
108	1	0.44786197E+00
109	1	0.61496061E+00

110	1	0.76259784E+00
111	1	0.58329089E+00
112	1	0.76240285E+00
113	1	0.52538537E+00
114	1	0.56257001E+00
115	1	0.54235742E+00
116	1	0.41522254E+00
117	1	0.69015172E+00
118	1	0.63348845E+00
119	1	0.69753206E+00
120	1	0.64251860E+00
121	1	0.57950233E+00
122	1	0.31304027E+00
123	1	0.62468209E+00
124	1	0.62223415E+00
125	1	0.57686656E+00
126	1	0.61920870E+00
127	1	0.38044158E+00
128	1	0.39201671E+00
129	1	0.74305759E+00
130	1	0.43134139E+00
131	1	0.34653707E+00
132	1	0.39654640E+00
133	1	0.41237746E+00
134	1	0.41322886E+00
135	1	0.27985200E+00
136	1	0.74370379E+00
137	1	0.29823857E+00
138	1	0.41486963E+00
139	1	0.39553548E+00

140	1	0.45722575E+00
141	1	0.41594954E+00
142	1	0.48338268E+00
143	1	0.40060123E+00
144	1	0.43024499E+00
145	1	0.20756043E+00
146	1	0.51747756E+00
147	1	0.43235971E+00
148	1	0.54162116E+00
149	1	0.49466288E+00
150	1	0.78701921E+00
151	1	0.69096907E+00
152	1	0.74104540E+00
153	1	0.48317399E+00
154	1	0.38876958E+00
155	1	0.72195982E+00
156	1	0.63847890E+00
157	1	0.42955491E+00
158	1	0.46635354E+00
159	1	0.34158824E+00
160	1	0.57414931E+00
161	1	0.64495358E+00
162	1	0.58165291E+00
163	1	0.61818211E+00
164	1	0.41156559E+00
165	1	0.46762558E+00
166	1	0.58682148E+00
167	1	0.27499952E+00
168	1	0.47583716E+00
169	1	0.27847759E+00

170	1	0.14076713E+00
171	1	0.40564987E+00
172	1	0.33982392E+00
173	1	0.42853167E+00
174	1	0.37172488E+00
175	1	0.39053852E+00
176	1	0.44159581E+00
177	1	0.56013568E+00
178	1	0.72893806E+00
179	1	0.74059930E+00
180	1	0.66264914E+00

mean efficiency = 0.59125854E+00

T-Test

Notes

Output Created		30-DEC-2019 04:05:14
Comments		
	Data	C:\Users\BRIAN\Documents\Uche translog and cobdouglas analysis 2020.sav
	Active Dataset	DataSet0
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	180
	Definition of Missing	User defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on the cases with no missing or out-of-range data for any variable in the analysis.
Syntax		T-TEST PAIRS=COBBDouglas WITH TRANSLOG (PAIRED) /CRITERIA=CI(.9500) /MISSING=ANALYSIS.
	Processor Time	00:00:00.02
	Elapsed Time	00:00:00.14

Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
COBBDouglas	.6822	180	.15950	.01189
TRANSLOG	.5913	180	.17720	.01321

Paired Samples Correlations

	N	Correlation	Sig.

Pair 1	COBBDouglas & TRANSLOG	180	.615	.000

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	COB-DOUGLAS-TRANSLOG	.09094	.14851	.01107	.06910	.11279	**8.216**	179	**.000**