PROCESSING TECHNIQUES AND EFFICIENCY DIFFERENTIALS AMONG RICE PROCESSORS IN NIGERIA

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DEDICATION

This thesis is whole heartedly dedicated to God Almighty, my husband and children and the loving memories of my late parents, Pastor Olanrewaju Onaolapo and Deaconess Adewunmi Alake Abe-Ajakaiye OJEWUMI, who despite all odds believed in me and took full responsibility for my education.

ABSTRACT

The quality of processed rice is optimised by processing techniques used. It also impacts on the efficiency differentials among processors when paddy is transformed into edible rice. However, information on the nexus between processing techniques and efficiency differentials among rice processors is scanty. Hence, processing techniques and efficiency differentials among rice processors in Nigeria were investigated.

A four-stage sampling procedure was adopted. Ogun and Ekiti (South-West), Ebonyi (South-East) and Nassarawa (North-Central) States were purposively selected based on high rice processing activities. Twenty-three Local Government Areas (LGA) were selected in Ogun (4), Ekiti (5), Ebonyi (7) and Nassarawa (7) States using sample proportionate to size with respect to processing centres in the state. Twenty-five (Ogun), 20 (Ekiti), 15 (Ebonyi and Nassarawa) rice processors were randomly selected from each LGA resulting into 410 rice processors. Information on socio-economic characteristics (age, household size, marital status, educational status) and processing characteristics (years of processing experience, paddy-source, processing-techniques, membership of processing association, processing activities, distance to processing centre) were collected using structured questionnaire. Index of processing techniques was categorised into Traditional-Techniques (<0.2-0.39), Traditional and Modern-Techniques (0.40-0.79) and Purely Modern-Techniques (>0.79). Data were analysed using descriptive statistics, Multinomial Logit regression, Data Envelopment Analysis and Tobit regression model at $ά_{0.05}$.

Age and household size of processors were 47.8±9.9 years and 6.5±4.2 persons, respectively. Majority (88.7%) were married, 73.6% had formal education and years of experience was 16.4±9.2. Overall, 65.7%, 20.4% and 13.9% used Traditional and Modern-Techniques, Traditional-Techniques and Purely Modern-Techniques, respectively. Main processing activities were parboiling and drying (50.0%), milling (40.0%) and de-stoning (10.0%). The probability of choice of Traditional-Techniques relative to Traditional and Modern-Techniques reduced by years of education (4.5%), paddy source (1.8%) and distance to processing centre (4.4%), while probability of choice of Purely Modern-Techniques relative to Traditional and Modern-Techniques increased for male processors (7.3%), membership of processing association (18.0%) and other income sources (6.2%). Technical Efficiency (TE) was 0.4±0.3, 0.5±0.6 and 0.8±0.9 for Traditional-Techniques, Traditional and Modern-Techniques and Purely Modern-Techniques, respectively. Allocative Efficiency (AE) was 0.4, 0.6 and 0.9 for Traditional-Techniques, Traditional and Modern-Techniques and Purely Modern-Techniques, respectively; while Economic Efficiency (EE) was 0.8, 0.3, 0.2 for Purely Modern Techniques, Traditional and Modern-Techniques and Traditional-Techniques, respectively. The TE differentials of Purely Modern-Techniques relative to Traditional and Modern-Techniques and Traditional-Techniques were 0.4 and 0.5, respectively. The AE differentials of Purely Modern-Techniques relative to Traditional Modern Techniques and Traditional-Techniques were 0.3 and 0.5, respectively, while EE differentials of Purely Modern-Techniques relative to Traditional and Modern-Techniques and Traditional-Techniques were 0.5 and 0.6, respectively. This implies Purely Modern-Techniques had higher TE, AE and EE than Traditional and Modern-Techniques and Traditional-Techniques. Efficiency of rice processors increased with years of education (β=0.01); paddy source (β=0.01); membership of processing association (β=0.09) and years of processing experience (β=0.02) while it decreased with distance to processing centre (β=-0.01).

Technical, allocative and economic efficiency were low among rice processors that used traditional, and traditional and modern techniques; and high among processors that used purely modern techniques.

Keywords: Rice processing activities, Rice processors, Traditional processing techniques, Efficiency differentials.

Word count: 491

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``*Our God is indeed faithful*``

O.O. Obisesan

CERTIFICATION

I certify that this work was carried out by Omobolaji Olubukunmi OBISESAN under my supervision in the Department of Agricultural Economics, University of Ibadan.

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Supervisor

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MEANING OF ABBREVIATIONS AND ACRONYMS

ABS	Anchor Borrowers' Scheme (Programme)
ACCESSCRE	Access to credit
AGE	Age of rice processor
AMIS	Agricultural Market Information Systems
ATA	Agricultural Transformation Agenda
DEA	Data Envelopment Analysis
DISTPADY	Distance of paddy source to processing unit
EDUSTA	Educational Status of rice processor
EXP	Experience in years as a rice processor
FAO	Food and Agriculture Organisation
FMA&RD	Federal Ministry of Agriculture & Rural Development
GESS	Growth Enhancement Support Scheme
GRAIN Report	Global Agricultural Information Network Report
GRiSP	Global Rice Science Partnership
HOUSIZE	Household size of rice processor
LABO	Labour
MAININC	Main income source
MARTSTA	Marital status of rice processor
MEMASS	Membership of rice processing association
MNL	Multinomial Logistic Regression
MNP	Multinomial Probit Regression
NBS	National Bureau of Statistics

NFRA	Nigeria Food Reserve Agency
NPC	National Planning Commission
NRDS	National Rice Development Strategy
NRDS	Nigerian Rice Development Strategy
OTHERINC	Other income sources
PADTSOU	Paddy source
PIF	Presidential Initiatives on fertilizers
PMT	Purely Modern Techniques
RIFAN	Rice Farmers' Association of Nigeria
RIPAN	Rice Processors' Association of Nigeria
RTFA	Recursive Thick Frontier Approach
SCPZ	Stable Crops Processing Zones
SDG	Sustainable Development Goals
SEX	Sex of rice processor
STTFA	Stochastic Production Frontier Approach
Tradmodern	Traditional and Modern Techniques
TT	Traditional Techniques
USAID	United States Agency For International Development
USDA	United States Department of Agriculture

CHAPTER ONE
INTRODUCTION

1.0 Background to the study

Rice (*Oryza sativa*) is a plant that is extremely old with its exact time and place of origin not too precise (Global Rice Science Partnership – GriSP, 2013). It is a major food crop supplying over 52 percent of man's calorie intake alongside wheat and maize (Agricultural Market Information System - AMIS, 2016). It has become the dominant staple with special imprint of rice-stalks, husks and grains traced to Asia, Europe and America – GriSP, 2013). It found its way into African continent from movement of persons through slave trade and bilateral movements (Global Agricultural Information Network Report - Grain Report, 2015) and has henceforth become an accepted staple introduced into African diet from other nations of the world (Food and Agricultural Organization – FAO, 2016).

Rice a food crop of importance and an acceptable source of calorie to many households in Nigeria (Inuwa *et al.* 2011) has had an increase in its demand dated back to the early 1970s (1971-1977) which was the era of oil boom [1](Ado, 2017; Ammani, 2013; Scherr, 1989). This increase in demand can be attributed to its acceptability during that era, and up until now. The demand for rice could also be attributed to rapid urbanisation, increased income levels[2], population growth, taste, change in family's occupational structures and perceived status of households (Okeowo, 2016; Inuwa *et al.* 2011). Rice production activities include cultivation, harvesting, storage, processing[3], packaging, transportation and marketing (Ogisi *et al.* 2012; Ugalahi *et al.* 2016); while rice-processing is an important and distinct feature in rice production, involving the transformation of harvested paddy into edible-rice (Grain Report, 2015). Rice processing techniques is the practical method or art applied in converting paddy into edible rice (www.wordweb.info). The quality and appearance of paddy[4] are therefore dependent on techniques used; based on the ability to efficiently transform inputs into outputs (paddy into edible rice) (Okpe *et al.* 2014), thereby, suggesting that the quality and

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[1] Source: (http://www.onlinenigeria.com/economics/).
[2] resulting from moving out of agricultural related jobs to white collar jobs
[3] Processing is a form of value addition geared toward increasing quality of commodities produced within sectors of an economy (United States Department of Agriculture (USDA), 2016). This implies that value added to a product at each stage of production determines the rate at which the products will appeal to a prospective buyer (Oguntade, 2011).
[4] Rice paddy is the raw rice removed from harvested stalks brought in from the field. This paddy could either be kept as seed for the next season, stored until times of scarcity or transformed through series of processes/processing for sale and consumption to final consumers (Mabette, 2014).

appearance of processed rice will determine overall acceptance and revenue derivable (Oguntade, 2011; Patil, 2016); while final output and outlook of processed rice is dependent on the efficiency of techniques of processing (Okpe *et al.* 2014).

Consequently, efficiency which is an aspect of production[5] results when scarce resources (inputs) are harnessed in such a way as to produce the best possible results (outputs) (Oladebo and Oluwaranti, 2014). Efficiency involves transforming inputs to obtain end products reflecting best practice (Nazaki *et al.* 2013; Nimoh *et al.* 2012). Processing efficiency is a quality change of inputs to outputs at the least cost possible (Saediman *et al.* 2015; Akerele, 2014). The overall goal of processing efficiency centres on techniques[6] and choices made by processors in an input-output combination which must be cost-minimizing or profit maximising (Talujdar and Vatta, 2016; Olayide and Heady, 2006). Choice on the other hand can be described as the selection among alternatives, based on preference and utility maximisation (Korh and Eijk, 2003; Unnevehr, 1992, 2015). Meanwhile, preferences and maximisation of utility alone do not determine choice (Korh and Eijk, 2003). Choices are further dependent on budget and other major constraints. Thus, the choice of a processing technique is dependent on processors' budget, preferences, utility-maximisation and other constraints (Korh and Eijk, 2003; Olayide and Heady, 2006). This signifies that choice and efficiency of techniques and equipment used during processing affect output and quality of locally processed rice (Donkoh and Awuni, 2013; Oluwatoyin, 2011).

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[5] Production according to Olayemi (2004) is the process, techniques or technology of transforming input into output. However, this definition does not suggest or imply how efficient the process is/might be, hence the reason for the study of the efficiency of the processes/techniques/technology used in production.

[6] **Techniques**

1. Practical method/art applied to some particular task

Technologies

1. Operationalisation of science in commerce or industry
2. Branch of knowledge addressing art or science and applying scientific knowledge to practical problems (www.wordweb.info).
3. ***Thus; the reason why the use of techniques which is a simple easy to relate with definition which is most appropriate/applicable in this study, as against technology***.

1.2 Problem Statement

The Food and Agriculture Organization in 2016 predicted that a combination of low oil prices, increased consumption, climate change and increase in the need for grains may mean that the era of cheap supply of grains, especially rice, has come to an end. The implication of this was a gradual increase in the cost of rice (FAO, 2016). Worse hit as regards this low oil prices and high cost of grains is Nigeria in Sub-Saharan Africa and West African sub-region (FAO, 2016). Sequel to this, at the country level according to FAO (2017) Nigerian's paddy production and milled rice equivalent (July, 2017) were 5.3 and 3.2 million tonnes, respectively[7]. This figures, when compared to the country's population and rice output of other countries is very low, thereby implying that the paddy and milled-rice produced in the country is not enough, and this is a reason for the disparity between milled rice equivalent and harvested paddy. This therefore, is a contrasting situation considering governments' effort to promote production growth and attain self sufficiency through diverse initiatives such as the Growth Enhancement Support Scheme (GESS), Anchor Borrowers' Programme plus Presidential Initiatives on fertilizers (to support rice farmers and rice production in Nigeria). This therefore does not adequately bridge the gap and the disparity between harvested paddy and milled rice equivalent wherefore further widening the demand-supply gap; hence a reason why importation of rice into the country has been on the increase (FAO, 2017).

Rice has been identified as a crop that can be used in the achievement of goal two of the 17[8] Sustainable Development Goals (AMIS, 2016). However, due to limited production of paddy and the gap[9] witnessed in actual transformation of paddy into edible rice which actually results from improper processing and management, the achievement and actualization of SDG two with rice might be difficult in Nigeria. Subsequently, despite Nigeria's pronounced increase in rice production (Abba and Mohammed, 2000; FAO, 2017)[10], it is still a paradox

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[7] RIFAN on the 18th of May, 2017 in one of Nigeria's daily Newspapers confirmed this based on a pronouncement made that rice produced in the country as at the middle of May 2017 has risen to about 5.8 million metric tons, while the demand has also shifted to about 8 million metric tons (www.punchng.com, Nigerian Television Authority, NTA network centre).

[8] Goal 2 of the 17 sustainable development goals: Zero Hunger.

[9] This gap in actual fact are the losses witnessed in the course of processing rice

[10] Punch News Paper, Published on May 17, 2017. Rice output increased to 5.8m tonnes in 2017 RIFAN (Rice Farmers Association of Nigeria); www.punchng.com.

that the country still imports rice, which means the true situation was, the rice produced in the country does not actually meet demand (Okeowo, 2016). While, the little produced is lost during processing. Pre-supposing that there is no proper focus on the link between paddy production and transformation via agricultural processing (Fleshman, 2008; Ado, 2017).

Consequently, those involved in transforming agricultural products (processors) are fewer (FAO, 2017). When processing is carried out, about one-third of the produce never reaches consumers (FAO, 2013; Omonona *et al.* 2010). This results from low efficiency of equipment and machines used, as well as inadequate allocation of inputs and resources (www.irri.org/rice-today/adding-value-to-africa-s-rice). Thus, it suggests that a sizeable amount of farmers' produce and processors' proceeds is lost during processing (Onyekwena, 2016; Patil, 2016).

Although rice processing in Nigeria has witnessed diverse focus and attention by diverse stakeholders among whom were Rice Farmers Association (RIFAN), Rice Processors Association (RIPAN), State governments etc, there is still the unanswered question on why rice processed locally is not enough. Likewise, when rice is processed, why is it not meeting the demand of Nigeria's teeming population? For instance, states like Lagos and Kebbi are into partnership in cultivation and sale of locally processed rice, named Lake Rice. University of Ibadan is also in partnership with Benue state government in production and processing of rice locally. Similarly, there is the provision of soft loans to rice out growers in Taraba state and engagement of rice farmers/out-growers by Olam in Nassarawa state etc (www.punchng.com). However, results generated from all these partnership are not bridging the rice-gap strong enough to nullify importation. This therefore implies that there is a lot to be done in order for local rice processing to meet the expectations and demand of rice-consumers in Nigeria. Hence, the reason why this study is focussed primarily on rice processing techniques in order to identify techniques available to processors, what informs the choice of these techniques and the efficiency of these techniques.

Another important factor affecting value-addition and processing of agricultural products, especially rice (Ado, 2017) is the inadequate knowledge and inaccessibility to technologies or techniques (Nimoh *et al.* 2012; Donkoh and Awuni, 2013). There is also a situation of high cost of facilities and spare parts [11] (Oluwatoyin, 2011). This, coupled with inconsistent

[11] resulting into continuous use of poor equipment and facilities

government policies[12], is limiting the support rice processors get in the long run. Organized markets are also not helping matters; they are not in favour of rice processed in the country because the processing cost per unit of rice is high (Basorun, 2013). Instead of supporting, local rice processing, they opt for parboiled imported rice from countries like Vietnam, Indonesia, China and India (Strker, 2010). Likewise, getting consistent varieties of rice from local farmers all year round is another challenge of rice-processing (GRAIN Report, 2015). Another major challenge was the fragmentation of the processing enterprise, which makes it difficult to create quality brands and standards[13] among local actors (National Rice Development Strategy (NRDS, 2009; 2013). Other technological challenges faced during rice processing in Nigeria are: use of sun as dryer, old and outdated parboilers and mills; lack of de-stoning machines; use of firewood[14]; high cost of diesel to power milling machines; manual de-hulling and winnowing to mention but a few (Mbuk *et al.* 2011).

Furthermore, a recent twist to the problem associated with agricultural production and most importantly processing of locally processed rice in Nigeria is the incessant problem of Boko-Haram insurgency in North eastern Nigeria, Niger Delta militancy and the problem of Fulani cattle herders (Aghedo and Osumah, 2014; Sidney *et al.,* 2017). The problems associated with these insurgent groups and their incessant problems have made it difficult for peasant farmers and processors to attain high level of productivity as a result of constant unrest. Their actions in these regions have also reduced government interventions, supply and provision of subsidies and reduction in farming and rice processing activities as well as no access to credit.

In concluding this section, the perception that rice processing is all about milling is also misleading (Nazaki, 2013). There are other processing activities/procedures carried out before rice is milled. These includes threshing, winnowing, sorting, parboiling and drying, while de-stoning and packaging is usually done after milling (Mabette, 2014). The Agricultural Transformation Agenda (ATA) and other stakeholders sadly also have their focus on milling of rice while all other aspects of rice processing outside milling seem

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[12] high exchange rate to purchase equipment and no support for local fabricators/fabrication

[13] Due to the fact that the process from paddy harvesting to threshing, hulling, winnowing to parboiling and milling is based on how buoyant the processors were. This therefore determines the quality of edible rice consumers eventually gets (NRDS, 2013).

[14] as major source of energy in par-boiling

insignificant (NRDS, 2013). Therefore, there is a call for the meagre rice produced in the country to be well accounted for by properly focussing on processing which forms the focus of this study.

1.3 Research Questions

The following were the questions that guided this study;

i) Which rice processing techniques are available to processors in the study area?
ii) What factors determine choice of the processing techniques made by processors?
iii) Are rice processors efficient based on the techniques used?
iv) What is the efficiency differential among rice-processors by the techniques?
v) What are the factors determining the efficiency of rice processors based on the techniques used?

1.4 Objectives

The main objective of this study is to examine the efficiency differentials among rice processors as a result of the processing techniques used. The specific objectives are to:

i) profile rice processing techniques,
ii) analyze determinants of the choice of processing techniques used,
iii) examine efficiency of rice processors by the techniques
iv) estimate the efficiency differentials of processors by the techniques used.
v) examine the determinants of efficiency of rice processors by the techniques

1.5 Justification of the study

The food sub-sector in Nigerian parades diverse staple crops, and rice has surfaced at a preeminent position (FAO, 2017). Consumption has been increasing at an alarming rate since mid 1970s (FAO, 2015; Ugalahi *et al.* 2016). As such, the rice sub-sector of the nation is expected to produce paddy that can bring about over 6 million metric tons of quality edible rice to satisfy the increasing demand (FAO, 2017). However, actual production was put at about 3 million metric tons milled equivalent, such that there is a short fall (FAO, 2016; 2017). The short fall was ascribed to unequal production and improper management of paddy during processing (FMA&RD, 2014); hence, a reason for the choice of this study.

The United State Department of Agriculture in 2016, imputed a large amount of losses during paddy transformation due to techniques and management at processing; further buttressing the inappropriate management of paddy witnessed during processing as iterated by Federal Ministry of Agriculture, Water Resources and Rural Development (FMA&RD)[15]. They also assert that, all efforts will become futile with unconventional processing, handling and management; as rice will end up not being consumed because they are not of quality and standard. Hence this conclusion motivates this research on rice processing with a view to complementing the efforts of enhancing farm-level processing activities (Macaulay, 2015; USAID, 2009).

Agriculture, a major driver of the economy, has been focused on by the Nigerian governments at different points in time (National Planning Commission (NPC), 2009). However commitment over the past years to the sector has not yielded the desired results (Merem *et al*. 2017). Therefore, domestic creation of agric products is on the downward turn causing a form of scarcity, as the major areas of agriculture like processing, quality equipment, and facilities have not been in focus (Nazaki *et al.* 2013; Akerele, 2014). Hence, a good reason for this research on rice processing techniques and efficiency differential.

Although, there is need for evaluation to reduce cost, it is more likely that promoting efficiency at processing and management will be more cost effective (USDA, 2016). Furthermore, there is high disposition towards other countries' rice which are not as nutritious and of quality when compared to that produced in the country (Ogundele, 2014). A significant reason for this is the perception that imported rice is better in quality, has better price advantage and appealing lustre than that processed in the country (Oyinbo *et al.* 2013). Therefore, the increasing demand for rice by local and urban consumers as staple is enough a reason for the country to focus more on better rice processing options (Ijoku, 2016). This is also part of the motivation for this research.

This research further has its justification on the area of study. Rice grows well in the country (Ezedinma, 2013; FMA&RD, 2014); however, some states in Nigeria specialize in its production and processing more than others (Staple Crops processing zone (SCPZ); ATA, 2011-2014; Nigerian Food Research Agency, (NFRA), 2008). These states in no particular order are: Kwara, Nassarawa, Ebonyi, Ekiti, Ogun, Kaduna, Niger, Kebbi, Enugu, Cross-rivers, Benue, Rivers, Bayelsa, Imo, Anambra, Osun, Edo, Delta, Kogi, Taraba and Akwa-

[15] Federal Ministry of Agriculture, Water Resources and Rural Development in Nigeria.

Ibom (Ezedinma, 2013). Hence, the reason why this study was carried out in three geo-political zones focussing on four rice producing and processing states in the country, based on their long and standing contribution to rice production and processing (Nigerian Food Research Agency (NFRA), 2008).

Studies like those of Ogundele (2014); Sowunmi *et al.* (2014) examined preference of consumers for imported and/or domestic rice in Nigeria; while others have looked at technical efficiency differentials among rice producers in Nigeria (Okoruwa *et al*. 2006; Okoruwa and Ogundele, 2006; Olarinde, 2011; Kadiri *et al.* 2014). Tolga *et al.* (2010) focused on technical efficiency and determinants of efficiency of rice farms in Turkey. Nazaki *et al.* (2013) researches on factors influencing farmers' choice for selling milled versus un-milled rice. Nasiru (2014) examines factors influencing adoption of improved rice processing technologies. Tiamiyu *et al.* (2014) researches on on-farm and post-harvest rice quality heightening technology adoption while Oguntade (2011)'s research is on the protection and comparative advantage in rice processing. However, with all the aforementioned researches, none has carried out research coalescing processing techniques and efficiency differentials of processors. Therefore, this research will be adding more to knowledge on value addition/transformation (also called rice processing) as it relates to techniques, and efficiency of techniques of rice processing in Nigeria.

In examining/investigating choice, methodologies like, Probit and Binary Logit have been used (Javier, 2013). They are however limited to dichotomous dependent variables and do not give room for variability in more than two dependent variables. The Ordered Probit, when used as a determinant of choice, must have the dependent variables following a natural ordering having a weight greater than the former or vice-versa (Nazaki *et al.* 2013). Hence, the Multinomial Logit regression model (MNL) was preferred in the analysis of choice in this study. MNL allows for the choice probability of more than two alternatives which could be compared relative to other categories (Hahn and Soyer, 2008; Bamidele *et al.*, 2010; Viton, 2014). MNL also allows for the choice of more than two categorical dependent variables which were mutually exclusive and is unmoved when alternatives are added or deleted (Ojo *et al.* 2013). The selection of this model is also founded on its better execution ability with discrete choice framework (McFadden, 1997; Judge *et al.* 1985).

Methodologically, in estimating efficiency, two generalized methods (the parametric and non parametric methods) are common (Noor and Mahazir, 2010). The parametric approach especially the stochastic frontier function helps in capturing in-efficiency and factors beyond the control of processors (Okoruwa and Ogundele, 2006; Oladeebo and Oluwaranti, 2014). It also captures any measurement errors and observable or non observable white noise. The stochastic frontier approach however is limited in that; it necessitates the fitting of a functional form, which at times might not be a good judge in efficiency measurement (Watkins *et al.* 2014). This therefore necessitated the introduction of the Data Envelopment Analysis (DEA) which is a non-parametric method of measuring efficiency. DEA has the capacity of equating the efficiency performances of different decision making units (DMUs) (Okeke *et al.* 2012).This non-parametric method or approach of measuring efficiency is however limited in that it is deterministic in nature. It lacks a well defined data generating process and it is vulnerable to outliers and measurement errors when not properly managed and when making use of very large data sets (Watkins *et al.* 2013). However, it is able to augment for the classical regression model by a non-positive error term, with no need of fitting a qualified functional form (Sale and Sale, 2016).

The Tobit regression model was used in this study as next stage regression for analysing determinants of efficiency of processing techniques (Rahman and Awerije, 2015). Although, the Tobit regression accommodates more than two variables, it was not the most suitable option in the analysis of choice because the dependent variables must be censored in a range of 0 to 1 (Bhatta *et al.* 2011; Rahman and Chima, 2016). Therefore, in the estimation of the determinants of efficiency, it was able to augment for any measurement error that could have occurred during the DEA analysis (Ogunniyi and Oladejo, 2011).

1.6 Organisation of the report

This thesis is segmented into five main chapters; first is the introductory section and this contains the background to the study, problem statement, objectives and justification. The second chapter reviews concepts, theories and existing literatures on production, efficiency, choice and rice processing. Chapter three presents research methodology which consists of the area of study, data and sampling procedures and techniques of analysis employed in this study. The fourth chapter discussed the findings, while the fifth chapter consists of the conclusion, summary, policy implications, recommendations, limitations to the study and areas of further research.

CHAPTER TWO

LITERATURE REVIEW

This chapter discusses theories which underpin this study. These are theories of production and choice. There is a theoretical review on measurement of choice, efficiency and rice processing systems. There are empirical and methodological reviews on production, efficiency, choice and rice processing.

2.1 Theoretical Review

2.1.1 Theory of Production

Production cannot be easily defined without an understanding of what producers of goods and services do (Greene, 2007). A producer is an economic agent that takes an input and transforms it in form, shape or location into an output (Duffy and Papageorgiou, 2000; Paul, 2015). This theory exhibits theoretical and empirical framework facilitating adequate selection among alternatives so that any one or all of the production objectives[16] are attained. Thus, the production process is one wherein goods are changed to other goods called output (Olayide and Heady, 2006). The main pointers of production as a major aspect of economics are those of maximization and minimization, although, there might be other goals and aims. The maximization problem comes about when the decision maker sets out to maximize profit, utility/satisfaction while that of minimization is the reduction of cost of inputs used (Rahji *et al.*, 2015). In production, a decision maker/entrepreneur faces constraints which must be overcome in order to achieve the goals of profit maximization and cost minimization (Debertin, 2002).

2.1.2 Production function

This stipulates the technical relationship between inputs and outputs in a production process. In mathematical terms, this is assumed to be continuous and differentiable. This differentiability renders capable rate of return (Olayide and Heady, 2006).

[16] Production Objectives (Processor's Objective) is Output maximization, Profit maximization, Utility/Satisfaction maximization and Cost minimization (Olayide and Heady, 2006).

Mathematically:

$$g = f\ (T) \qquad (1)$$

Where g is output, T is vector of input(s) which could be T_1, T_2, T_3.........$T_{n.}$

Thus, the production function links the maximum total output producible by using each combination of inputs (Kadiri *et al.* 2014). In discussing the production function, an understanding of parameters like the average product and marginal product is a requisite. The average product of an input is determined in response to the proportion of the total output to the total input while the marginal product is a derivative of the total output to that of the total input. This can be explained as:

$$\text{Average Product (AP)} = \frac{q}{x} \qquad (2)$$

$$\text{AP} = \frac{f(X)}{X} \qquad (3)$$

$$\text{Marginal Product (MP)} = \frac{dq}{dx} \qquad (4)$$

$$\text{MP} = \frac{df(X)}{dX} \qquad (5)$$

These parameters i.e. the Average Product (AP) and the Marginal Product (MP) will help the decision maker (in production) to determine and specify the use of inputs, maximize outputs and profits and reduction of cost (Olayemi, 2004).

2.1.3 Agricultural Production

Agricultural production can be viewed as an economic theory concerned with the production of agricultural commodities (Derbertin, 2002). It touches on the goals and objectives of the decision maker. It is also concerned with the choice of outputs to produce, allocation of resources, assumption of risks and uncertainty, and the competitive environment in which the farm/firm will operate (Uwaoma, 2015). Agricultural production seeks to determine the efficiency at which inputs employed in the process of production produces output in an optimal manner (Derbertin, 2002).

2.1.2.1 Returns to Scale

An important aim of agricultural production economics is returns to scale (Olayemi, 2004). It depicts what happens to output when all the factors of production are changed simultaneously by the same percentage (Olayide and Heady, 2006). It also signifies what goes on when inputs are increased or decreased by a factor (Ismatul and Andriko, 2013). Assuming we have inputs say labour or capital and they are doubled or reduced by a factor say m, we would desire to know if output doubled, less than double or remain exactly as it was before the increase or decrease of input. As such, a terminology like the constant returns to scale is used when inputs are raised by a constant (d), and the resultant output increases exactly. Decreasing returns to scale is when inputs are increased by a multiplier effect (m), and output increases by less than the effect (m). Increasing returns to scale is when inputs are increased by (m) while output now increased by more than (m).

2.1.2.2 Efficiency and Production

Efficiency concept is concerned with the comparative performance of the processes used when metamorphosing given inputs to outputs (Bifarin *et al.* 2010). Efficiency in production can be explained as the ability to derive maximum output per unit of input used (Dictionary and Thesaurus, 2001; Ogundari *et al.* 2006). Farrell (1957) keys out three types: Technical, Allocative and Economic efficiency.

2.1.2.3 Technical Efficiency

Kahrajan and Veragunsingh (1992) describes technical efficiency (TE) as the ability and disposition of an economic unit to produce maximum attainable output from given inputs based on technologies regardless of demand and market prices of inputs and outputs. O'Neill *et al.* (2006) views technical efficiency via its elasticity value as the output change percentage given input change percentage. If producers were producing and elasticity value is more than one, then technical efficiency is yet to be reached (Perez *et al.* 2007). Technical efficiency can be achieved when producers are bringing forth elasticity values in range zero and one (Suresh *et al.* 2008). This implies that the greater the TE ratio as it moves towards 1 (one), the greater the magnitude of technical efficiency (Akanbi *et al.* 2011).

In line with stochastic frontier production function, technical efficiency of processors will be outlined as ratio of the observable output to its corresponding frontier output, conditioned by levels of inputs (Carmill, 2008; Isa and Abur, 2012).

Thus, the technical efficiency of a processor *i* is:

$$TE_i = Yi/Yi^* \quad (6)$$

$$TE_i = h\ (Xi, \beta)\ \exp\ (v_i - u_i)\ /\ h\ (Xi, \beta)\ \exp(vi)\ \exp\ (-u_i) \quad (7)$$

This expressed further:

$$TE_i = \frac{E(\frac{Yi}{UiXi})}{E(\frac{Yi}{Ui},Xi)} \qquad (8)$$

$$TE_i = E(\frac{-Ui}{Ei}) \qquad (9)$$

$$TE_i = \exp(-u_i), \qquad (10)$$

That is: TE_i = Technical efficiency of processor *i*= TE; Observed output=Y_i;

Frontier output= $Yi*$; X_i = inputs; ε= error-terms, v_i-u_i = decomposed error terms; while Technical efficiency of a producer/processor/farmer ranges from 0 to 1 (Okoruwa *et al*. 2010).

2.1.2.4 Allocative efficiency

This can be described as choosing of optimal sets of inputs (Eze *et al.* 2010). Allocative efficiency occurs at a point where marginal value product equals the marginal factor cost i.e. MVP = MFC (Earfan Ali and Samad, 2013). Also called price efficiency it's the ability of decision makers to select inputs in cost-minimizing way (Murillo-Zamorano, 2004).

Mathematically, allocative-efficiency could be written as:

$$MVPx_i = Px_i \qquad (11)$$

$$MVPx_i / Px_i = 1 = k_i \qquad (12)$$

$$\text{Where } MVPx_i = MPx_i . P_y \qquad (13)$$

$$MPx = b . \frac{y}{x} \qquad (14)$$

If k_i=1, equation (12) signifies that input utilization is efficient, k_i>1 means that utilization of input is not yet efficient, more needs to be added; while k_i<1 stands for over utilization there is need for reduction in input used (Ismatul and Andriko, 2013). The allocative efficiency rule of thumb could also be put as when MVP=MFC is allocative efficiency. MVP>MFC = under utilization of inputs, hence there is room for increased utilization of input; while MVP<MFC= over utilization of inputs, hence inputs should be reduced (Adesimi, 1982; Emakaro and Erhabor, 2006; Izekor and Alufohai, 2014).

2.1.2.5 Economic efficiency

Economic efficiency bears on capacity to produce preset quantity of output at minimal cost using given level of technology (Dictionary and Thesaurus, 2001). It is elicited when technical and allocative components of efficiency are multiplied (Bravo-Ureta, 1997). Economic efficiency occurs when there is both technical and allocative efficiency (Earfan Ali and Samad, 2013). The simultaneous achievement of both efficiencies (allocative and technical) occurs when price relationship are engaged to indicate maximum profits. All the three measures (technical, allocative and economic efficiencies) are delimited between zero and one (Murillo-Zamorano, 2004).

2.1.3 Theory of Choice

Choice theory is a way of analyzing how equilibrium is achieved between preferences and expenditures in order to maximize utility (Fousekis and Pantzios, 2000) and this is subject to consumer budget constraints (Korh and Eijk, 2003). This theory is based on the assumption that there is a full understanding of choices and preferences (Griliches, 2005; Ying So, 2014). Consequently, choice is viewed as the selection from a given set of alternatives (Rahman and Chima, 2016) subject to budget and income (Korh and Eijk, 2003). Utility maximization, preference(s) and budget constraints are therefore important attributes in a consumer's choice set. This is the reason why economists have devised innovative indirect measurement methods of assigning monetary value to market goods (Louviere, 2000; Sakisan, 2010). This includes revealed and stated preference techniques which rely on observable behaviour in order to decide how much a particular commodity is worth and how much it is traded in markets (Louviere, 2000). In as much as product quality describes the characteristics of market goods, their economic value will thus be revealed in their market prices which will determine if a consumer will demand for the good or not (Oguntade, 2011). This therefore suggests that:

i) The utility of each set of alternatives must first be assessed
ii) The choice is now made based on a set of decision rules and utility maximization.

In order words, utility function can be built having an ordinal or a cardinal scale with choice(s) made by decision rules based on attributes and utility maximization.

2.1.3.1 The Cardinal Utility Concept

Cardinal Utility concept suggests that utility is measurable, and decision makers can assign numerical utility values to alternative bundles of commodities (Olayemi, 2004). It also implies that the numerical values represent measurements on at least equal interval which should be even on an equal ratio scale.

Mathematically, this can be represented as:

$$U = f(q_1, q_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots, q_n) \qquad (15)$$

$U = u_1 + u_2 + \dots\dots\dots\dots\dots\dots\dots, u_n)$ (16)

Where: $q_1, q_2 \dots\dots\dots\dots\dots\dots\dots, q_n$ are individual commodities in the bundle

$u_1 + u_2 + \dots\dots\dots\dots\dots\dots\dots, u_n$ represents the individual utility contents derivable from the n commodities in the bundle. However, due to the restrictive assumptions of the cardinal utility concepts, there arose strong criticisms about it. This therefore led to the ordinal utility concept.

2.1.3.2 The Ordinal Utility Concept

The ordinal utility concept assumes that the decision maker is rational enough to rank commodity bundles in an order of preference (Olayemi, 2004). The ordinal utility represents a unique simplification of the rationality behind the assumption of the cardinal utility concept. Therefore, when decision makers are ranking preferences, the ranking is expressed by the decision makers' utility function which is unique up to a monotonic transformation[17]. The most important to the decision maker is the realization that one commodity bundle has a utility greater than another or a commodity bundle with lesser utility than another.

Mathematically, the ordinal scale can be represented as:

$U_1 = f\ (q_1 q_2)$ (17)

This equation can be transformed as:

$U_2 = f\ (kq_1, kq_2)$ for $K > 0$ (18)

Hence, the most important factor guiding the choice made by decision makers[18] is that consumers are rational and they have the objective of maximizing utility or satisfaction.

2.1.3.3 Choice by decision rule and utility maximization

In contrast to the individual choice theory where decision makers are faced with bundles of commodities and decisions are made based on rationality and utility satisfaction or maximization, Kroh and Eijk (2003) show that rationality and satisfaction are not the exclusive determinants of decisions made. They suggest that preferences, administrator/decision-makers decision/choices and other constraints are also crucial.

For instance:

Utility function can be maximized as:

$Max_{q1 \geq 0, q2 \geq 0} U_1 = f\ (q_1 q_2)$ (19)

[17] Monotonic transformation is a mathematical sequence or function; consistently increasing and never decreasing. It could also be an ever decreasing and never increasing value.

[18] For either the ordinal as well as cardinal utility concept

This according to Kroh and Eijk must be subject to some constraints:

$q_1x + q_2y \leq \Phi$ (20)

where Φ could be Income, Price, and other socio and demographic characteristics.

This means the equation based on Φ can be estimated as:

U_1 = f (Income, Price, and other socio and demographic characteristics) (21)

Not forgetting rationality and preferences of decision makers.

The overriding equation for decision-makers' choices made will now be written as:

U_1 = f (Preference, rationality of decision makers, income, price, and other socio and demographic characteristics) (22)

i.e. (q_1q_2) = f (Preference, rationality of decision makers, income, price, and other socio and demographic characteristics) (23)

However, since majority of these factors are non-quantifiable, they can be exemplified in a model by some expressions in order to assume a deterministic component. Therefore the safest application of the above equation is for it to be represented in an equation as:

U_1 =f (Prices, Income and ε) (24)

Where ε = preference, rationality of decision makers, and other socio and demographic characteristics. Hence, this can be used to model the deterministic component of the variables of expression and choice based on utility and preferences of processors

2.2 Methodological Review

2.2.1 Choice Models

Choice model explains the behaviour of respondents when they are faced with diverse options, having common consumption objectives (McFadden *et al.*, 1997; Javier, 2013). Some choice models have been used to exemplify selection of one among a set of mutually exclusive options (Carson *et al.* 1994). In an adoption decision involving choices, analytical tools that are normally used include: binary logit model, binary probit model, multinomial logit (MNL) model, multinomial probit (MNP) model, the nested logit model etc (Javier, 2013).

2.2.1.1 Logistic Regression

Logistic regression models have being used to address discrimination problem and model the probability of a "success" or "failure" as a function of several explanatory variables (Noorhosseini-Niyaki and Allahyari, 2012). Thus, it provides an appropriate alternative to multiple linear regressions when the response variable is binary (i.e. either 0 or 1). Logistic regression is useful in any situation where the response variable is of the "either-or" type (Arellanes and Lee, 2003; Ying So, 2014). Logistic regression models are usually used in the analysis of binary responses and/or proportional odds models. Hence, logistic regression models, probit regression models and the binary logit regression models are a bit similar, and used when the dependent variables are dichotomous in nature (Lopez, 2014).

2.2.1.2 Ordered Probit

Ordered Probit is the most frequently used when dependent variables are measured in an ordinal scale (Gunes *et al.* 2016). Outcomes must be easy to rank according to a single criterion (Etwire *et al.* 2013) with the result showing significantly different outcomes (Williams, 2008). This thus explains that with significant ordering of variables, different outcomes will be generated (Greene, Harris and Hollingsworth, 2012). It suggests that results are sensitive to how variables are ordered before use in the model (Elias *et al.* 2015). This can be further explained as, if the ordered probit-model showed statistical significance for the rank of choices or categories, the interpretation of the independent variables would be conditioned on the premise/assumption implicit on the rank and ordering of these dependent variables (Tobias, 2009). However, in the aftermath of relaxing the ordering of variables, a multinomial regression model that ignores ordering of values/variables can be used (Benoit, 2012).

2.2.1.3 Probit Regression

This likewise is used in analysing binomial response variables, which are reasonable choices when changes in the cumulative probabilities are gradual (Hahn and Soyer, 2008). The use of a probit model is justified on the premise of dichotomous dependent variable, suggesting using a binary model (Martey *et al.* 2013). A probit regression fit random effects models with moderate data sets. However, when there are sharp changes, other link functions should be used (Donkoh and Awuni, 2013).

2.2.1.4 Multinomial Probit Model (MNP)

The multinomial probit model (MNP) easily fits in a class of choice models which comprise of multinomial logit (MNL), generalized extreme values (GEV), mixed logit models (MXL) (Alvarez and Nagler, 2001). It does not enforce the restrictive assumption that choices are independent across alternatives; however, these pose a series of significant problems (Bond, Soderbom and Wu, 2011). These problems might be difficult to trace in the absence of fact-finding and exceptional efforts (Bartholomew and Horowitz, 1991). The commonest of these is that MNP specifications are weakly identified in application (Brokešovà *et al.* 2014); the reason why so many researchers are silent about its usage in real life situations. This problem of weak identification is severe because it is not easily diagnosed leading to wrong inferences (Williams, 2008). Many times the MNP presents a difficult maximum likelihood optimization problem that occasionally fails to meet at a unifying optimum (Brokešovà *et al.* 2014). The MNP also produces parameter estimates that may be imprecise making statistical inferences subject to suspicion.

2.2.1.5 Multinomial Logit Model (MNL)

The Multinomial logit regression (MNL) is usually used when there are multiple categories which are not necessarily ordered, or when they can be ordered but the parallel/ordinary regression assumption cannot hold (Sarkisian, 2010). In MNL, the order of categories is not important, and the model can be equated to simultaneous estimation of multiple logits (Long and Freese, 2001). In this wise, each category is compared with preselected base category, of which if estimated separately vital information will be lost (Williams, 2016). The multinomial logit (MNL) model is also an important tool when it comes to analyzing adaptation decisions (Javier, 2013; Long and Freese, 2001).

Probabilities of diverse possible outcomes of a categorically distributed dependent variable can be predicted by the model with availability of independent variables (Viton, 2014). The model explains the behaviour of respondents when they are faced with diverse choices having a common consumption objective (Mcfadden.*et al.* 1997). The multinomial logit regression, like other classification in statistical techniques, introduces the construction of a linear prediction function from a set of weights and then linearly combines them with the explanatory variables (Danso-Abbeam *et al.* 2014).

For instance:

$$\operatorname{score}(\mathbf{X}_i, k) = \boldsymbol{\beta}_k \cdot \mathbf{X}_i, \qquad (25)$$

where $\mathbf{X}_i$ is vector of explanatory variables describing observation *i*, $\boldsymbol{\beta}_k$ is a vector of weights or regression coefficients corresponding to outcome *k*, and score ($\mathbf{X}_i$, *k*) is the score associated with assigning observation *i* to category *k*. . In order to achieve this, in this study, the multinomial logistic regression is used.

(econweb.umd.edu/~kaplan/courses/intmicrolecture4.pdf).

2.2.2 Efficiency

The efficiency concept deals with relative performance of processes used in changing given inputs into outputs (Dictionary and Thesaurus, 2001). Another way to define it is the ability to derive maximum output per unit of input used (Fried *et al.* 2008). Efficiency measurements can take the form of parametric and non-parametric methods (Green, 2007). The nonparametric approach assumes a deterministic approach which does not allow for any random disturbance (Ismatul, 2013). It does not make use of functional forms that takes on the shape of the frontier. Example of which are the Data Envelopment Analysis (DEA), Free Disposal Hull (FDH) and the Partial Frontier Efficiency (PFE) (Noor and Mahadzir, 2010). However, unlike parametric approach, nonparametric approach enforces less structure on the frontier (Kahrajan, 1992; Ismatul, 2013). They do not allow for random errors resulting from luck, data collection problems and other errors of measurement (Drake and Hull, 2013).

The parametric method of measuring efficiency on the other hand allows for deviations from the frontier (Aigner *et al.* 1977). The error term can be decomposed for adequate distinction between technical efficiency and random shocks e.g. labour or capital performance variations (Meeusen, 1997, Kareem *et al.,* 2008). The Parametric method of measuring efficiency comprises of the Stochastic Frontier Function Approach (SFFA), the Distribution Free Approach (DFA) and the Thick Frontier Approach (TFA) (Yildrin and Philippatos, 2007).

2.2.2.1 Stochastic Production Frontier Function (SPFF)

Different from non-parametric approaches that assume deterministic frontiers, the stochastic production frontier function (SPFF) also called stochastic production frontier (SPF) allows for deviations from the frontier (Aigner *et al.* 1977). Here, there is room for decomposition of error term in order to distinguish between technical efficiency and random shocks (e.g. labour or capital performance variations) (Meeusen, 1997). The model of STFF addresses technical efficiency and recognises random shocks beyond control of processors which may tamper-with production output (Ismatul, 2013). Therefore, in these models, the impact of random shocks (labour or capital performance) on the product can be separated from the impact of technical efficiency variation (Mastromarco, 2008). The function can be represented as:

$Q_i = f(X_{i1}\beta) + V_i - U_i$ (26)

Where Q =	Output level
X_{i1} =	quantities used by ith processor or the explanatory variable.
f(X) =	represents an appropriate function of the vector
β =	Parameter to be estimated or vector of unknown parameters,
$V_i - U_i$ =	Decomposition of the error term
V_i =	symmetrical disturbance and it captures random effects on outputs outside processor/decision-maker' control.
U_i =	asymmetrical error component which captures technical inefficiency.

2.2.2.2 The Recursive Thick Frontier Model

According to Wagenvoort and Schure (2010), in order to estimate technology function, more standard regression techniques are required. This is because the maximum/total cost incurred in relation to the maximum/total output produced is put into consideration rather than estimating average costs and or average outputs. Thus, in order to estimate the production process using a production function or its dual counterpart (the cost function) these deviations should be taken into account. Furthermore, for separation from randomness and efficiency, use of stochastic frontier approach might be limiting wherein being a traditional approach, wherein feasible assumptions are not easy to test. Hence, the recursive thick frontier approach comes in handy as a useful regression tool or technique capable of estimating production or cost functions.

With the objective of ascertaining RTFA, a panel data set is of upmost importance. The RTFA is a less vulnerable technique or method of measuring efficiency as a producing or cost minimizing firm is less liable to criticism on its own; as the usual distributional assumptions and criticisms are shared by all firms involved. Although it is more worthy of being depended on than traditional stochastic production frontier in estimating efficiency, production and cost functions, it is limited in that it relies basically on pooled data i.e. cross sectional and time series (Panel data). Furthermore, RTFA does not adjust for outliers, wherein the Langrangian Multiplier tests and the Binomial tests become rejected (Wagenvoort and Schure, 2010).

2.2.2.3. Data Envelopment Analysis (DEA)

Charnes *et al.* (1978) first developed DEA using linear-programming method. The goal of the DEA is to establish whether decision making units (DMUs) operate efficiently or not. If a processors' input-output combination is on DEA frontier, that processor is said to be efficient; otherwise, input-output combination lies outside the frontier. DEA requires assumptions concerning the regularity properties of the production frontier. DEA does not involve any error terms. It excludes assumptions about systems' means and variances. In order to obtain measures of processors' performance there is need to be cognizant of the production possibilities (Chris and Kim, 2011).

2.2.2.4 Distribution Free Approach

This specifies functional form for the frontier while sorting of in-efficiencies and random error is done separately (Yildrin and Philippatos, 2007). The distribution free approach makes no strong assumption when it comes to precise format for inefficiencies and random-errors unlike the stochastic frontier approach which puts all this into consideration. The assumption of the distribution approach is that the efficiencies of the basic units under consideration are stable over time. The approach also makes use of panel data in order for it to estimate inefficiencies, by looking at the departure from the residual-average and the average-units (Yildrin and Philippatos, 2007).

2.2.2.5 Free Disposal Hull

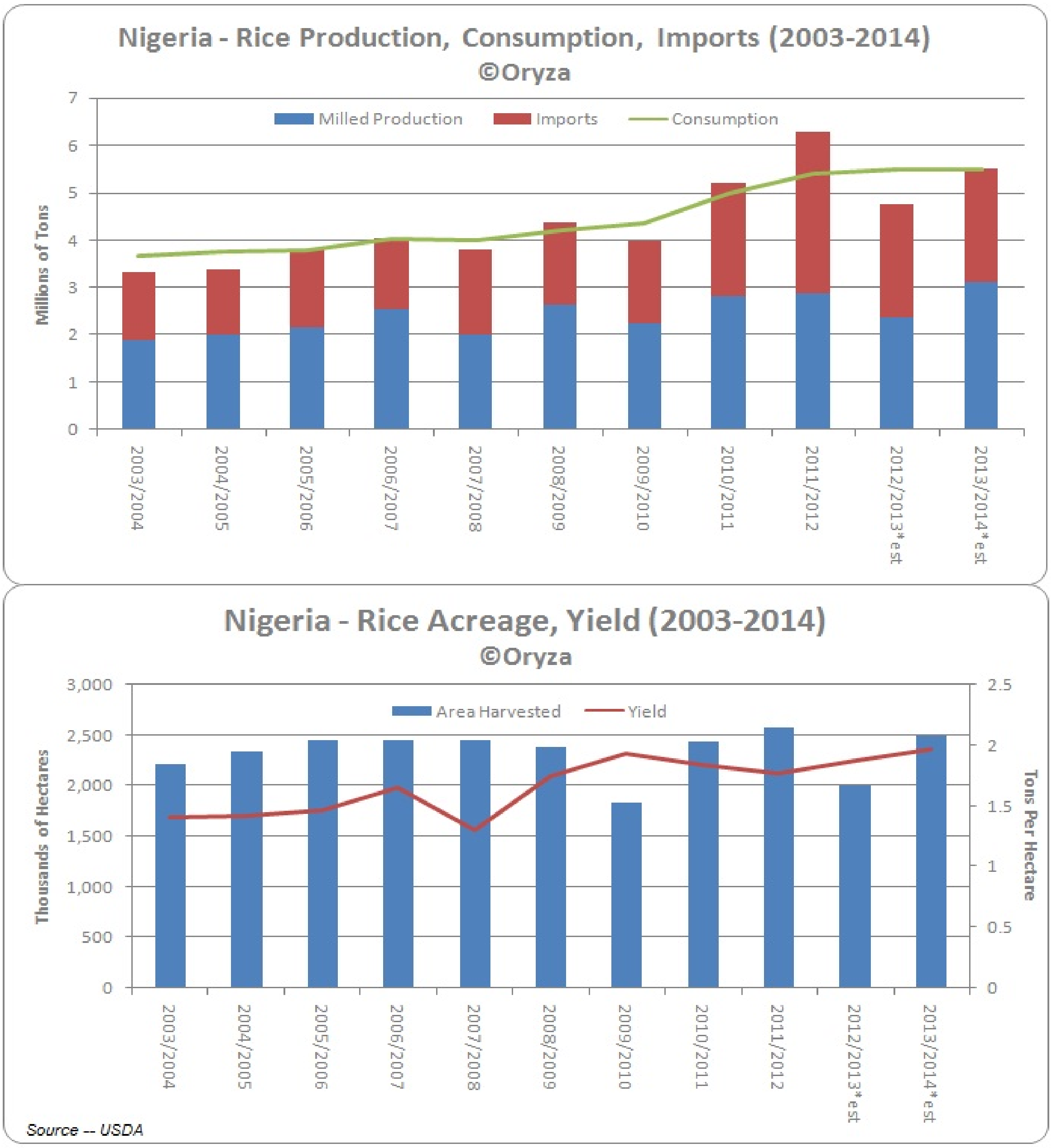
This is a unique display case of Data Envelopment Analysis (DEA). Here, details on the lines linking the DEA vertices are not admitted in the frontier production possibility sets. It compose only points interior to the highest-point (Tahir and Haron, 2008). The significance of this is that the FDH will be coinciding with DEA frontier; hence, free disposal hull is capable of generating large estimates of average efficiencies compared to DEA. This method is assumed to have a better envelopment or approximation for the data under observation, however, its operation is better with the use of diagrams or graphs (Tahir and Haron, 2008).

2.2.3 Reviews on rice processing

This section reviews rice processing in Nigeria, theories and concepts of processing, efficiency and choice.

2.2.3.1 Rice Production in Nigeria

Rice producing areas in Nigeria can be subdivided into deep water floating producing about 5 percent; the rain fed upland producing about 30 percent and the rain fed lowlands also known as the Fadama which constitutes about 47 percent of the rice producing areas in the country (Ugalahi, 2016). Major rice producing states or rice cultivating states in Nigeria are middle belt and Northern states: Benue, Kano, Niger, Nasarawa, Kwara, Kogi, Taraba, South-Eastern and South Western states of Cross Rivers, Enugu, Ogun, Ebonyi, Ekiti, Ogun and Osun. Rice yield witnessed an increase estimated at 2.01kg/ha to 2.04kg/ha in 2004 to 2.18kg/ha in 2006/2007 (National Food Research Agency (NFRA), 2008). Thus, to NFRA, the land area cultivated for rice in 2004-2014 was estimated to be around 1.7 million hectares (Figure 1).



Source: United States Development Agency (USDA, 2015).

Figure 1: Nigerian Rice Production Consumption and Imports, 2003-2014 and Nigerian Rice Acreage and Yield, 2003-2014

Major states in Nigeria saddled with the cultivation and production of rice produce varying quantities per planting season. If rice production and cultivation in Nigeria are viewed by geo-political zones, the North central zone of the country will account for the largest amount of rice produced. The zone has a record of about 44 percent of rice produced, followed by the North West with an average production of about 29 percent. South East and South-South zones together account for about 23 percent, with the South West producing the least with an average of about 4 percent (http://www.fao.org/3/a-at581e.pdf).

2.2.3.2 Domestic Rice Processing

Milling as described by Dhankhar (2014) is the process of transforming rice grain (via removal of husk and bran layer) into a form suitable for human consumption. Milling comes in different forms: traditional system (small mills, medium mills and large mills system). The Hand-Pounding milling technique is gradually fading out making the small mills and medium milling units/techniques more predominant. The small and medium milling units were set up based on the capacity of the mills (per hour/per day/per milling period). Milling also depends on the availability of paddy to the millers and available funds to buy fuel. Maintenance ability/capacity of millers is also based on availability of funds. One common factor to all the machines is the presence of a common huller. This implies that the millers do not have to purchase separate equipment in order to hull chaff from the milled rice. Some milling machines[19] are:

1) Black stone engine: This machine has a capacity of 800 rotations per minute (this is also a self cooling engine).
2) 16/26 HP: This can mill more than 10,000 tons of paddy. It is very durable.
3) Peter Fieldene: This can mill 5000 tons of paddy rice at a time
4) HR Lister: This can mill 1,500 tons of paddy per milling time nonstop. It is the fastest (speediest) milling machine. It can work for more than 8 hours capable of milling about 8,000 tons of paddy per milling time. However, it must be allowed to cool intermittently.
5) 16/2 Lister: This implies 16 capacity motor with 2 cylinders. It uses Lister engines capable of milling 1 – 4 tons at a time.

[19] observed in course of this survey

6) Electric motor: This is a milling machine powered by electricity. It has the capacity of over 1 ton per milling time. However, it is limited by the inconsistency of electricity supply. .

2.2.3.3 Demand for rice in Nigeria

Rice consumption in Nigeria has risen to over 10 percent since the mid 1970s as a result of changing preference of consumers for rice over other staples (Akande, 2002). It is further noted that the demand for rice is on the increase in Nigeria compared to other West African countries. Diverse factors have been noted to have triggered this increase in demand for rice; one of which has been traced to the increase in population (Ammani, 2013) with Nigeria now a growing nation with more than 170 million people. Another factor which is linked to the increase in the demand for rice consumption is urbanization (Ado, 2017). A tremendous shift in consumer preference as a result of easy to prepare mode of rice as compared to other cereals has made it easily adaptable to fit into the consumption list of both old and young in the country Ogundele (2014). Consequently, annual rice demand for Nigeria is forecasted at about 6 million metric tonnes. Actual quantity is about 3 million tonnes, thus, there is a deficit gap of about 3 million tonnes, with importation serving as the bridge for the deficit.

Table 1 and 2 give an overview of rice field production, harvesting of paddy and milling in Nigeria.

Table 1: Targets for area, paddy and milled rice output

		2012	2013	2014	2015
1	Planting Target (ha)	250,000	450,000	700,000	1,000,000
2	Output Paddy in Metric Tonnes (Mt)	875,000	2,025,000	3,850,000	6,500,000
3	Output milled rice in metric tonnes (Mt) Targeting (60 % Paddy)	525,000	1,215,000	2,310,000	3,900,000

Source: Agric Transformation Agenda (ATA, 2011-2014).

Table 2: Projected Total Milled Rice Production (Metric Tonnes) (Mt).

		2012	2013	2014	2015
1	Planting Target (ha)	200,000	300,000	400,000	500,000
2	Output paddy (Mt)	500,000	900,000	1,400,000	2,000,00
3	Output milled rice (Mt)	300.000	540,000	840,000	1,200,00
	Projecting (60 % Paddy)				
	Projected Total milled rice production (Mt)	825,000	1,755,000	3,150,000	5,100,00

Source: Agric Transformation Agenda (ATA, 2011-2014).

2.3. Empirical Reviews

2.3.1 Rice production

Ogundele and Okoruwa (2005, 2006)'s research was carried out focusing on technical efficiency differentials in rice production technologies. They found out that to have an output expansion in rice production, significant area expansion with the use of vital inputs like fertilizer and herbicides is essential. Tiamiyu *et al.* (2009) concentrate on how technology adopted can bring about productivity difference among NERICA farmers. Likewise, other studies have been carried out on production, marketing, demand for, supply of, trade liberalization of and value chain analysis of rice to mention but a few. These studies include researches of Imolehin and Wada (2000); Kebbeh *et al.* (2003); Ajetumobi (2005); Tijani *et al.* (2006) and Oguntade *et al*., (2011). Alarima *et al*. (2011) carried out a research examining the constraints to sawah rice-production systems in Nigeria on one hundred and twenty four respondents (rice farmers) who are randomly selected. Regression and correlation analysis was used on the variables in the study. Constraints affecting on-farm production are flood and management of water, lack of viable agencies of finance, insufficient capital, non loan acquisition and land acquisition technology. The study reveals that problems facing sawah rice production were interwoven, and the existence of one brings about another. Hence, adoption rate and rice productivity will increase if these problems are addressed.

Odu and Okoruwa's research conducted in 2012 on credit constraints effect on profit shows that credit is crucial to higher level of output among rice farmers. The research unveils that over 65 percent are credit constrained, making them less efficient and profitable. Farmers who have credit access can afford modern farm inputs like fertilizers and herbicides and so they were able to generate more profit. The researchers recommend suitable credit support and educational programmes to heighten profitability via the use of improved inputs.

Lawal *et al.* (2013) discover that farm size, labour input, cost of purchasing inputs, and household size are positively significant ($p<0.05$) to the level of income realized by NERICA farmers. Farm budgetary techniques and the ordinary least squares regression was used in analysing data from 150 NERICA rice farmers. It is revealed in the study that labour cost accounted for the highest cost incurred by 68 percent of the farmers. There is reduction in the use of fertilizer and herbicides. Farm mechanization in land preparation is also under-utilized. The results obtained therefore supported efficient use of farm mechanization to reduce labour and production cost. The research also recommends availability of credit and provision of inputs at subsidized rates.

Kagbu *et al. (*2016) valuate the factors influencing how women adopt recommended rice production practices in Nassarawa state, Nigeria. The survey was carried out among 203 female rice farmers. Their selection was done based on multistage procedure of sampling with the aid of structured questionnaires. Tools used in analysing the dataset were multiple regression and descriptive statistics. The survey reveals that 70.9 percent (which were in the majority) are below 45 years of age. 82.5 percent respondents are married with education below secondary school. 80.0 percent respondents have experience as farmers with more than 10 years with the major form of farmland acquisition being inheritance (81.4perecnt). The largest farm land based on this research ranged between 2.6353 on a probability ratio of 0.05. Major impedance to the adoption of the recommended rice production practises by respondents are unstable prices, poor marketing systems, unavailability of credit, and inadequate contacts with extension agent. Hence, the research suggests a buy-back of rice produced by the women farmers and provision of credit (making it available and accessible).

2.3.2 Rice processing

Rural communities of most countries under development are linked with processing, production and provision of food, especially rice (Basorun, 2013). Hence, rice is now the traditional staple of most rural sub-Saharan West Africa and especially Nigerian populations. Dunstan *et al.* (1976) in a research carried out on income, employment and efficiency in Sierra-Leone's rice processing industry identifies the technical efficiency of different rice producers/processors and their different rates of technical efficiency differentials. The research outcome shows that employment and income of rural poor involved in rice processing in Sierra-Leone will increase drastically if capital was made available at reduced interest rates. The inclusion of location, input and output costs should be considered to ascertain type of techniques for rice processing as suggested by the researcher. The study therefore concludes that if investment in new mills is to be done, the level of capacity utilization and recovery rates must be utmost in the minds of stakeholders. It is also suggested that rice processing mills should be located at rice producing areas to enhance performance and reduce location and transportation cost[20].

Furthermore, Dustan *et al,* (2009) looks at rice production economics in Sierra-Leone. The appraisal is done putting into consideration northern districts, wherein a rice value chain analysis is conducted. This is done in order to determine sections of the chain that need intervention to achieve profitability and sustainability. A thorough inquiry of farms, mills, input supply systems, product assemblage, output marketing, knowledge transfer/extension and alternative financing mechanisms was carried out. The major respondents focussed on by the survey are local government authorities, rice importers, handlers of trade for imported and domestic rice, Ministry of Agriculture, field extension staff, customs departments and Sierra-Leone agricultural research institute. At the end of the research, it is suggested that more focus should be on input supplies to farms and mills, and use of mechanization to supplement the use of high cost of labour. In places where there are marketable surpluses, it is recommended that government (Ministry of Agriculture) and established exporters should mop up for producers/processors. Finally, it is suggested that rice prices should be set to favour processors and producers. While stakeholders should set out on buying locally produced and processed rice from source and re-packaging to meet the world rice demands and standards.

Inuwa *et al.* (2011) in a study carried out to determine profitability of processing rice and marketing in Kano state Nigeria, evaluate the value added to rice at each stage of rice processing. This is done in a bid to enhance marketability. 120 respondents categorized based on their processing activities as par-boilers, millers, retailers and wholesalers are selected. Data brought forth during the course of the survey undergo various analyses like farm budgetary techniques, value added model and measures of engineering efficiency. The outcome of the study shows that net milling income for millers is ₦3,378,855.08 per respondent per year, the value added is ₦5,736,658.82 and service/engineering efficiency is 243.3. This indicates that milling net income, added value and millers' service efficiency was greater compared to that of wholesales. These are within the range of ₦2,239.086,

[20] Interestingly, rice processing in Nigeria is witnessing the same constraints faced by processors in Sierra-Leone since 1976. Therefore the suggestions made in relation to the constraints faced in rice processing in Sierra-Leone can as well be applied to rice processing business in Nigeria.

₦2,239.086, 3.5, respectively for retailers, while par-boilers have the least with net milling income, value added and service efficiency of ₦422,230.77, ₦422,230.77 and 5.65, respectively. The research therefore suggests that value adding (processing) to rice cannot be overemphasised and each segment/sector should be paid their services/dues separately.

Furthermore, Frederic *et al.,* (2003) conducted a survey on rice processing in Nigeria sampling five states: Niger, Kaduna, Taraba, Ekiti and Benue. The survey also sampled additional mills from Nassarawa and Ebonyi states which formed the major rice processing and marketing hubs in the country. The outcome from the research shows that milling of rice as a cottage industry is mainly executed by pocket-sized millers. Their hourly capacity is about 200kg. Produce are not traded by millers; this means they do not purchase paddy nor sell rice. They only process the paddy brought to them based on a fee. Millers who venture into other aspects of rice processing assume parboiling cost which gulps huge sums per total cost of processing. As such those involved in milling alone affirmed that the venture is profitable under the marginal milling rate of ₦ (200-300)[21].

Likewise, in order to enhance the quality of rice based on on-farm and post harvest enhancing technologies, Tiamiyu *et al.* (2014) considered in detail the rate and what determined how improved rice enhancing technologies were adopted. This was carried out among randomly selected farmers and processors numbering 150 and 18, respectively from six rice producing areas of Niger state. Ordinary Least squares regression was used in analysing the survey data. The research came up with the result that adoption indices for on-farm was 0.46 while 0.37 was obtained for post harvest quality enhancing practices. Attributes like age, level of education, contact with extension agents, access to credit and level of commercialization were significant statistically at 0.05, thus, influencing farm level adoption while adoption of post harvest technology was influenced by access to credit, membership of co-operatives and level of education.

[21] However presently in Nigeria as at 2016, when this survey was carried out, milling is now ₦ (300- 400) per Brussels or 25kg of rice.

2.3.3 Technical efficiency

Kahrajan and Veragunsingh (1992); Ismatul (2013) described technical efficiency as the ability and willingness of an economic unit to produce the maximum possible output from a given combination of inputs and technologies regardless of demand and market prices of outputs and inputs.

Amaza and Maurice, (2005) in a research carried out to identify factors influencing technical efficiency of rice-based production systems in Nigeria among Fadama farmers in Adamawa state of Nigeria, used primary data. Analysis of data was carried out using descriptive statistics and stochastic frontier production function which incorporated technical inefficiency model using the maximum likelihood estimation (MLE) applied on 122 farmers during the 2002/2003 planting seasons. The outcome of the research showed that sole cropping (growing rice alone), growing of rice and maize, and growing of rice and coco-yam were the common cropping patterns adopted by farmers in the study area. Results from Stochastic production frontier showed that elasticity of output with respect to land, seed and other costs significant at the probability level of 0.01 were 0.157, 0.146 and 0.382, respectively. Technical efficiency was found to vary among farms ranging between 0.26 and 0.97 with a mean technical efficiency of 0.80, implying that rice production among rice farmers in Adamawa state can be improved upon or increased by 20 percent with the use of better resources made readily available to the farmers. Also, rice production, based on the research can be improved with the provision of improved seeds, irrigation, fertilizer and other farm specific efficiency factors like education of the farmers.

Okoruwa and Ogundele (2006) in examining the technical efficiency differentials in rice production technologies in Nigeria focused on farmers who planted two varieties of rice; traditional and improved. The research made use of a multistage random sampling procedure, in selecting 302 respondents. These were subdivided into 160 traditional rice producers and 142 respondents involved in the planting of improved rice varieties. The results from the survey using the stochastic production frontier indicated that area expansion was the major significant increase in the level of output of rice in the country, while the use of some critical inputs like fertilizer and herbicides were used in quantities below the required per hectare. However, the estimated average technical efficiencies recorded for the two group of farmers were high (>0.90), indicating that there is need for 0.10 increase in efficiency based on the present state of the technology in use. Thus, the research suggested a labour saving low cost technology to ease constraints on farms and farmers.

In order to cope with worse food situation as well as provide a coping strategy in the production of rice, Akanbi *et al.* (2011) did an analysis of technical efficiency of 72 rice farming families in Duku, Kwara state, focusing on irrigation as their main coping strategy in averting calamity of reduced rice production. The study estimated the technical efficiency, cost and returns of rice farms in Government irrigation scheme located at the Duku area in Kwara state. Technical efficiency was estimated using the Cobb-Douglas Stochastic Production frontier. The result of the analysis showed that the mean technical efficiency of rice farms was 0.98, this high efficiency score was attributed to the assistance gotten by rice farmers in form of input/output linkages. Gross margin for the rice farms was also found to be ₦94,376.35 while the rate of returns to the rice farmers was 88 percent. It implies that for every ₦1 invested on each rice farm a sum of ₦0.88k was expected as profit. Therefore, the research suggests that high yielding rice cultivars, credits and other forms of institutional support should be provided for rice farmers by the government in order to improve and sustain production.

In order to estimate the technical efficiency of tomato production in Oyo state Nigeria, Ogunniyi and Oladejo (2014) sampled 150 farmers. The study employed a second step regression model to determine the farm specific attributes explaining the technical efficiency of respondents. The results from the study showed that 16 farms were technically efficient under constant returns to scale (CRS); 26 farms were technically efficient under variable returns to scale (VRS); while 42 farms under CRS and 29 farms under VRS showed a performance ratio of below 0.2. The greatest efficiency score in the study was therefore found to be 0.548. The average overall technical efficiency was 0.423 and 0.548 for CRS and VRS, respectively. The implication of this was that there is more room to improve on the technical efficiency of farmers by more than 50 and 40 percent, respectively.

2.3.4 Allocative efficiency

Minh and Long (2009) carried out an efficiency estimate for agricultural production in Vietnam comparing the parametric and non-parametric approaches. The study under different technology specifications shows that the average technical, allocative and economic efficiency estimates were not high for agricultural producers in Vietnam. This therefore suggests that there will be an opportunity to improve agricultural production efficiency. In order to examine the consistency of the estimates from the two approaches under the different specifications of returns to scale, the spear-man rank tests was carried out. The results obtained indicate that parametric and non-parametric approaches provide different estimates. The mean technical and allocative efficiencies for DEA model was 0.663 and 0.805, respectively while the mean technical and allocative efficiencies for the parametric approach was 0.469 and 0.373, respectively.

The study conducted in 2013 by Ismatul and Andriko in the province of Maluku, Indonesia on economies of scale and allocative efficiency of rice farmers using the Cobb-Douglas production function showed that labour, use of urea fertilizer and use of NPK fertilizer achieved the technical efficiency of 0.55, 0.19 and 0.11 while the returns to scale was that of an increasing rate. This means farmers in the region have to reduce the inputs used without losing being in the rational production region or area. The allocative efficiency test carried out on farming input shows the ratio $\frac{MVPxi}{Pxi} > 1$. This implies that farmers where allocative inefficient in this region. Therefore, economically, rice farming according to the outcome obtained from the study has not yet given farmers maximum profit because average input allocation level by the farmers was not optimized.

In the research of Adedoyin *et al.* (2016) on resource use and allocative efficiencies of paddy rice production in Mada, Malasysia 396 rice farmers were sampled using the multistage random sampling through well structured questionnaires. A combination of F-tests, ordinary least squares analysis techniques, descriptive statistics, gross margin and Cobb-Douglas production function was used to bring out the neoclassical test of economic and technical efficiencies of rice farmers in the study area. The result obtained for the allocative efficiency of input used confirms that rice producers in the area do not attain optimal allocative efficiency. However, seed input has the highest allocative efficiency at 0.29, while fertilizer had the least allocative efficiency at 0.06. It was therefore recommended that rice farmers be encouraged to improve farm efficiency at all level.

Khan *et al.* (2016) in the research carried out on technical, allocative, cost, profit and scale efficiencies in Kedah, Malaysia used a Data Envelopment Analysis for rice production analysis. In the study, in order to estimate profit and scale efficiencies, the profit DEA model was used, while the cost DEA model was used in estimating the technical, allocative and cost efficiencies of farmers. Majority of the rice farmers were found operating under increasing returns to scale (54.29 percent). Those operating with decreasing returns to scale were 34.29 percent, while 11.43 percent were operating under constant returns to scale. The average technical, allocative and cost efficiencies were estimated and found to be 0.28, 0.88 and 0.26 under CRS; while it increased into 0.61, 0.83 and 0.53, respectively under VRS.

Ajoma *et al.*(2016) in the research conducted in Cross rivers state Nigeria on allocative efficiency of rice production using a production function approach showed that there was gross inefficiency in the allocation of productive resources among small scale rice farmers in the study area. A multistage sampling technique was used in selecting 219 rice farmers using a structured questionnaire. The result obtained further showed that apart from fertilizer which had an allocative efficiency index of 0.50, other inputs such as farm size (282.90), labour (1.97), seed (241.80), pesticide (223.12) and herbicides (194.05) were all under-utilized. This implies that there was no optimal allocation of resources among rice farmers in Cross rivers state, Nigeria. However, fertilizer was over-utilized by rice farmers in the study area. It was therefore recommended that fertilizer application be reduced while farm size, labour, seed, pesticides and herbicides should be maximized in order to improve efficiency.

2.3.5 Economic efficiency

Watkins *et al.* (2014) in a study on the technical, allocative, economic and scale efficiencies of rice production in Arkansas, estimated technical, allocative, economic and scale efficiency scores for 158 fields enrolled in the University of Arkansas between 2005-2012. Although the results of the study reflect a high technical and scale efficiencies for Arkansas rice production. However, the comparison of allocative and economic efficiency scores reveals the existence of inefficiency in relation to input mix and cost minimization. The mean allocative efficiency (AE) and economic efficiency (EE) scores for the rice fields were 0.711 and 0.622, respectively. However, rice farmers do not use inputs in the combinations necessary for cost minimization on their fields thereby making them allocative and economic inefficient. The efficiency scores for the field could be improved by better irrigation management and use of multiple inlet irrigation as suggested in the study.

In the research on economies of scale and allocative efficiency of rice farming at West Seram Regency, Maluku Province of Indonesia, Ismatul and Andriko (2013) sampled 40 respondents using the quantitative analysis of production function, production elasticity and farming scale in order to estimate the technical and allocative efficiencies of rice farming. The outcome of the study shows that labour, urea fertilizer and NPK fertilizer had elasticity of 0.55, 0.19 and 0.11, respectively. This implies that the allocative efficiency of these inputs are very low; thereby suggesting that there is the possibility of labour, Urea fertilizer and NPK fertilizer to be optimally utilized at 0.45, 0.81 and 0.89, respectively. The study therefore concluded that based on the decision rule for allocative efficiency of $\frac{MVPxi}{Pxi}$= 1, which was not achieved ($\frac{MVPxi}{Pxi}$ signifying allocative efficiency), then these inputs used were not optimized by the farmers in the study area. Hence, allocative efficiency of the inputs was not actualized.

Allocative efficiency of rice production in Cross rivers state, Nigeria was estimated using a production function approach by Ajoma *et al.* (2016). The population of the study comprised of small scale rice farmers (219) using a multistage sampling technique. The cob Douglas stochastic production function frontier and the marginal analysis were used. The result revealed that there is high level of in-efficiency in the allocation of productive resources among the small scale rice farmers in the study area. Fertilizer is the only resource with an allocative efficiency index of 0.50 which signifies over utilization of the input; while inputs and resources like farm size (282.90), labour (1.97), seed (241.80), pesticides (223.12) and herbicides (194.05) are under-utilized by the rice farmers. The outcome of the research further shows that 99.6 percent adjustment is required in order for optimum utilization in farm size, seed and pesticides while 49.2 percent optimum utilization is required for labour and 99.5 percent for herbicides. Thus, in the study, there was a recommendation that more farm lands, labour, seeds, pesticides and herbicides should be utilized.

2.3.6 Stochastic Production Frontier

Enwerem and Ohajianya, (2013) in a research on farm size and technical efficiency of rice farmers in Imo state, Nigeria sampled 160 respondents during the 2009 cropping season; they were able to analyse the technical efficiency and inefficiency sources of large and small scale rice production with the use of the stochastic frontier production function. The results from the study showed that factors affecting output of the farmers were labour, capital, land and planting materials. The level of farmers' technical efficiency was affected most by low capital base, poor extension contact and poor access to credit. The mean technical efficiency were 0.65 for large farms and 0.69 for small farms implying that technical efficiencies of the farmers could be increased by 35 and 31 percent, respectively for the farmers through efficient allocation of resources.

In the Niger Delta region of Nigeria, using a multistage sampling technique and the stochastic frontier production function, Kadiri *et al.* (2014) researched on the technical efficiency of paddy rice production. Farmers' level of efficiency in rice production was found to be 0.63, suggestive of the fact that the farmers had about 37 percent room for improvement based on their production efficiency. Gender and household size were also significant determinants of how technically efficient the farmers were. It was found out in the study that when cost of productive inputs are reduced and affordable, this would go a long way in improving households' income and allow farmers to have better prices for their output.

Ajijola *et al.* (2012), in an appraisal of rice production in Nigeria, with particular focus on North Central states used secondary data collected from the National Bureau of Statistics on rice cultivation and output of cropping season for the period of 1994/1995 to 2005/2006. In the study, the regression model using four different functional forms was used; however it was the double log functional form that had the best value of coefficient of determination at 0.625. It was thereby suggested in the study that improving quality, management and efficiency along rice marketing chain is of utmost importance.

2.3.6.1 Other Methods of Measuring Efficiency

Noor and Mahadzir (2010) asserted that measuring efficiency involves the use of parametric and non-parametric methods. Examples of non-parametric methods are Data Envelopment Analysis (DEA), Free Disposal Hull Analysis (FDH) and the Partial Frontier Efficiency Analysis (PFE), while examples of parametric are Stochastic Frontier Function, Distribution Free Approach and The Thick Frontier Approach (TFA) (Yildrin and Philippatos, 2007). Samuel and Martha (2016) mentioned that the stochastic frontier approach necessitates the fitting of a functional form, which at times might not be a good judge in efficiency measurement.

2.3.6.2 Data Envelopment Analysis

The Data Envelopment/Enveloping Analysis (DEA) is an efficiency measurement method preferred to other methods of measuring efficiency because of its capacity to produce individual measures of performance which allows individual actors to be identified. It also allows for the determination of profit efficiency if and when the input and output prices of commodities and/or activities are known (Smith and Gemma, 2007; Coelli, 2002). Thus, the envelopment characteristics of DEA model in measuring efficiency is estimated. subject to the fact that efficiency is not greater than one.

Therefore, in order to measure the technical efficiency of rice farms in Marmara region of turkey, Tolga *et al.* (2010) used an input oriented Data Envelopment Analysis (DEA) to identify the determinants of technical inefficiency in Balikesir and Edime provinces of Turkey. As an additional tool, Tobit regression was used in explaining the variation witnessed in the efficiency scores and relating it to farm specific factors. 70 rice farming households were selected randomly during the 2007 rice production year. The results from the study showed that the efficiency scores of the farms ranged between 0.75 and 1.00 with an average score of 0.92 meaning that sampled farms could reduce their inputs by 8 percent and would still be able to produce the same output of rice. However, the Tobit regression showed that factors like number of rice plots, farmers' age and off-farm income negatively influenced technical efficiency, while farm size and membership of a co-operative society had a positive impact on the efficiency scores.

Odu and Okoruwa (2012) in a study on the effect of credit, used data collected from African Rice centre with the help of agricultural development programme in Niger State. They sampled 228 rice producing households; with production technology that was consistent using Data Envelopment Analysis (DEA) in capturing the technical efficiency of rice farmers and input quantities generated from farm gate prices. The result from the study based on a difference between profit functions with and without credit constrains showed that 65 percent of the rice farmers were credit constrained; while credit unconstrained farmers were able to spend more on fertilizer and herbicides than their credit constrained counterparts. In order for credit constraint rice farmers to obtain input i.e. fertilizer and herbicides, ₦16,675±9627.48/ha and ₦7,591.18±7503.02/ha were spent while credit unconstrained rice farmers spent ₦23,583.87±8662.16/ha and ₦11,806.45±6927.71/ha respectively on these inputs. A significant difference was recorded in the gross margins of rice farmers that were credit constrained to those that were credit unconstrained; as those who were credit unconstrained were more profitable than those constrained by credit. Hence, the research recommends that suitable credit support and educational programmes should be established for rice farmers in order to encourage efficient use of improved inputs, increase profitability and enhancement of rice production.

Ogisi *et al.* (2012) conducted a research in Ebonyi state on the efficiency of resource use by rice farmers making use of the Data Envelopment Analysis (DEA). The results from the study showed that majority of the farmers were operating under increasing returns to scale

(77.2 percent), 18.99 percent decreasing returns to scale and 3.9 percent constant returns to scale. Also, the study showed that only 5.56 percent of the rice farmers were 100 percent technically efficient in resource utilization under variable returns to scale. Educational level, farmers' experience, extension visits and farm size had a significant influence on the efficiency of resource used. Thus, based on the research outcome, education and extension should be improved upon to enhance farmers' efficiency, reduce wastage and cost of production.

Okeke *et al*. (2012) while examining the technical and scale efficiency of irrigated and rain fed rice farmers in Anambra state, purposively selected two local governments, three communities and a random selection of six communities (in order to have a total of a hundred and fifty rice farmers). They used descriptive statistics and the data envelopment analysis. The outcome from the research showed that irrigated rice farmers were more resource efficient than their rain fed counterparts; there was also an indication for the reduction in input usage in order to maintain same output levels. Education of rice famers was recommended for improvement in order to enable them take advantage of the modern agricultural techniques for the main purpose of increasing productivity.

In a bid to investigate agricultural efficiency, Bànyiovà *et al.* (2013) in a study conducted to measure the efficiency of the agricultural sector in the states of the European Union basing their research on 27 member states investigated efficiency by means of a non-oriented SBM-model under the assumption of variable returns to scale using the agricultural production year 2010. The non oriented SBM-model used is a form of DEA model which has neither input nor output orientation formation for its analysis. The result of the efficiency analysis showed that, out of the 27 EU member states, only 5 of them were agricultural production efficient at the time of the survey. The major factors to be focused on based on the outcome of the survey were agricultural holdings and utilized agricultural area in order for an appreciable level of improving efficiency.

Watkins *et al.* (2013) in a research measuring the technical, allocative and economic efficiencies of rice production in Arkansas on 137 fields enrolled in the University of Arkansas rice research verification programme (RRVP) from 2005-2011 calculated and compared the efficiency scores across RRVP field using Data Envelopment Analysis (DEA). The results from the research indicated that RRVP fields had high Technical efficiency scores, with mean (0.899); the mean allocative efficiency AE was 0.696; while the mean economic efficiency (EE) was 0.625. The TE, AE and EE reported in the study was a result of alternative management practices practised. The implication of this therefore was the use of alternative management practices like planting of hybrids, clear field-hybrid combinations medium grain varieties with a zero-grade and use of inlet irrigation produced higher EE scores for field that used them relative to other RRVP fields that did not use them.

Toma *et al.* (2015) used the DEA technique at the regional level making use of various inputs and output in order to analyse the performance of agriculture practised in the plain, hill and mountain areas; making use of 36 countries classified into three categories based on their geographical main characteristics. The input oriented DEA was used to determine technical efficiency scores, constant returns to scale (CRS) and the scale efficiencies. The results from this study showed that there were 5 countries in the plain, 5 in the hill and 4 in the mountain which exhibited full DEA efficiency operating at their optimal scale. However, from the study, the overall efficiency was not reached; thus, the regions needed to decrease the input levels especially work hours which were too high compared to productivity, and increase the output levels in terms of production value through better use of capital in order to experience a higher yield.

Furthermore, deviating out of rice processing, rice production and the agricultural sector out-rightly and looking at efficiency measures in these other sectors:

Silva *et al.* (2004)'s research on technical efficiency of dairy farms in Azores, Portugal used thee non-parametric efficiency analysis and a panel data of 122 respondents. The DEA with constant and variable returns to scale of the in-put oriented form used showed that technical efficiency was 66.4 percent; which is low when compared to the results from other dairy farms which are found to be more technically efficient due to the use of two inputs.

Amaza and Maurice (2005) in a research carried out to identify factors influencing technical efficiency of rice-based production systems in Nigeria among Fadama farmers in Adamawa State of Nigeria, used primary data. Analysis of data was carried out using descriptive statistics and stochastic frontier production function which incorporated technical inefficiency model using the maximum likelihood estimation (MLE) applied on 122 farmers during the 2002/2003 planting seasons. The outcome of the research showed that sole cropping (growing rice alone), growing of rice and maize, and growing of rice and coco-yam were the common cropping patterns adopted by farmers in the study area. Results from

Stochastic production frontier showed that elasticity of output with respect to land, seed and other costs significant at the probability level of 0.01 were 0.157, 0.146 and 0.382, respectively. Technical efficiency was found to vary among farms ranging between 0.26 and 0.97 with a mean technical efficiency of 0.80, implying that rice production among rice farmers in Adamawa state can be improved upon or increased by 20 percent with the use of better resources made readily available to the farmers. Also, rice production, based on the research can be improved with the provision of improved seeds, irrigation, fertilizer and other farm specific efficiency factors like education of the farmers.

Inoni (2007) in a research carried out in Delta state Nigeria, examined the allocative efficiency in pond fish production using the production function approach. The data for the study was obtained from 72 farms using the multi-stage sampling procedure. The regression results obtained indicate that pond-size, feed, fingerlings and labour are significant determinant of output in fish pond production. The index of resource-use efficiency obtained revealed that fish farmers were inefficient in the allocation of productive resources. They over-utilized feeds, fingerlings, fixed costs and labour with an allocative efficiency index of 0.0025, 0.00064, -0.00017 and 0.00025 respectively. The fish farmers however under-utilized pond size with an allocative efficiency index of 3.22. Therefore, improved strategies aimed at improving utilization of the ponds and efficiency of other resources was suggested.

Ogundari and Ojo (2007) in their research carried out on technical, economic and allocative efficiency of small cassava farms in Osun state, Nigeria used farm level data in estimating the productive and cost functions model to predict farm level technical and economic efficiency. The predicted technical and economic efficiency were then used in estimating the allocative efficiencies of farmers in the study. The mean TE, EE and AE obtained are 0.903, 0.89 and 0.87 respectively while the cassava farms exhibit positive decreasing returns to scale. This implies that a unit increase in the use of resources brings about a less than proportionate increase in output of cassava farmers. By implication, cassava farmers can increase and continue with the use of resources until the optimal output is reached. The cassava farmers were therefore found to be technically more efficient in the use of resources than being allocative efficient, as a gain in economic efficiency.

Begum *et al.* (2009) in a research carried out on the evaluation of economic efficiency of poultry farms in Bangladesh make use of the DEA approach using farm level survey data to sample 100 poultry farmers. The study estimates the technical, allocative and the economic efficiencies of the poultry farms, and this shows that there is a substantial level of inefficiencies among these farms. When the constant returns to scale (CRS) and variable returns to scale (VRS) specifications based on average were estimated, farms have differing economic efficiency of 88, 70 and 62 percent technical, allocative, economic efficiencies, respectively under the constant returns to scale. The farms also had 89, 73 and 66 percent technical, allocative and economic efficiencies under the variable returns to scale. In explaining the variations observed in the efficiency scores obtained, the following human capital variables were used in the study; farmer's age, education, main occupation, family size, experience, training received, total farm size and poultry farm size. The estimation of the variation was carried out with the aid of a Tobit regression model. The result from this study therefore showed that efficiency in poultry production was influenced by farmer's socio-economic characteristics.

Minh and Long (2009) carried out an efficiency estimate for agricultural production in Vietnam comparing the parametric and non-parametric approaches. The study under different technology specifications shows that the average technical, allocative and economic efficiency estimates were not high for agricultural producers in Vietnam. This therefore suggests that there will be an opportunity to improve agricultural production efficiency. In order to examine the consistency of the estimates from the two approaches under the different specifications of returns to scale, the spear-man rank tests was carried out. The results obtained indicate that parametric and non-parametric approaches provide different estimates. The mean technical and allocative efficiencies for DEA model was 0.663 and 0.805, respectively while the mean technical and allocative efficiencies for the parametric approach was 0.469 and 0.373, respectively.

Ogunniyi (2011) in a study carried out among maize producers in Oyo state, employed a stochastic frontier profit function in order to measure the profit efficiency among maize producers. 240 maize producers were selected using a multistage random sampling procedure. The outcome of the study showed that the profit efficiencies of the producers vary widely between 1perecnt and 99.9 percent having a mean of 41.4percent, which therefore implied that 58.6 percent of the producers' profit was lost when there was a combination of both allocative and technical inefficiencies in maize production. The research was also able to capture the inefficiency factors influencing maize production like education, experience, extension visits and non-farm employment which were highly significant.

Ogunniyi and Oladejo in a study carried out on technical efficiency of tomato production in Oyo state Nigeria in 2011 used the DEA to analyse a cross section of 150 tomato farmers in the four agricultural zones of the state. The technical efficiency index was found to range from 0.031 to 1.000 under both constant returns to scale and variable returns to scale (CRS and VRS). The scale efficiency was found to be between 0.175 and 1.000 with a mean of 0.826. The study also showed that the mean technical efficiency were 0.423 and 0.548 under CRS and VRS, respectively. The technical efficiency was determined by factors like education, experience, diversification, gender and marital status of the respondents. As deduced from the study, excess use of inputs especially fertilizer, and over use of family and hired labour added to the incidence of inefficiency among the respondents.

In another research Ogunniyi and Omoteso (2011) determine the economic analysis of 80 swine producers in Oyo state, Nigeria. The Cobb-Douglas production function was used. The results of the Cobb-Douglas production function showed an in-efficiency outcome of 1.0782. This is greater than unity, thereby suggesting that the farmers were operating at the irrational stage of the production possibility frontier. The farmers were therefore not operating at the optimum in the scale of production. Therefore, based on the outcome of the research, there is an in efficient utilization of available resources by respondents. It was found out in the study that lack of access to formal credit facilities was also hindering large scale pig production in the study area. Also, problem of feed procurement and disease management are other factors hindering the efficiency of pig farmers in the study area.

Himayatullah and Imranullah (2011) measured the technical, allocative and economic efficiency of tomato firms in Northern Pakistan, using a multistage sampling technique. The Cobb-Douglas frontier production function and cost models was used in estimating productive efficiency. The result obtained showed that the average technical efficiency was 65 percent, while the average allocative efficiency was 56 percent. There was a wide gap between the highest and lowest economic efficiency obtained with a mean of 35percent. It was therefore concluded in the study that there is a greater tendency for farmers to increase their productive efficiency if farmers' education, access to credit and extension visits were focused upon by the stakeholders in the country.

Ashagidigbi *et al.* (2011) carried out a research on technical and allocative efficiency of poultry egg producers in Nigeria. The main aim of the research was to carry out the determinants of efficiency among poultry egg farmers in Jos metropolis of Plateau state, Nigeria. The outcome of the research showed that about 69 percent of the variations in the output of poultry egg production was due to technical inefficiency among the farmers. The study therefore recommended that stakeholders should intensify farmers' access to credit and extension services on how to combine inputs in order to improve on the level of efficiency among poultry egg farmers in Nigeria.

Mlote *et al.* (2013) estimated the technical efficiency of small scale dairy beef cattle fattening in Lake Zone of Tanzania. The study made use of the stochastic frontier production approach in estimating technical efficiency. The descriptive statistics was used in determining the socio-economic characteristics of respondents. In analysing the technical efficiency and the socio-economic characteristics, 90 randomly selected respondents were used. The estimates from the stochastic frontier function showed that herd size was a major determinant of technical efficiency. The technical efficiency was found to be within the range of 48-98percent. The mean technical efficiency for the study was 91percent. This implies that respondents involved in the cattle fattening operations were efficient though not at the 100 percent mark. The main socio-economic characteristics determining respondents' technical efficiency were age, education, experience, visit by extension agents and tribe (ethnicity).

Aboki *et al.* (2013) in the research carried out on cassava production in Taraba state, Nigeria with a purposive selection of 300 respondents estimate the technical, economic and allocative efficiencies of these farmers. The data collected was analysed using the descriptive statistics, the stochastic production frontier and cost function. The result obtained showed that about 90percent of the variations in output among cassava farmers in the study area was due to differences in technical efficiency. The mean technical, allocative and economic efficiencies were 0.887, 0.856 and 0.826, respectively. This therefore implied that the respondents were relative in allocating their limited resources. The inefficiency factors affecting cassava production are farm size, family labour, hired labour, fertilizer, household size, years of schooling and source of funds. It was therefore recommended in the study that farmers should be encouraged to adopt more intensive cultural practices instead of continuous expansion of land used in cassava production.

Bazkar and Khalilpour (2013) carried out a comparative study, ranking banks and the banking sector in Iran. They made use of the DEA and the stochastic production frontier, sampling ten (10) banks in Iran within a period of five (5) years from 2005 to 2010. The input variables used for the DEA were banks' number of branches, total deposits and total costs, while the output variables were the volume of facilities granted, investment to the bank in total and the total income of the banks. The outcome of the study showed that two banks were efficient under the DEA method, two banks had relatively good performance, two banks had poor performance, while the remaining four banks were ranked as averagely performing banks. The efficiency score was in the range 50-90.

Oladeebo and Oluwaranti (2014) in their research conducted on profit efficiency among cassava producers are able to isolate factors leading to variations in farm specific profit inefficiency. The study obtains cross-sectional data from 109 cassava farmers, which are analysed with the aid of descriptive statistics and stochastic frontier profit function. The results from the study show that profit efficiencies of farmers are in the range of 20-91 percent. The mean profit efficiency was found to be 79 percent. The implication of this is that an estimate loss of 21 percent in profit efficiency is due to the combination of both technical and allocative inefficiency; while household size and farm size are identified as major and significant factors influencing profit efficiency positively.

Ogunniyi *et al.* (2014) in another research to determine the efficiency of livestock production in Oyo state Nigeria, make use of the stochastic frontier production function in estimating economic efficiency. It is found that livestock farmers have an economic efficiency of 0.497. Poultry farmers have an economic efficiency of 0.346. Pig farmers have an economic efficiency of 0.699. Pig farmers have a significant level of economic efficiency as a result of inefficiency factor, 'experience' which has a positive sign, as compared with inexperienced pig farmers who have a negative coefficient. The result from the in-efficiency model shows that all the variables used in the model except education are not significant. The author therefore suggests that the conventional production function is not an adequate representation and analysis for the data set.

In order to estimate the technical efficiency of tomato production in Oyo state Nigeria, Ogunniyi and Oladejo (2014) sampled 150 farmers. The study employed a second step regression model to determine the farm specific attributes explaining the technical efficiency of respondents. The results from the study showed that 16 farms were technically efficient under constant returns to scale (CRS); 26 farms were technically efficient under variable returns to scale (VRS); while 42 farms under CRS and 29 farms under VRS showed a performance ratio of below 0.2. The greatest efficiency score in the study was therefore found to be 0.548. The average overall technical efficiency was 0.423 and 0.548 for CRS and VRS, respectively. The implication of this was that there is more room to improve on the technical efficiency of farmers by more than 50 and 40 percent, respectively.

Another study by Sanusi and Singh (2015) where the stochastic frontier production function was used in estimating cost and profit efficiency of maize farmers in Nigeria showed that profit efficiency varied widely among farmers. The variation was in the range of 12 to 95 percent with a mean efficiency of 77 percent, as obtained from the data of 120 respondents using a multistage sampling technique were sampled. The outcome of the efficiency results shows that there were lots of achievable improvements for the maize farmers. The least profit efficient farmer needs an efficiency gain of 88 percent, while the most efficient farmer needed 5 percent gains.

The research of Biam *et al.* (2016) was carried out to estimate economic efficiency of small scale soyabeans farmers in central agricultural zone of Nigeria using a Cobb-Douglas stochastic cost function. The study used the multistage sampling techniques in selecting 485 soyabeans farmers from the zone. The result showed that 52 percent respondents had economic efficiency. Age, farm size and household size were found to be negative but significantly related to economic efficiency at $p<0.05$. However, education, farming experience, access to credit and fertilizer were also significant and positively related to economic efficiency at $p<0.01$. The study therefore suggested policies that would increase farmer's economic efficiency by improving on farmers' education. Also farmers' were to be supported to have easy access to credit facilities and fertilizer.

Hina *et al.* (2017), in the research carried out on allocative efficiency and profitability of high-tech cotton melon multiple cropping system in Punjab, Pakistan on 150 farmers used the stochastic cost frontier analysis in estimating allocative efficiency. The average allocative efficiency was 75 percent, with 36 percent of the farms in the range 0.20 and 0.60 while 60 percent of the farms have an allocative efficiency in the range 0.61 to 0.90. The over and under utilization of inputs like land, seeds, fertilizers and pesticides reflect the general performance of inputs used and allocative efficiency. The study therefore recommends that farmers ought to be trained on the rate of inputs application and the suitability for the local weather pattern and cropping systems.

2.3.7. Analysis of Determinants

Rahman and Chima (2016) in a study on the determinants of food crop diversity and profitability in south-eastern Nigeria, used the multivariate Tobit approach to jointly determine the factors influencing decisions to diversify into multiple food crops (i.e. rice, yam and cassava) *vis-a-vis* profitability. In the study 400 farmers from Ebonyi and Anambra states in south east Nigeria were sampled and the outcome revealed that the decision to diversify into multiple crops and profit generated therein were significantly correlated with farm size, relative price of ploughing, proximity to markets, proximity to extension offices/agents, extension contacts, training, agricultural credit, subsistence pressure and location of farm lands. The research therefore recommended that investments in market infrastructure, access to credit, land and tenure reforms alongside input price stabilization were necessary to promote food crop diversification and profitability in south-eastern Nigeria.

Kagbu *et al.* (2016) assessed the determinants of adoption of recommended rice production practices among women rice farmers in Nassarawa state, sampling a total of 203 women rice farmers using the descriptive statistics and the multiple regression analysis. The results showed that farm size was the only significant factor influencing the adoption of recommended rice production practices by these women rice farmers. However, other constraints hindering the adoption of recommended rice production practices by women in Nassarawa state as shown in the study were unavailable credit facilities, poor marketing systems, unstable prices and inadequate extension contacts. The research therefore recommended that government should ensure availability of credit, introduction of buy-back arrangement for rice produced by the women in order to ensure good prices/pricing of rice produced.

However, when Awotide *et al.* (2014) assessed the extent and determinants of adoption of improved cassava varieties in south-western Nigeria, sampling 841 households selected using a three-stage stratified random sampling procedure, and the double hurdle regression model. They found out that adoption increases with age of household head, gender, hired labour, farm size, access to credit and cultivated land. Furthermore, the research also found out that the intensity of adoption was influenced by hired labour and farm size, while access to information about improved cassava varieties was determined by gender, age and off-farm income, and the level of education of the household head.

In another research carried out in Uganda on the factors influencing farmer's choice to sell milled versus un-milled rice, Nakazi *et al.* (2013), using data collected from a survey of 194 rice farmers, examined why some rice-growers still sell un-milled rice and the possible effect of these on production profitability. The factors influencing the proportion of rice sold as grain were analysed using the Tobit regression model. The results from the Tobit regression showed that price of rice, volume of harvest, household size, group membership and distance to the nearest mill significantly influenced the proportion of rice sold as milled rice. The research therefore suggested that extension services and low power consuming stationary and mobile mills should be provided in order to ensure better rice production returns to farmers.

Furthermore, the determinants of commercialization among small holder farmers in Abia State, Nigeria, Agwu *et al.* (2013) made use of Household Commercialization Index (HCI) and Multiple Regression. The study with the survey carried out on 180 farmers showed that none of the crops attained a commercialization index of 30 percent. Of all the crops surveyed, cassava had the highest commercialization ratio of 29.58, with water yam having the least ratio at 13.55. The coefficient of household size, income farming experience, farm size, distance to market, membership of society and access to credits were significant at varying levels of probabilities and signs influencing the commercialization of small holder farmers in the study area.

Asogwa *et al.* (2012) researched on the analysis of determinants of poverty among rural farmers in Nigeria, using the censored regression model (Tobit Regression) to analyse the determinants of poverty; sampling 233 rural farmers in Benue state. The study showed that there was 87.63 percent variation in poverty severity as explained by the Tobit Regression. Based on this, critical determinants of poverty severity were economic efficiency, household income, household production enterprise structure, extent of household production diversification, extent of production and commercialization, expenditure on education, access to agricultural extension services, membership of co-operative societies or other farmer's association, market access, total value of household assets, household size and formal education.

In order to improve on the efficiency of rice production in Ogun state Nigeria, Akinbode *et al*. (2011) examined technical, allocative and economic efficiencies of Ofada rice farmers. Stochastic Frontier Analysis (SFA) and the Tobit Regression were used for the analysis of efficiency and determinants of efficiency, respectively. The mean technical, allocative and economic efficiency obtained from the research were 0.726, 0.928 and 0.674 respectively. The research therefore concluded that rice farmers in Ogun state could increase output or save cost without having to change their existing technologies, if the available technologies to them were properly harnessed.

Moreover, in another study the Tobit model was used to estimate the adoption function of hybrid rice based on several combinations of farms and farm specific variables in Bangladesh by Hussain *et al.* in 2011. The result of the Tobit Regression model shows that educational level, landownership, farm size (gross cropped area) have a significant and statistical relationship with the adoption probability of hybrid rice, which implies that small farmers were the potential adopters of hybrid rice.

Tolga *et al.* in 2010 measured technical efficiency and the determinants of efficiency of rice (*Oryza sativa*) farms in Marmara region of Turkey, with the aid of the input oriented DEA and Tobit regression model in explaining the variations in the efficiency scores relative to farm specific factors. In the research 70 respondents were sampled. The overall technical efficiency scores of sampled rice farms was 0.92 on the average and in the range of 0.75 and 1.00. When the calculated efficiency scores were regressed against the explanatory variables using the Tobit regression model, number of plots, farmers' age, off-farm income and membership of cooperative were significant causes of variations in the efficiency of farms.

Akinola *et al.* (2010), in order to determine the adoption and intensity of use of balanced nutrients management systems technologies in northern guinea savannah of Nigeria, projected two technology packages; a combined application of inorganic fertilizer and manure (BNMS-manure) and a soybean/maize rotation practice (BNMS-rotation). The study made use of the Tobit regression and was able to examine factors influencing the adoption and intensity of use of these technologies. The empirical results showed that within five years of introduction, the adoption of BNMS-rotation had reached 40 percent while that of BNMS-manure was at 48 percent. When this was related to land area, it was found out that BNMS-manure occupied 35 percent of the available land area, while BNMS-rotation was found to cover only 12 percent for the total maize land in the zone. Also factors like access to credit, farmer's perception of land degradation state and asset ownership were significant determinant for BNMS-manure, while off-farm income was the main determinant factor determining the adoption of BNMS-rotation by farmers.

In the analysis of the determinants of agricultural lending decisions and loan approval making use of two banks in Nigeria, Olagunju and Ajiboye (2010) used the Tobit regression model. The estimates from the Tobit regression model showed that institutional, environmental and resource variables were important if a loan was to be approved or not.

2.3.8 Analysis of Choice

2.3.8.1. Multinomial Logistic Regression

Louviere (1988); Batsell and Louviere (1991) reviewed designs that satisfy the statistical properties of the Mother Logit or its nested form called the Multinomial Logit (MNL) and discovered that it allows for a wide range of utility specification and estimation. Due to non linearity, design efficiency in most choice models depends on the (unknown) true value of the model parameters. A better approach to this problem is to look for designs that are relatively robust to changes in the true parameter values. Bunch, Louviere and Anderson (1993) have performed such exercise for MNL models using D-Optimality criteria. Their results highlighted an important difference between choice models and standard linear models in that choice models probabilities are based on utility differences and hence on difference among attributes levels rather than on absolute levels.

Chinwumba *et al*. 2016 in a study conducted analysing agricultural value chain finance and small holder palm oil processing in Delta state, used the Multinomial Logistic regression model in order to determine the factors affecting the choice of credit channel. The Multinomial Logistic regression results for the study showed that in order to choose a given source of credit channel, the following were positive and significant factors; gender, age, education, experience, level of income, location of business as well as membership of organization. The research therefore recommended the intervention of government by implementing measures which would bring down the interest rate paid on agricultural loans.

Assessing the use of post harvest loss prevention technologies for cassava in Nigeria, Adejumo *et al.* 2015, made use of the Multinomial Logistic regression model to examine the factors influencing the choice of post-harvest technologies used by cassava processors in

Kwara state using the data collected from 150 cassava processors. The outcome of the study showed that factors like years of education, post-harvest technology capacity, processing experience, motives for processing were found to influence the choice of post-harvest technologies. The study therefore concluded that policy should be directed towards investment in improved post-harvest technologies by both private and public sector.

Uwaoma (2015), in her research on the economics of small scale soybean processing firms in Anambra state, Nigeria examined the socioeconomic and influential factors affecting the choice of technologies used, technical efficiency, and the value added by processing soybean. The profitability, factors affecting profitability, constraints to small scale and the level of gender participation in small scale soybean industries were examined. The study made use of descriptive and inferential statistics such as the Multinomial Logit model, stochastic frontier production model, gross margin and the profit analysis. The results of the multinomial logistic regression on 150 soymilk processing firms and 100 soy-flour processing firms showed that age, income, level of education, household size of processors, cost of processing technology, age of processing firm, availability of spare-parts, technicians, household employees and paid employees were the significant factors affecting the choice of processing technology at $p<0.05$. This research therefore made some policy recommendations that there should be provision of credit facilities, granting of tax incentives and provision of adequate power and water to soybean processors in the study area.

In the research of Ojo *et al*. (2013), the Multinomial Logistic regression was used to analyse the factors affecting the choice of enterprise among small holder yam and cassava farmers in Niger state, Nigeria. From the research, it was discovered that income, farm size and output had a positive significance on farmers' choice of either or both of the enterprises, which implied that the probability of choosing yam or cassava enterprises increased with the income earned, farm size and the output from these enterprises. The study therefore recommended that more awareness be created by extension agents on the different methods and techniques available for yam and cassava cultivation. The study further suggested training and farm advisory services on improved management practices to boost yam and cassava production as well as an improvement on adoption by respondents.

Javier (2013) used both the tobit and probit regression models in the analysis of choice. Bhatta and Lansen (2011) used the Multinomial Logit regression analysis (MNL) to determine the level of service (LOS) attributes representing the performance of transportation system and characteristics of travellers, and travelling demand. Louviere, (1988) and

Louviere *et al.* (2000) reviewed designs that satisfy the statistical properties of the Mother Logit or its nested form called the Multinomial Logit (MNL). They discovered that it allows for a wide range of utility specification and estimation. Bunch *et al.* (1993) also performed an exercise for MNL models using D-Optimality criteria.

In the analysis of small scale farmer's choice of organic soil management practices in Bunguno county Kenya, Ayuya *et al.* (2012) selected 150 small holder maize farmers with the use of primary data. The multinomial logistic regression model was employed as a means of establishing the factors influencing the choice of management techniques. The results from the study indicated that extension, farm size, household size, gender, age, education, credit, group membership, land tenure, farm distance and slope of land were significant factors influencing the choice of the different techniques. The study therefore recommended policies in support of organic soil management and a need to increase the extension visits to improve on farmers' awareness on the advantages of the various techniques.

2.3.8.2 Other methods of analysing choice

In Turkey, Gunes *et al.* (2016) conducted a research accessing the factors affecting Turkish farmer's satisfaction with agricultural credit making use of the ordered probit model. Data used in the study was obtained from 550 randomly selected farmers with the use of structured questionnaires. The ordered probit regression model showed that age, educational level of farmers, size of farm, use of family labour, financial ratios, willingness to purchase insurance, sources of agricultural credit, types of credit and usage of credit were significant factors influencing credit satisfaction among farmers in Turkey.

Hailu *et al.* (2014) made use of probit and ordinary least square regression models in identifying the determinants of agricultural technology adoption decision and the impact of adoption on farm income. Semi-structured questionnaires were used in collecting cross-sectional data on 270 respondents, randomly selected from small holder farmers in Northern Ethiopia. The results from the study showed that agricultural technology adoption decision of farming households was determined by use of irrigation, land ownership right, credit access, distance to the nearest market, distance of plot to farmstead, off farm participation and tropical livestock unit. The study also showed that technology adoption by farmers had a positive and significant effect on income generated by farmers. The implication of this was the adopters of technology were found to be better off than non-adopters.

In an on-farm evaluation of maize varieties in Ghana within the transitional and savannah zones, Etwire *et al.* (2013) made use of the ordered logistic regression model. The research assessed the preference of farmers using the Kendall's coefficient of concordance. The estimates from the ordered logistic regression showed that area under cultivation, fertilizer usage and family size were factors determining farmers' preference for improved maize varieties; while maize varieties that were early maturing and drought tolerant were most preferred based on the Kendall's concordance coefficient results.

A research conducted on hybrid rice adoption in Bangladesh by Husain *et al.* (2011) found out the farm-level adoption pattern, differential performances, relative profitability and constraints to the adoption of two hybrid varieties. These varieties Alok 6201 and Sonar Bangla (CNSGC 6) were introduced during the 1999 Boro season in Bangladesh. Empirical findings from the research showed that education of farmers had a positive effect on the adoption rate of farmers while farm size had a negative effect. Grain yield and profitability of Sonar Bangla were higher than that of Alok 6201.

In order to expatiate more on the use of Logistic regression in agriculture, Arthur and Qaydi in 2010 administered questionnaires to farmers in the region of western Abu Dhabi to determine the farming practises, perceptions and attitudes towards expanding their market research into other countries especially the gulf coast council countries. The Logistic regression model was used to analyse and provide the needed information on the preferences of farmers. The outcome of the research was used in interpreting farmers' responses as majority of the farmers in the region were part time farmers, using farming as a hobby.

Isik *et al.* (2009) carried out a research on factors affecting dairy farmers' utilization of agricultural supports in Erzurum in Turkey, making use of the ordered probit regression model. Their research found out that, education, form of farming, breed and roughage were good predictor variables of dairy farmer's utilization of agricultural supports. The study therefore recommended an increase in the educational level of farmers, introduction of market oriented production and culture breeds.

Pycroft (2008) investigated the factors determining the adoption and productivity of improved seeds among small farmers in Ethiopia. The research made use of data derived from an agricultural census of west Gojam zone, using the tobit and probit models in analysing the decision to adopt improved seeds. Results from the study indicated that large farm size, and literacy were the main determinants of adoption of improved seeds in the zone.

2.3.9 Preference for local rice

Different factors underline the consumption patterns and preferences of consumers for rice produced in the country as against those imported from other nations. Some of these factors could be socio-economic in nature while some could be socio-cultural; others could even be physiological and psychological in nature depending on the conditions and environments in which consumers find themselves all over the country.

Walisinghe and Gunaratne in 2010 carried out a research on consumer preference for quality attributes of rice in Sri Lanka using a conjoint analysis. They found out that four attributes which were type, colour, purity and price were important in the choice of a consumer for rice. However in order to determine the relative importance of attributes of rice on the preference of consumers, the part-worth and the ANOVA were used in the study. The results from the study therefore indicated that of the four attributes, type, colour and purity of rice were the most significant. The part-worth estimates also indicated that purity of rice was the highest and the most important attribute determining a consumer's preference for rice in Sri-Lanka. The study therefore recommended that with further expansion in income growth and changes in technological advancement, rice production, processing, value-addition and marketing will bring about established changes in preferences, lifestyles as well as urbanization and scale effects in the study area.

Ogundele (2014) researched on the factors influencing consumers' preference for local rice in Nigeria, using the Multinomial Logistic regression to analyse data obtained from two states in Nigeria; Niger and Ekiti state. The research was able to discover that consumers' social economic characteristics were the major determinants of the preferences of consumers for locally produced rice. Some of which were the ages of the respondents, marital status of the household head, educational status of the household head, sex of the household head and primary activities of the household head. The research also brought out the fact that aside from the socioeconomic characteristics of the respondents, consumers' preference for locally produced rice could be influenced by frequency of purchase and price. However, based on the outcome of the research the two most highly rated criteria for rice bought in the market are whiteness and absence of foreign matter.

Consequently, Danso-Abbeam (2014) in a research conducted in Ghana on the determinants of preference for local rice in Temale metropolis in Ghana discovered that age of household head, household size, monthly expenditure on food and taste were the major factors determining consumers' preference for locally produced rice. In the research, logistic regression model and the Kendell's coefficient concordance were used. The results from the research showed that poor packaging of local rice was the major factor inhibiting consumers from patronizing producers of local rice in the region. The research therefore suggested that local rice processors should work hard at improving on the packaging of rice processed in order for it to be more competitive in the market.

2.4 Conceptual Framework

2.4.1 Choice of Rice Processing Techniques in Nigeria

Processors are decision making units (DMU) who are guided by the rational choice theory in the processing of rice. The rational choice theory which is an economic principle explains that individuals always make prudent and logical decisions (www.investopedia.com), while processing an integral part of rice production is the process of transforming production factors or inputs into outputs (Olayemi, 2004). Therefore, in order to bring rational decision making side by side with processing decisions, an understanding of choice and production processes are of utmost importance. These therefore implied that prudent, rational and logical decisions are affected by some factors; examples of which are budget, income and characteristics of individuals (Korh and Eijk, 2003) which determine the actual decisions taken and the end result obtained. In line with these, the distribution of processing techniques used is based on the use of automated and augmented techniques (Uwaoma, 2015; Patil, 2016; Tanzania Assessment, 2012) which processors have to decide on whether to use or not considering rationality, utility/satisfaction, as well as constraints.

Processors are characterised by socio-economic characteristics (sex, age, marital status etc) and processing characteristics which are jointly affected by budget, processors' income despite preference and utility expected. These usually determine the category of a processor and the processing activity to go into. These combinations of processors' characteristics, budget, income, preference and expected utility determine the type of technique a processor will use. This therefore implies that based on constraints of budget and limited income (although majority of the processors would prefer the modern techniques which would make them more economically efficient in output and outcome of rice) processors were found using the traditional and tradmodern techniques of processing which were readily accessible with least cost.

Processors are in business to maximize profit; however, they are faced with factors which determine the type of processing technique they use in transforming paddy into edible rice. This can further be explained as; though processors are rational human beings out in rice processing business to make profit, they still put a lot of considerations on how they will effectively reduce cost as well as make the best use of available resources per processing time. There are a number of factors and conditions which they must consider before any decision is made as regards their business of processing. Therefore, the choice made by processors or the choice of processing technique is expected to determine the eventual outcome of paddy processed by processors and the amount of processed rice obtained. This thereby implies that rice processors, in order to achieve a seemingly good output irrespective of constraints, have to choose from traditional, tradmodern and purely modern techniques of processing rice. This decision is made based on the technique which they consider suitable in all the surrounding conditions. They also have to consider the accessibility to, the affordability of and the availability of such a technique before processing decisions are made. Furthermore, processors no matter the type of technique used and depending on the rice processing involved in will make use of rice paddy, fuel, machines, equipments and operating space. Processors also incur expenses on some other areas which include among others; communication (use of phone/payphones), duties and taxes (to local authorities, transport regulatory bodies, associations etc), labour (family, hired or both); maintenance and repairs (pots, tanks, milling machines, de-stoners); depreciation on machine etc.

The processing option/processing technique used will bring about technical and allocative efficiencies, a combination of which will result in economic efficiency of the processors. Efficiency in paddy processing will bring about quality processed rice and increase output. This will eventually result in good market for processed rice which will not only attract buyers from within the country, but also open up an opportunity for export in the long run. The resultant effect of choice of processing will therefore bring about quality processed rice and a good market-price advantage. Thus, choice of rice processing technique and efficiency differential of rice processors as illustrated in Figure 3 depict these in the conceptual frame work as best as possible

Conceptual Framework

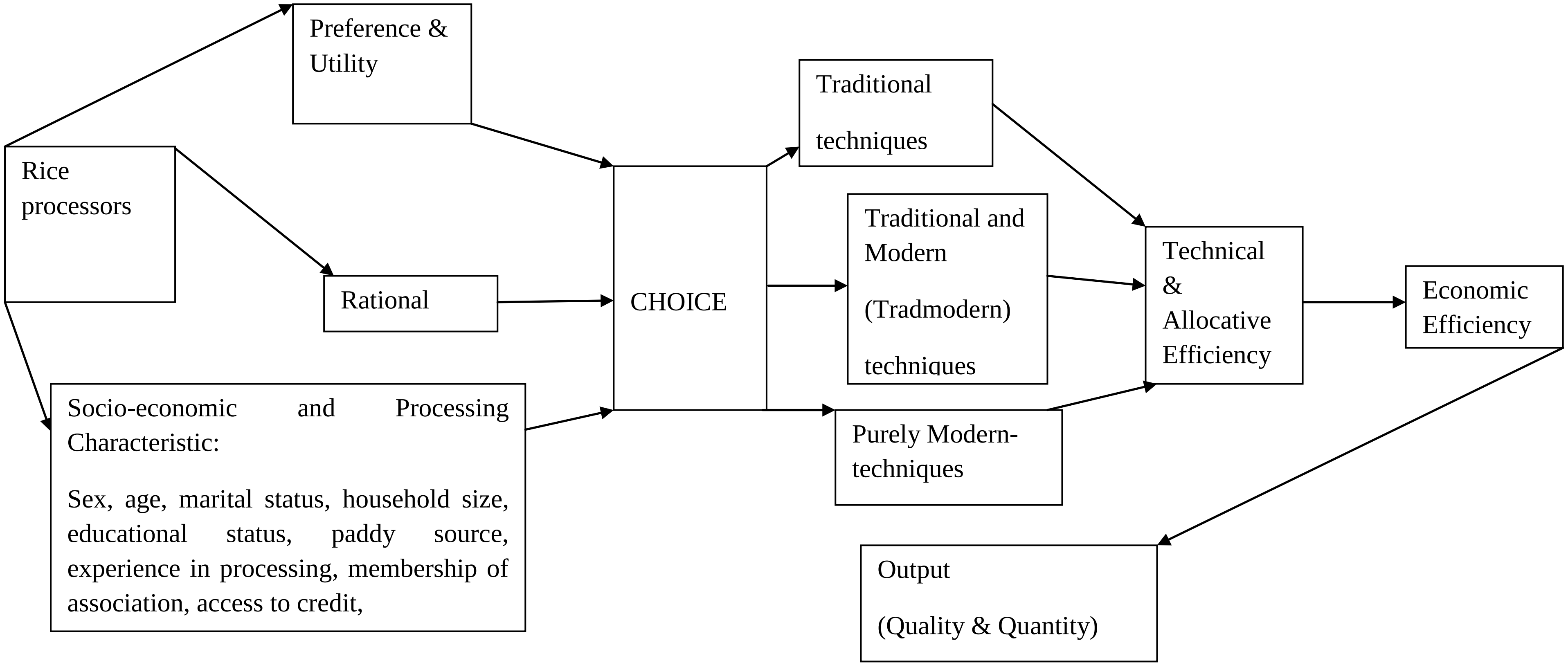


Figure 2: Choice of processing techniques and efficiency differentials among rice processors in Nigeria.

Source: Author's Compilation and conceptual design (Adapted from Korh and Eijk, 2003; Olayemi, 2004; Dunstan *et al.* 2009; Okeke *et al.* 2012, Tanzania, Assessment, 2012; Okpe *et al.* 2014).

CHAPTER THREE
RESEARCH METHODOLOGY

In this chapter, the study area, sources of data, data types and the analytical tools used in achieving the study objectives are discussed.

3.1. Study Area

This study was carried out in Nigeria; because of its importance in the country, rice is produced in all the six geo-political zones, all the agro-ecological zones and in virtually all the states of the federation (Nigerian Rice Development Strategy (NRDS), 2013); National Bureau of Statistics (NBS), 2010). Therefore, as a result of their long and standing contributions to rice processing and rice value addition in Nigeria (Ezedinma 2008, 2013; ATA, 2011-2014), the four states used in this study were purposively selected from three geo-political zones in the country. The four states are part of the staple crops processing zones (SCPZ) according to agricultural transformation agenda (ATA, 2011-2014; FMARD, 2016). The four states Ebonyi, Ekiti, Ogun and Nassarawa States are located in the South-East, South West, South West and North Central zones of Nigeria respectively. Based on agro-ecological zones, Ebonyi is located in the tropical high forest zone; Ekiti belongs to the rain forest zone; Ogun has been grouped into Fresh water swamp zone; while Nassarawa is located in the wood land and tall grass savannah zone. All of these are shown in figure 4.

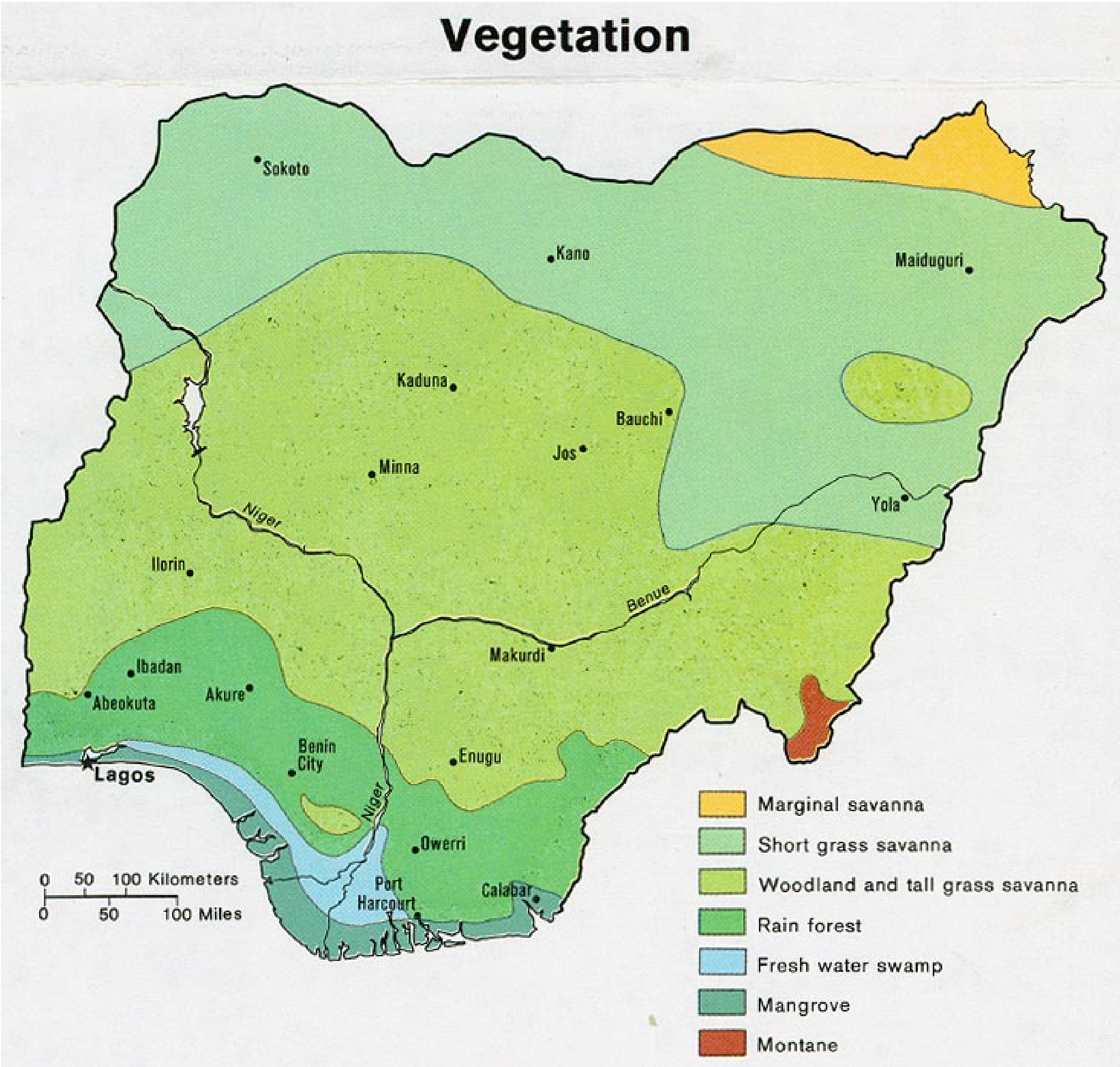


Figure 2: Nigerian Agro-Ecological zones.

Source: http://soilsnigeria.net.

Furthermore, the four states are noted for their high level participation in Nigeria's rice processing industry (Nigerian Food Research Agency, (NFRA) 2008). Ebonyi State has Abakaliki, Afikpo North, Afikpo South and Ebonyi rice processing centres; Ekiti State has Igbimo, Ise, Ijero, Iyin, Oye, Ado-Ekiti and Ikole rice processing hubs; Ogun State has Ofada town, Ogun waterside, Ijebu-ode and Obafemi Owode rice processing hubs; while Nassarawa state has Olam rice processing plant, Lafia North, Lafia South, Nassarawa Eggon, Awe and Doma rice processing hubs.

3.2 Source of Data

Primary data from a cross section of rice processors were used for this study. Data were collected on their socioeconomic characteristics, processing activities and processing techniques used (Adapted from Inuwa *et al*. 2009; Tiamiyu *et al*. 2009, 2014).

3.2.1 Sampling Procedure and Sample Size

A multistage sampling technique was used; the first stage was the purposive selection of four (4) states (Ebonyi, Ekiti, Ogun and Nassarawa) based on their contributions to rice processing in the country (Ezedinma 2008, 2013; NFRA, 2008). The second stage was the selection of 23 local government areas proportionate to size. In selecting the local government areas proportionate to size from the four states sampled, the following proportionate factor were put into consideration:

$$N_i = \frac{n}{N} \text{ X p} \qquad (27)$$

Where N_i = actual number of LGAs selected from state i (outcome)

i = selected states (i = 1, 2, 3, 4)

n= number of LGAs in i_1

N = total number of LGAs in the four states

P = the desired number of LGAs from the four states (23).

Four (4) LGAs were selected out of the 13 in Ebonyi, five (5) LGAs were selected out of the 16 in Ekiti, seven (7) LGAs were selected out of the 20 in Ogun and Nassarawa states, respectively based on the above proportionate to size. The third stage was the purposive selection of rice processing centres from the designated LGAs based on the proportionate factor. The fourth stage was the random selection of rice processors 25 (4), 20 (5), 15 (7), 15 (7) from the selected processing centres to have a total of 410 respondents. However, 382 respondents were used in the study, while 28 questionnaires (from rice processors) were unsuitable for use.

Table 3: Local government areas and processors sampled

S/N	State	Local Government	Local Government proportionate to size	Number of processors sampled proportionate to size	Total Questionnaires sampled	Total Questionnaires retrieved
1	Ekiti	i) Aisegba				
		a) Igbimo				
		ii) Ise-Ekiti	4	25	100	94
		iii) Gbonyin				
		iv) Oye-Ekiti				
2	Ebonyi	i) Afikpo South				
		a) Osso-Edda				
		b) Amasiri			100	90
		c) Akeeze	5	20		
		ii)Afikpo North				
		iii) Abakaliki				
		iv)Ezza North				
3	Ogun	i) Yewa North				
		ii)Yewa South				
		iii) Lafenwa				
		a) Ofada town	7	15	105	100
		iv) Obafemi Owode				
		v) Ogun Water Side				
		vi) Egbado				
		vii) Ifo				
4	Nassarawa	i)Lafia North				
		a) Quandare				
		b) Doma	7	15		
		ii)Lafia South			105	98
		iii) Akwanga				
		iv) Nasarawa-Eggon				
		v) Awe				

Source: Field Survey, 2016.

Table 4: Description of Processors by Processing Techniques used

S/N	Activity	Traditional Techniques	Tradmodern Techniques	Purely Modern Techniques
1	Parboiling	Use of old pots and pans	Use of old and new pots and pans	Use of steam parboilers (different sizes)
2	Drying	Sun as dryer mainly on the roadside	Sun as dryer (concrete floors, jute bags, tarpaulins, sacks)	Steam dryers
3	Milling	Outdated milling machines, hand winnowing	Milling (old or new mills with hullers and winnowers optional i.e. not necessarily inbuilt), hand winnowing	Milling machines with inbuilt hullers and winnowers.
4	Destoning	Optional	Destoning (using sieves of different sizes as stone removal/ not done at all)	Destoners (different sizes). Sealers and packaging machines also available.

Source: Tanzania Assessment (2014); Patil (2016); Basorun (2013)

3.3 Method of Data Analysis

Different analytical tools were used in analysing the variables obtained from rice processors on processing techniques used in the study areas. These include descriptive statistics, Multinomial Logistic regression, data envelopment analysis and the Tobit regression model.

3.3.1 Multinomial Logistic Regression

The Multinomial logistic regression model (MNL) was used in estimating the determinants of the choice of processing techniques of processors. The MNL method can be used to analyse preferences and choice (Ogundele, 2014) as well as adaptation decisions (Seo and Mendelssohn, 2006). In describing the Multinomial Logit regression, a dependent variable capable of taking on more than two categorical variables such as Y = (0, 1, 2, 3,........, n) was specified, the independent variables (X_i) could be discrete, categorical or continuous. Therefore, in describing the Multinomial Logit as used in this study, the dependent variable Y representing the processing techniques used was categorized into traditional, traditional and modern (tradmodern) and purely modern techniques of processing rice.

This can be specified as:

$$Y = \begin{bmatrix} Traditional\ processing\ technique = 0 \\ Traditional\ and\ modern\ processing\ technique = 1 \\ Purely\ modern\ processing\ technique = 2 \end{bmatrix}$$

The Multinomial Logit (MNL) Model is represented as:

$$\Pr(Y_i = K) = \frac{1}{1 + \sum_{k=1}^{K-1} e^{\boldsymbol{\beta}_k \cdot \mathbf{X}_i}} \qquad (28)$$

While the regression equation can be explicitly specified as:

$$Y = \beta_o + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \text{----------------} \beta_mX_m + e \qquad (29)$$

$$f(k,i) = \beta_{0,k} + \beta_{1,k}x_{1,i} + \beta_{2,k}x_{2,i} + \cdots + \beta_{M,k}x_{M,i}, \qquad (30)$$

$\boldsymbol{\beta}_k$ is the regression coefficient associated with outcome k,

$\beta_{m,k}$ is a regression coefficient associated with the Mth explanatory variable and the Kth outcome. One fairly simple way to arrive at the Multinomial Logit model is to imagine, for *K* possible outcomes, running *K*-1 independent regression models, one outcome is chosen as a "pivot" and then the other *K*-1 outcomes are separately regressed against the pivot outcome. This would proceed as follows, if outcome K=2 were chosen as the pivot:

$\Pr(Y_i = 1) = \Pr(Y_i = K)\, e^{\beta_1 \cdot X_i}$ (31)

$\Pr(Y_i = 2) = \Pr(Y_i = K)\, e^{\beta_2 \cdot X_i}$ is the pivot regression, regressed against others

$\Pr(Y_i = 3) = \Pr(Y_i = K)\, e^{\beta_3 \cdot X_i}$ (32)

$\Pr(Y_i = k) = \Pr(Y_i = K)\, e^{\beta_{k-1} \cdot X_i}$ (33)

K_1 = Traditional; K_2 = Traditional and Modern; K_3 = Purely Modern

K – 1= for the other K(s) i.e. other K possible outcomes: K_1 & K_3, while (K_2 was set as base category or pivot). i.e. K_2 = base category i.e. (Traditional and modern techniques).

The explanatory variables $X_{i(s)}$ associated with observation (i) are:

Household Characteristics:

SEX= Sex of rice processors (1 if male, 0= female)

AGE = Age of rice processors (years)

MARTSTA = Marital status of rice processors (1 if married; 0= otherwise)

HOUSIZE = Household size of rice processor (number)

EDUSTA = Educational status of rice processors (years of schooling).

Processing Characteristics:

PADYSOU = Paddy source (Own farm=0, other sources =1)

MEMASS= Membership of processing association (1= yes, 0=no).

EXP = Experience as a rice processor (years)

LABO = Labour (man days)

MAININC = Main income source (1 if Processing, 0= Otherwise).

OTHERINC= Other income sources (1 if yes; 0= otherwise).

ACCESSCRE = Access to credit (1= Access, 0= otherwise)

DISTPADY = Distance paddy source to processing unit (Km)

While for the *i*th individual, K_i is the observed outcome represented by the different types of rice processing techniques used and X_i is a vector of explanatory variables sub-divided into household characteristics and processing characteristics. Explanatory variables were selected based on some previous studies of Basorun (2013); Basorun and Fasakin (2013); Ajala and Gana (2015); Afolami *et al.* (2012); Dimelu *et al.* (2014).

i) A priori expectation of exogenous variables used in determinant of choice of processing techniques used by rice processors in the study area

Sex of processors: It can have a positive or negative effect on the choice of rice processing technique used by processors. It is usually represented as a dummy variable with the male= 1 and the female=0.

Age of processors: It is a discrete variable expected to influence the choice of processing techniques either positively or negatively.

Household size: This is a discrete variable representing the number of people living as a family unit together with the processor. The size of respondents' household is expected to either affect choice of processing positively or negatively.

Educational level: This is a measure of the number of years processors have put into formal education. It is a discrete variable which is expected to affect the choice of processing techniques positively.

Marital Status: This variable showed whether a processor is married or not and it is usually represented in the dummy form as married=1, and otherwise=0. It is expected to have a positive or negative effect on the choice of rice processing technique used.

Access to credit: This is a dummy variable. It shows whether a processor has an access to credit or not. Access to credit is expected to have a positive effect on the choice of rice processing technique. It is represented as Access=1, no access=0

Years of experience: Years of experience in rice processing is a discrete variable, showing the number of years a processor has been in the rice processing business. It is expected to have a positive or negative effect as a determinant of the choice of processing technique.

Membership of association: This is to show if a processor was involved in rice processing association or not. It is a dummy variable represented as membership of association=1, not a member=0. Being a member of a rice processing association is expected to have a positive effect on the choice of rice processing technique.

Other income source: Rice processing as the main income source for the processors is a dummy variable. It is expected to have a positive effect as a determinant of choice. It is represented as a dummy variable as other income sources=1, no other income sources=0.

Distance to paddy source/processing unit: This is a discrete variable showing the distance processors have to go before they get paddy, as well as the distance they have to go before this paddy is processed. It is expected to have a positive or negative effect on the choice of rice processing technique.

3.3.2 Measure of efficiency using the Data Envelopment Analysis

The Data Envelopment Analysis (DEA) is a non-parametric method that provides a measure of efficiency which allows for the estimation of inputs and outputs thereby resulting in a frontier which represents the best practice (Giordano *et al*. 2012). In literature, DEA represents production units or firms as Decision Making Units (DMUs), and as such, each processor identified in this study is called a DMU. Assuming we have M inputs and N outputs used by P DMUs (processing units, firms, production units), for the i^{th} DMU, we will represent M and N as vectors of input and output respectively, and as such the vectors could be represented as x_i and y_i. Thus, the M x P input matrix will be X, and the N x P output matrix will be Y together representing the data of all P DMUs. Data Envelopment Analysis (DEA), being a non parametric method of measuring efficiency (Copper *et al.* 2011), uses the linear programming or mathematical programming in determining the efficiency of decision making units (DMUs) (Mecit and Alp, 2013). The DMU can be represented as individual processor making decisions on input-output used in rice processing. DEA provides analyses of efficiency by evaluating each DMU and measuring performance relative to an envelopment surface comprising of other DMUs (Giordano *et al*. 2012). In the use of Data Envelopment Analysis (DEA) as a means of estimating efficiency, we can have the following models:

1. Input Oriented model
2. Output oriented model
3. Constant returns to scale.

To introduce DEA, these can be a ratio of all outputs over all inputs,

i.e. $$\frac{u'yi}{v'xi} \qquad (34)$$

where u is a Nx1 vector of output weights and v is a Mx1 vector of input weights. To have an optimal weight we will have to specify a mathematical programming problem of the form:

$\max_{uv} (\frac{u'yi}{v'xi})$

subject to: $\frac{u'yk}{v'xk} \leq 1$, k= 1----------------------------K (35)

or u,v ≥ 1, (36)

In order to impose a constraint $v^{'}x_i$ which will equal to 1

i.e. $\max_{uv} (\alpha^{'} y_i)$,

subject to: $v^{'}x_i = 1$,

$\alpha^{'}y_k - v^{'}x_j \leq 0$, k = 1,2,..K (37)

$\alpha, v \geq 0$

Note: the notation change from u and v to α reflects the transformation and can be referred to as the multiplier form of the linear programming problem (Sale and Sale, 2016).

Rule of Thumb: A decision making unit (DMU) is said to be efficient when the DEA score equals to one (Copper *et al.* 2006).

i) Determination of efficiency using Data Envelopment Analysis (DEA)

Based on Chopper *et al.* (1978), Banker *et al.* (1984), Silva *et al.*, (2004) and Sale and Sale (2016) we can have input oriented or output oriented DEA model however, in the determination of technical efficiency of processors, the output orientation DEA was used, For the output oriented DEA, we have

max $z = uy_j - (u_j)^*$ (38)

subject to: $vx_j = 1$

$-vX + uY - (u_je)^* \leq 0$ (39)

$v \geq 0$, $u \geq 0$, (u_j is free in sign)

and the dual is min Θ

subject to: $\Theta x_j - X\lambda \geq 0$ (40)

$Y\lambda \geq y_j$ (41)

$(e\,\lambda = 1)^*$ for $\lambda \geq 0$.

A usefulness of the DEA model is: There is no limit to the number of input and output and it also provides useful information about the input-output mix decision (Sale and Sale, 2016; Copper *et al.* 2011).

ii) Variables for output orientated DEA (Technical Efficiency)

Y= Quantity from rice processing (kg)

Input Variable

X_1= fuel (litres)

X_2 = rice paddy (kg)

X_3= labour (mandays)

X_4 = operating space (square meter).

iii) Input Oriented DEA (Allocative and Economic Efficiencies)

$$\min z = vx_j - (v_j)^* \tag{42}$$

subject to. $uy_j = 1$

$$vX - uY - (v_je)^* \geq 0 \tag{42}$$

$u \geq 0$, $u \geq 0$, (v_j is free in sign)

however the dual is max ɲ

subject to: $$x_j - X\lambda \geq 0 \tag{43}$$

$$ɲy_i - Y\lambda \leq 0 \tag{44}$$

$((e\lambda = 1)^*$ for $\lambda \geq 0$.

iv) Variable for input-oriented DEA

Y = Quantity of processed rice (kg)

Input Variables

X_1 = fuel (₦)

X_2 = paddy (₦)

X_3 = labour (₦)

X_4 = transportation (₦)

X_5 = maintenance and repairs (₦)

Fixed Input

X_6 = operating space/its equivalent (₦)

Variable used in the Data Envelopment Analysis (DEA) to capture efficiencies (allocative, economic and technical[22] were selected based on previous studies of Ogundari and Ajibefun (2006); Dunstan *et al.* (2009); Ogisi *et al.* (2012); Okeke *et al.* (2012); Watkins *et al.* (2013); Watkins *et al.* (2014).

Some Usefulness of the DEA model

There is no limit to the number of input and output and it also provides useful information about the input-output mix decision. It gives information on reference sets for benchmarking. The input-oriented DEA shows how much it is possible for the input used to be reduced with the mind of maximizing the quantity of output while the output-oriented DEA shows how possible it is to expand the output proportionately without altering the quantity of input used (Ogunniyi and Oladejo, 2011). Therefore, in this study, the two stage output and input orientated DEA model was used in estimating the technical and allocative efficiencies of the processors. The output oriented DEA was used in estimating the technical efficiency of processors while the input oriented DEA model was used in estimating the allocative and economic efficiency of processors in the study areas, giving credence to the neo-classical production function of maximized output based on the given amount of input (Fare *et al.,* 1994). The slack obtained helped in the determination of input wasted and output not achieved during the course of processing rice.

3.3.3 Returns to scale

According to Olayemi (2004), the law of production describes the alternative ways in which the level of an output can be expanded. These laws also describe the technical relationship existing between inputs and an output, as inputs are increased in order to increase output. In production economics, there are two types of this laws dealing with the short run and the long run production situations. The basic law governing production increases or expansion is the law of diminishing returns; while in the long run, the main law governing production increase or expansion is the law of returns to scale. Returns to scale focuses on the rate at which an output changes when all factors of production (inputs) changes simultaneously in the same proportion (Olayemi, 2004).

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[22] Technical efficiency is defined independent of prices and cost; therefore, the unit used (litres, km, man-days, ₦ and tonnes) to measure the values of inputs used is allowed.

Therefore, the technical efficiency of a processor which is the conversion of physical inputs into outputs can be determined under variable returns to scale (VRS), constant returns to scale (CRS), increasing returns to scale (IRS) or the decreasing returns to scale (DRS) (Perez *et al.* 2007).

In the short run, there is an assumption that during the course of production, some inputs are variable while others are fixed. However, this assumption is relaxed in the long run and all inputs are variable, hence it is possible to vary the expansion of production by varying the levels of all the inputs used; by decreasing them, increasing them or leaving them as they are in order to produce a given output. Therefore, since returns to scale focuses on the rate at which an output changes when all factors of production (inputs) changes simultaneously in the same proportion (Olayemi, 2004) the DEA helped in the determination of how the observed output is closer or nearer to the frontier or corresponding output at an increasing, constant and decreasing rate.

In conclusion, since technical efficiency of an individual processor is the ratio of the observed output to the corresponding frontier output, there is an in-between distance not covered both by the observed as well as the corresponding frontier output. This distance or in-between away from the production frontier is what is referred to as technical inefficiency. Therefore, technical efficiency of a processor can be determined under variable returns to scale (VRS), constant returns to scale (CRS), increasing returns to scale (IRS) or the decreasing returns to scale (DRS) (Rajconiova, 2004).

i**) Output and Input Slacks**

The output and input slack is got no matter which DEA orientated model is considered. The output slack estimates the level of output that could have been achieved, if all the DMUs were efficient in processing of rice. The input slack on the other hand estimates the excess inputs utilized by the DMUs which could have been reduced if there were an efficient utilization of inputs by processors.

ii) Scale Efficiency

Technical efficiency of a (DMU) processor can be broken down into pure technical efficiency and scale efficiency. The pure technical efficiency occurs when DMUs' technical efficiency cannot be attributed to deviations from optimal scale (scale efficiency), while scale efficiency measures the extent with which DMUs deviates from optimal scale (Kirigia and Asbu, 2013). The value for the scale efficiency can be obtained by diving aggregate efficiency by the technical efficiency (Tlotlego *et al.* 2010). A DMU (processor) is scale efficient when any modification on its size of operation renders its less efficient. The scale efficiency value is usually obtained by dividing the aggregate efficiency by the technical efficiency. Scale efficiency score shows whether a firm is operating at the most productive scale or size. The score is usually equal to 1, a score lower than 1 indicates that the firm is under sized while a score more than one show that the firm is oversized (Watkins *et al.* 2014).

3.3.4 Efficiency differential among rice processors in the study area

The degree to which observed inputs are used to produce observed outputs of a given quality, and matching the optimal use of inputs to produce optimal outputs of a given quality, has been embedded in describing technical, allocative and economic efficiencies (Eze and Nwibo, 2014). The technical efficiency simply put is the ratio of product output and the factor input or ratio of the observed output to the corresponding frontier output. It can also be defined as the conversion of physical inputs such as labour and raw materials or semi-finished goods into outputs (Suresh, 2008). Allocative efficiency occurs when optimal sets of inputs are used in the production of output. This implies that, for any level of production, inputs are used in the proportion which minimizes the cost of production based on the prices of inputs (Ismatul and Andriko, 2013). Economic efficiency can be referred to as optimal allocation of inputs in producing outputs in the best way possible wherein waste and inefficiency is minimized (Nwaru and Iheke, 2010).

Different studies have used the analysis of variance also called Anova and the chi square in estimating the differences and significance among and between means. The ANOVA is used in the determination of statistical differences between the means of three or more independent groups (Braun, 2012). The F-test obtained after the analysis of variance (anova) could be used to statistically interpret the equality or otherwise of the means of the variables used in a study (Heron, 2012). However, in most analysis involving differentials, a simple difference among aggregate means or averages is usually carried out (Gbebru and Holden, 2015).

Hence, in this study, a simple difference of aggregate means of technical, allocative and economic efficiencies of processors was carried out in order to compare the mean with best outcome relative to those of others.

3.3.4.1 Allocative efficiency of rice processors in the study area

Marginal Product (MP) = $\frac{dq}{dx}$ (45)

$$MP = \frac{df(X)}{dX} \quad (46)$$

The slope of the TPP is the MPP which means

$$MPP = \frac{dTPP}{dX} \quad (47)$$

While $MPP = \frac{r}{Px}$; (48)

or $MPP.\ P_x = r$; (49)

or $MVP_x = r$ (50)

Signifies the allocative efficiency; where MPP_x is the marginal physical product of the variable X, r is the input prices, P is the output price and MVP_x is the marginal value product of input x.

$MVP_x = P\ .\ Q$ (51)

This implies also that Marginal value product is the product of the price of output and the quantity of out (Kadiri *et al.* 2014). Furthermore, the MVP_x can be equated to the Marginal factor cost, which is simply the unit price of each input used in the processing process.

$MVP_x = MFC$ (52)

$\frac{MVP}{MFC} = 1$ = Allocative efficiency (53)

$1- \frac{MVP}{MFC}$ = Allocative inefficiency (62)

Allocative efficiency occurs where price is equal to Marginal cost (P=MC), since price is society's measure of relative worth of a product at the margin or its marginal benefit.

Rule of thumb: A ratio of less than one shows overutilization of inputs, a ratio of equal to one is allocative efficient input utilisation and a ratio of more than one is under-utilization of input.

We can also deduce processor's allocative efficiency when the Marginal Benefit derivable (MB) > Marginal Cost of inputs (MC), we have under utilization of resources or under production. When the Marginal cost of inputs (MC) < Marginal Benefit (MB) we have over production or over utilization of resources. When the MB=MC, we have optimal production or optimal utilization of resources.

3.3.4.2 Economic efficiency of processors in the study area

Economic efficiency (EE) can be determined by the product of the technical efficiency and the allocative efficiency (Farrell, 1957; Asogwa *et al.* 2011; Watkins *et al.* 2014). It can also be referred to as the processors' ability to process a predetermined amount of rice at minimum cost given the available technology. It can be represented using mathematical and economic functions as;

Marginal benefit from/of buyers or users = marginal cost of production (54)

Economic efficiency can be obtained using the parametric measures or methods of efficiency measurement, by constructing a functional form for the stochastic production frontier as well as with the non-parametric method or measure of efficiency measurement, using the Data Envelopment Analysis, not requiring the setting of a functional form. In the use of the non-parametric method of determining the economic efficiency of rice processors, the economic efficiency scores of processor (p) can be obtained following the cost-minimization non parametric model shown as below:

$$MC_p = \min_{\lambda x^{*}rq} \sum_{j-i}^{j} PnjX * nj \quad (55)$$

Subject to:

$$\sum_{i=1}^{j} \lambda iXij - X * nj \leq 0 \quad (56)$$

$$\sum_{i=1}^{j} \lambda iPij - Ynj \geq 0 \quad (57)$$

$$\sum_{i=1}^{j} \lambda i = 1 \quad (58)$$

$$\lambda_i \geq 0 \quad (59)$$

Where MC_p = the minimum cost of processing; Pn_j = the price of inputs used in processing rice; X^{*}_{nj} = the cost minimizing level of input j used in processing rice, given their prices and for the different amount of rice processed. Furthermore, the economic efficiency of processors can also be calculated using the equation 60

$$EE_p = \frac{\sum_{j-1}^{j} PnjX*nj}{\sum_{j-1}^{j} PnjXnj} \quad (60)$$

Where $\sum_{j-1}^{j} PnjX*nj$ which is the numerator, is the minimum total cost of processing, while $\sum_{j-1}^{j} PnjXnj$ which is the denominator is the actual total cost of processing rice (Watkins *et al.,* 2013). Economic efficiency takes on the value of ≤1, whereby an EE of 1 indicates that the processors are economically efficient and an EE of <1 indicates that processors are economically in-efficient.

3.3.4.3 Determinants of efficiency

In estimating the determinant of efficiency of rice processors, a Tobit regression was used. This was done as a second stage regression by incorporating the efficiency scores generated from the DEA model into the Tobit regression model (Ogunniyi and Oladejo, 2011). In many statistical analyses when the dependent variable is censored either to the left, right or both left and right giving a lower or upper limit, the generalized or standard model to use is the Tobit regression model (Tobin, 1958; Rahman and Chima, 2016). In many instances, the use of Tobit regression model helps in overcoming selectivity bias that could have been introduced earlier from a preceding model (Olagunju and Ajiboye, 2010).

For a standard Tobit model, assuming a dependent variable Y that is censored at zero, thereby generating another variable as a result after the censoring; such that:

$$Y_i* = X_i^{`}\beta + \varepsilon_i \quad (61)$$

$$\text{While } Y_i = \begin{cases} 0 \ if \ Yi* \leq 0 \\ Yi* \ if \ Yi* > 0 \end{cases} \quad (62)$$

The subscript i= 1......N, indicates the observation Y_i* is an unobserved or latent variable, X_i is the vector of explanatory variables, β is a vector of unknown parameters, and ε_i is the disturbance term.

Hence for this study, i= the efficiency scores generated from the DEA model,

Y_i^* is a censor of the efficiency score setting a lower limit of 0

$X_{i(s)}$ are the explanatory variables.

i) Variables for the Tobit Regression

The tobit regression to estimate an equation of the general form can be given as equation 62 an expansion of equation 63.

$$Y_i^* = \alpha + \beta Z_1 + \beta Z_2 + \beta Z_3 + \beta Z_4 + \text{----------} + \beta Z_n + \varepsilon_1 \quad (63)$$

Dependent Variable

Y_i^* = the efficiency scores generated from DEA analysis.

Independent Variables

Household Characteristics:

SEX= sex of processors (1 if male, 0= female)

AGE= Age of processors (years)

MARTSTAT= Marital Status of processors (1 if married; 0= otherwise)

HOUSSIZE = Household size (number)

EDUSTAT= Educational level of processors (years of schooling)

Processing Characteristics:

PADYSOU = Paddy Source (0= Own farm, Purchased = 1).

MEMASS= Member of processing association (1= yes, 0= no),

EXP = Experience as a Processor (years)

OTHERINC= Other income (1 if yes; 0= no)

ACESSCRE= Access to credit (1= yes, 0= no)

DISTPRO= Distance to processing centre (km)

Explanatory variables were selected based on previous studies of: Onyeneke (2017); Osanyanlusi and Adenegan (2016); Ijoku (2016); Oguntade (2011).

3.3.4.4 Pre-Estimation Tests

i) Test of Multi-collinearity

Ordinary least squares regression techniques assume that explanatory variables are independent and so there is no interaction between them (Viton, 2014). This could be further explained that two or more explanatory variables do not tend to move together in the same pattern, i.e. there is no linear relationship between the explanatory variables (Piantadosi *et al.,* 2007). An exact linear relationship is said to occur when the below condition is satisfied:

$$\lambda_1 X_1 + \lambda_2 X_2 + \text{-------------------} + \lambda_j X_j \quad (64)$$

where λ_1, λ_2,---------- λ_j are all constants such that not all of them are zeros simultaneously. However, when this assumption is violated or invalid, then the problem of multi-collinearity arises. This problem can only be found to arise in multiple regressions where there is the use of more than one explanatory variable (Lehman, 2005); wherein more than one exact linear relationship exists between explanatory variables, for instance:

$$\Lambda_1 X_1 + \lambda_2 X_2 + \text{-----------} + \lambda_j X_j + v_i = 0 \quad (65)$$

Where v_i is the stochastic error term, depicting that there is a level of interaction existing among the explanatory variables. Although the problem of multi-collinearity is found to be predominant and more serious in Time series data, it can also arise in cross-sectional data, as used in this study. This study relate processing techniques with a number of explanatory variables, thus the assumption that some or many of the variables might collinear cannot be ruled out hence; a need for a test of multi-collinearity. There are different ways of testing for multi-collinearity in data:

1) If there are only two explanatory variables, multi-collinearity can be measured using simple correlation co-efficient, but in the case of more than two explanatory variables, the use of partial correlation coefficient can be used.

2) Use of r^2, $\bar{R}^2$ and Standard Error of coefficient: A combination of the coefficient of determination r^2, adjusted coefficient of multiple determination $\bar{R}^2$ and the standard error of parameter estimate S_b in the detection of multi-collinearity.

3) Klein's Method: This suggests that there is the tendency for high multi-collinearity problem in three variable regression equations. However, the method is limited in that it may not be able to efficiently detect multi-collinearity when there are more than two explanatory variables in the model, even when the variables in question are taken two at a time.

4) The Farrar-Glauber Test: This involves the use of Chi-square, F statistics and the t-statistics.

5) Tolerance Value and Variance Inflation Factor (VIF): The i^{th} tolerance value is defined as the 1-R_k^2 and R_k^2 is the coefficient of determination for regression of the ith independent variable, X_1-X_n (Jeeshim and Kucc, 2003). The variance inflation factor is just the reciprocal of the tolerance value. This implies that low tolerance value is an indication of high VIF. The VIF thus shows how multi-colinearity has increased the instability of the coefficients of estimates; this therefore tells how inflated the variance of the coefficients is compared to what it would have been if the variables were not correlated with others in the model (Greene, 2000; Freund and Little, 2000).

Multi-collinearity simply implies a relationship between the explanatory variables causing the variances or standard errors of regression coefficient estimates i.e. the b_i to be inflated which means the variances or the standard errors of the b_i is too large. The magnitude of the b_i may be different from what is expected. Thus, in order to correct this among the various explanatory variables that was used in the model of this research, the Variance Inflation Factor (VIF) was used to correct multi-collinearity in the model. This was done by regressing an explanatory variable against other explanatory variables as against the norm of regressing a dependent variable against explanatory variables.

$$\text{VIF} = \frac{1}{(1 - Ri^2)} \qquad (66)$$

Where R^2 = coefficient of determination

And R^2 was obtained from regressing all the X(s) against each other i.e. .X_1, X_2........X_n.

Rule of Thumb: Collinearity exists if VIF is greater than 5.

3.34.5 Post Estimation Tests

Post estimation tests are tests of significance providing estimates of the strengths of relationships. There are different ways and techniques of doing this for different data and variables. However, for this study the post estimation test employed for the multinomial logistic regression model used was the relative risk ratio as against other tests of significance which do not provide adequate estimates for strength of relationships (Bland, 2006; www.turner.white.com).

i) The relative risk ratios

The probability of a risk of an event is the number (of individuals, respondents or variables) experiencing the event divided by the number who could experience it. The relative risk ratios therefore helps not just in considering the chance of an outcome occurring, but also the chance of observing the outcomes when certain conditions are present or absent. This further suggests that the determination or calculation of the relative risk ratios allows the quantifying of the magnitude of the influence of a factor's presence on an outcome (Spitalnic, 2005).

A relative risk ratio (RRR) of <1 implies lower probability of outcome variable being in the comparison group relative to the base category. This also implies that the risk of the outcome falling in the comparison group relative to it falling in the reference group decreases as the variable increases.

A relative risk ratio of >1 implies a greater probability of the outcome variable being in the comparison group relative to the base category. It also signifies the risk of the outcome variable falling in the comparison group, relative to the risk of the outcome falling in the reference group.

ii) The odds ratio

The odds of an event is the number (of individuals, respondents, variables) experiencing the event divided by the number who do not experience it.

iii) Risk is the probability of an outcome of interest, and it can be represented as a percentage, a fraction or as a number between 0 and 1).

Table 5: A priori expectations of variables used in Multinomial logit regression

S/N	Variable Name	Variable Description	A-priori Expectations	Previous Studies
		Household Characteristics		
1	Sex	Dummy	+	Dandedjorohoun *et al*. (2015), Dhanktar (2014)
2	Age (years)	Discrete	+	Kagbu *et al*. (2016); Nasiru (2015)
3	Educational status	Dummy	+	Tiamiyu *et al*. (2014); Fakayode *et al*. (2010)
4	Marital status	Dummy	-	Kagbu *et al*. (2016); Shabu (2013); Nimoh *et al*. (2012)
5	Household size	Discrete	+	Umoh (2013); Oko *et al*. (2012); Perez (2007); Umoh (2006)
		Processing Characteristics		
6	Years of experience	Discrete	+	Basorun (2013); Basorun and Fasakin (2013
7	Access to credit	Dummy	+	Akinbode (2012); Waqar *et al*. (2013)
8	Paddy source	Dummy	+	Dunstan *et al*. (2009); Basorun (2013).
9	Main income source	Dummy	+	Nwalieji (2016); Olaoye, (2014); Basorun (2013).
10	Other income sources	Dummy	+	Dimelu *et al*. (2014).
11	Distance to paddy source	Discrete	+	Ajala and Gana (2015); Dunstan *et al* .(2009),
12	Labour	Discrete	+	Oladebo (2014); Nimoh *et al*. (2012).
13	Membership of association	Dummy	+	Afolami *et al*. (2012); Martey *et al*. (2013); Nasiru (2014).

Source: Author's Compilation Field Survey, 2016.

Table 6: Economic expectations of variables in Tobit regression

Variable Name	Variable Description	A-priori Expectations	Previous Studies
Sex	Binary	+	Onyekwena (2016); Okpe *et al.* (2014).
Age (years)	Discrete	+	Nasiru (2014); Onyeneke (2017)
Educational level	Binary	+	Kadiri *et al.* (2014), Amasa and Maurice (2005)
Marital status	Binary	-	Asogwa *et al.* (2012), Ohajianya, *et al.* (2013)
Household size	Discrete	-	Nazaki *et al.* (2013), Akinbode *et al.* (2011)
Access to credit	Binary	+	Ayeomoni and Aladejana (2016), Akinbode (2013)
Paddy source	Binary	+	Nazaki *et al.* (2013), Alarima *et al.* (2011)
Other income	Binary	+	Rahman and Chima (2016), Akanbi *et al*. (2011)
Experience in (years)	Discrete	+	Osanyanlusi and Adeneagan (2016); Ogisi *et al.* (2012)
Membership of association	Binary	+	Obaniyi *et al.* (2014), Ajala and Gana (2015)
Distance to paddy source	Discrete	+	Dandedjrohoun (2015), Effiong *et al*. (2015)

Source: Author's Compilation Field Survey, 2016.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter discusses the results that emanated from study. It profiles the socio-economic and processing characteristics of rice processors by processing techniques used. This chapter also describes the choice, efficiency, efficiency differentials and determinants of efficiency of rice processors by processing techniques used.

4.1 Classification of rice processors by socioeconomic characteristics

4.1.1 Profile of household level characteristics by processing techniques used

This section presents the profile of rice processors' processing techniques used by some socioeconomic and demographic characteristics as shown in Table 7.

Distribution of processors by sex

Male processors who used traditional techniques to process were 17.44 percent while female processors who used the same techniques for processing rice paddy were 22.86 percent. Female processors (67.62 percent) used the tradmodern techniques of processing rice while male processors (63.37 percent) used these techniques (tradmodern). This outcome is similar to the research result of Udeh (2012) where more women were found involved in agricultural development projects in Enugu state Nigeria. Likewise, the report from www.sahelcp.com also attests to this research outcome that more females are involved in processing aspects of agriculture than males. The research of Nwankwo (2012) also showed that more females were involved in agricultural processing than males, although the research of Nwankwo focused on oil palm processing which is another aspect of agricultural processing; further buttressing the involvement of females in rice processing activities. This research result is also similar to the research of Dissanayake (2012) and Dandedjrohoun *et al.* (2015) whose major rice processing respondents were females. This result is not similar to the research result of Basorun (2013) in Ekiti state; whose study was on Igbimo rice where milling was carried out more by males (59.7percent) than females; while females (40.3percent) were found to engage more in parboiling and drying. The research result of Ogundele (2014) is also not similar to that obtained from this study. The result showed that less than 35 percent respondents were females. This result is also contrary to the findings of Coker and Ninalowo (2016), were majority (97.50percent) respondents involved in farming activities in Niger state, Nigeria were males. Male processors who used the purely modern technique for processing were 19.19 percent while the females were 9.52 percent.

Distribution of processors by age

The age distribution in table 11 shows that more processors were in the age category of 21-40 and 41-60 years. The processors in the age category 21-40 years (21.28percent) used the traditional technique to process rice. Processors (58.51 percent) used the tradmodern techniques while 20.21 percent of the processors used the purely modern technique in processing rice. Processors in the age category of 41-60 years (17.67 percent) used the traditional techniques of processing. 69.48 percent used the tradmodern techniques while 12.85 percent in the 41-60 years of age category used the purely modern techniques. The research of Osanyanlusi and Adenegan also had 64.9 percent respondents within this age group (41-60 years). The research outcome of Nwalieji (2016) is also similar to the outcome of this research where majority of the respondents (rice farmers in Anambra and Ebonyi state, Nigeria) were in their middle age, active and productive. The research of Nwalieji further showed that 49.18 percent were in the age group of 40-49 in Anambra state; while 49.20 percent were in this age group of 40-49 in Ebonyi state. The outcome of Kagbu *et al.* (2016) showed that 70.9 percent respondents were less than 45 years of age; implying that they were active, agile and productive.

Furthermore, the mean age obtained from this study is close to age group in the study of Oyinbo *et al.* (2014); whose respondents' household heads were within the age group of 41-50 years; which further suggested that respondents were still agile and productive. Processors in the age category of 61-80 years were also found involved in the rice processing business as 38.89 percent used the traditional techniques of processing. This distribution is more than the number of processors in the age category of 21-40 and 41-60 years who used the traditional techniques of rice processing. Rice processors (55.56 percent) who used the tradmodern technique of rice processing are more in the age category of 61-80 years than those who used the technique in the 21-40 years of age category. However, more processors in the 21-40 years of age category used the purely modern techniques more than those in the 61-80 years of age category.

Distribution of processors by marital status

In describing the processors by processing techniques used and their marital status 75 percent processors who were single used the tradmodern techniques of processing while 12.50 percent used the traditional and purely modern techniques, respectively. The distribution also shows that majority of the married processors (67.16 percent) used the tradmodern techniques, 18.0 used the traditional techniques while 14.79 percent used the purely modern techniques. However, among processors who were divorced or separated, 73.73 percent used the traditional techniques; 27.27 percent used the tradmodern techniques while none used the purely modern technique of processing. Rice processors who were widows 37.60 percent used the traditional technique of processing, 56.25 percent in this category used the tradmodern techniques while 6.25 percent used the purely modern technique. Overall, according to the result obtained from this distribution, majority of the processors were married. The implication of this is that, rice processors in this study are stable. This result is similar to the research of Kagbu *et al.* (2016) where 82.5 percent of the respondents were married.

Distribution of processors by educational status

Educational status of the rice processors when compared with processing techniques used shows that 27.71 percent with no formal education used the traditional techniques of rice processing, 55.42 percent in this category used the tradmodern techniques, while 16.87 percent used the purely modern techniques. Processors who had primary education (26.13 percent) used the traditional techniques of processing rice; 62.16 percent in this category used the tradmodern techniques while 11.71 percent used the purely modern techniques. This is quite low considering the minimum requirements and expectations for basic level formal education (Moja, 2000; Nuffic, 2017). This was however not in line with the outcome of Kagbu *et al.,* (2016); where more than 80 percent had below secondary education (i.e. primary education) among women rice producers in Nasarawa state. The implication of this as shown in the study of Adedoyin *et al.* (2016) was that education was an added advantage to assessing information, increasing productivity and adopting new techniques. However, Dandedjrohoun *et al.* (2015)'s research outcome showed that being educated does not necessarily change respondents' perspective of accepting improved processing techniques.

Processors who had the Quaranic School education (91.67 percent) used the tradmodern techniques of rice processing, while 8.13 percent in this category used the purely modern techniques. 15.32 percent processors who had access to secondary school education used the traditional techniques, 70.16 percent used the tradmodern techniques, while 14.52 percent used the purely modern techniques of rice processing. Those who had tertiary education (13.73 percent) used the traditional method of rice processing, 72.55 percent processors in this category used the tradmodern techniques, while 13.73 percent used the purely modern techniques.

Distribution of processors by household size

The distribution among rice processors by household size and processing techniques used shows that processors who had 0-5 household members (16.42 percent) used the traditional techniques of processing rice; 71.64 percent in this category used the tradmodern techniques while 11.96 percent used the purely modern techniques. Processors in the category 6-10 household members (22.83 percent) used the traditional techniques; 62.56 percent used the tradmodern techniques while 14.61 percent used the purely modern techniques. This positively implied that processors will have more hands as family labour; which was found similar to the research of Asogwa *et al.* (2012) where large family size increased the rice plots cultivated. However negatively, this also implied that respondents will have more responsibilities thereby reducing the amount ploughed back into the business, while consumption and consumables will increase; as was obtained from Oguntade in 2011. Those in the category 11-15 household members (20 percent) used the traditional techniques; 64 percent used the tradmodern techniques while 16 percent used the purely modern techniques. However, the research of Coker and Ninalowo (2016) is not similar to that obtained from this research; because respondents who had large household size (45percent) had between 11-15 persons in Niger state, Nigeria as against 7.6percent obtained from this study. None of the processors with household size in the category of 16-20 used the traditional techniques; all of them used only the tradmodern techniques.

Table 7: Profile by household level characteristics

Variables (Percent)	Traditional		Traditional and Modern		Purely Modern		Total
	Frequency (n=78)	**Percent (%=20.48)**	**Frequency (n=251)**	**Percent (%= 65.71)**	**Frequency (n=53)**	**Percent (%= 13.87)**	**382**
Sex of processors							
Female	48	22.86	142	67.62	20	9.52	210
Male	30	17.44	109	63.37	33	19.19	172
Age of processors (years)							
0-20	0	0.00	3	0.30	0	0.00	3
21-40	20	21.28	55	58.51	19	20.21	94
41-60	44	17.67	173	69.48	32	12.85	249
61-80	14	38.89	20	55.56	2	5.56	36
>80							
Marital status							
Single	2	12.50	12	75.00	2	12.50	16
Married	61	18.05	227	67.16	50	14.79	338
Divorced/Separated	8	72.73	3	27.27	0	0.00	11
Widowed	6	37.60	9	56.25	1	6.25	16

Source: Field Survey, 2016.

Table 8: Profile of rice processors by household level characteristics

Variables (Percent)	Traditional		Traditional and Modern		Purely Modern		Total
	Frequency (n=78)	**Percent (%=20.48)**	**Frequency (n=251)**	**Percent (%= 65.71)**	**Frequency (n=53)**	**Percent (%= 13.87)**	**382**
Educational level							
No formal Education	23	27.71	47	55.42	14	16.87	84
Primary Education	29	26.13	69	62.16	13	11.71	111
Quaranic Education	0	0.00	11	91.67	1	8.33	12
Secondary Education	19	15.32	87	70.16	18	14.52	124
Tertiary Education	7	13.73	37	72.55	7	13.73	51
Household size							
0-5	22	16.42	96	71.64	16	11.94	134
6-10	50	22.83	137	62.56	32	14.61	219
11-15	5	20.00	16	64.00	4	16.00	25
16-20	0	0.00	2	100	0	0.00	2
>20	1	50.00	0	0.00	1	50.00	2
Mean							**6.64**
Standard deviation							**4.18**
Main income source							
No	33	18.13	126	69.23	23	12.64	182
Yes	45	22.50	125	62.50	30	15.00	200

Source: Field Survey, 2016.

4.1.2 Processing techniques and processing characteristics

The distribution of processors when processing was the main income generating activity shows that 22.50 percent of the processors used the traditional techniques, 62.50 percent used the tradmodern technique while 13 percent used the purely modern technique. On the other hand, processors whose main income does not come from rice processing 18.13 percent of them used the traditional techniques, 69.23 percent used the tradmodern techniques while 12.64 percent used the purely modern techniques.

Processors who have other sources of income from rice processing, 20.15 of them percent used the traditional techniques of processing, 64.67 percent used the tradmodern techniques while 1.38 percent used the purely modern techniques. Processors who do not have other sources of income, 21.10 percent of them used the traditional techniques, 68.81 percent used the tradmodern techniques while 10.09 percent used the purely modern techniques.

Years of experience of processors when compared to processing techniques used as shown in Table 9 shows that 29.73 percent with 0-5 years of processing experience used the traditional techniques, 64.36 in this category used the tradmodern techniques while 5.41 percent used the purely modern technique. Processors with 6-10 years of experience (20 percent) used the traditional techniques; 64.21 percent used the tradmodern techniques while 15.79 percent used the purely modern techniques. Those in the category of 11-15 years of processing experience (17.46 percent) used the traditional method; 61.90 percent used the tradmodern technique while 20.63 percent used the purely modern technique. Processors in the category 16-20 years of processing experience (21.21 percent) used traditional techniques of processing rice; 70.71 percent used the tradmodern techniques while 8.08 percent used the purely modern techniques. 13.51 percent in the category of 21-25 years of processing experience used the traditional techniques; 62.16 percent in the same category used the tradmodern techniques while 24.32 percent used the purely modern techniques. Processors in the category of 26-30 years of processing experience (24.24 percent) used the traditional techniques; 63.16 percent used the tradmodern techniques while 12.12 percent used the purely modern techniques. Those with processing experience of more than 30 years (16.67 percent) used the traditional techniques; 72.22 percent used the tradmodern technique; while 11.11 percent used the purely modern techniques of processing rice.

Membership of processors in rice processing association was compared with the processing techniques used among rice processors in the study area. The distribution shows those processors who were not members of rice processing association (26.67 percent) used the traditional techniques of rice processing; 56.67 percent in this category used the tradmodern techniques while 16.67 percent used the purely modern techniques in the distribution. Processors who were members of rice processing associations (14.85 percent) used the traditional techniques of processing rice; 73.17 percent used the tradmodern techniques while 11.39 percent used the purely modern techniques of processing rice. Processors who used the tradmodern techniques were more who are in rice processing association. This as explained by Attah (2012) among rice farmers showed that membership of rice associations will increase access to basic farming facilities.

The source where processors obtained paddy was compared with the processing techniques processors opted for. The distribution shows that 27.85 percent processors who obtained paddy from their own farms used the traditional techniques of processing; 64.56 percent of the processors in this category used the tradmodern techniques while 7.59 percent of processors used the purely modern techniques. Processors who obtained paddy by purchase (18.48 percent) used the traditional techniques; 66.01 percent used the tradmodern techniques while 15.51 percent used the purely modern techniques.

Processors who had no access to credit (15.57 percent) used the traditional techniques of processing; 67.62 percent in this category used the tradmodern techniques while 16.80 percent used the purely modern techniques. Those who had access to credit (28.99 percent) used the traditional technique; 62.32 percent used the tradmodern techniques while 8.70 percent used the purely modern techniques. This further confirms the outcome of Oloye (2014) that although there is a great potential for the agro-based industries, they are constrained by various factors. Thus, according to this distribution by processors’ access to credit, although 67.62 percent had no access to credit; they still strove to use a supposedly better technique than the traditional technique of processing. Furthermore, according to Basorun (2013), despite the constraints faced by processors, they are rational and know what is best. This is further seen by the outcome from this study where 16.80 percent though not having access to credit still used the purely modern techniques of rice processing. Therefore, the overall implication of this as seen from the difference among processors who had access to credit and those who do not is that, if credit is provided to processors at adequate amount, it will better enhance their processing activities.

The distance processors had to cover before they obtained paddy was compared with the techniques used. This shows that majority of the processors (65.57 percent and 70.04 percent) had to cover a distance of 0-10km and greater than 40 kilometres before they could get to paddy source. This further confirms the distribution where processors obtained paddy from own farms as well as from other sources (purchase). Processors who had to obtain paddy from distances more than 40 km (18.06 percent) used the traditional techniques; 70.04 percent used the tradmodern techniques while 11.89 percent used the purely modern techniques. The distance processors had to travel before they got to the processing unit/centre was not as long when compared to the distance they had to cover before they obtained paddy. Processors (19.56 percent) who have to cover a distance of 0-10 km in order to process paddy used the traditional techniques; 66.67 percent in this category used the tradmodern technique while 13.77 percent in this category used the purely modern techniques.

Table 9: Distribution by processing techniques

Variables (Percent)	Traditional		Traditional and Modern		Purely Modern		Total
	Frequency (n=78)	**Percent (%=20.48)**	**Frequency (n=251)**	**Percent (%= 65.71)**	**Frequency (n=53)**	**Percent (%= 13.87)**	**382**
Other income sources							
No	23	21.10	75	68.81	11	10.09	109
Yes	55	20.15	176	64.47	42	15.38	273
Experience in processing (years)							
0-5	11	29.73	24	64.86	2	5.41	37
6-10	19	20.00	61	64.21	15	15.79	95
11-15	11	17.46	39	61.90	13	20.63	63
16-20	21	21.21	70	70.71	8	8.08	99
21-25	5	13.51	23	62.16	9	24.32	37
26-30	8	24.24	21	63.16	4	12.12	33
>30	3	16.67	13	72.22	2	11.11	18
Paddy sources							
Own farm	22	27.85	51	64.56	6	7.59	79
Purchase	56	18.48	200	66.01	47	15.51	303
Membership of association							
No	48	26.67	102	56.67	30	16.67	180
Yes	30	14.85	149	73.17	23	11.39	202

Source: Field Survey, 2016.

Table 10: Profile by processing techniques

Variables (Percent)	Traditional		Traditional and Modern		Purely Modern		Total
	Frequency (n=78)	**Percent (%=20.48)**	**Frequency (n=251)**	**Percent (%= 65.71)**	**Frequency (n=53)**	**Percent (%= 13.87)**	**382**
Access to credit							
No	38	15.57	165	67.62	41	16.80	244
Yes	40	28.99	86	62.32	12	8.70	138
Distance to paddy source (km)							
0-10	18	14.75	80	65.57	24	19.67	
11-20	7	50.00	6	42.86	1	7.14	
21-30	9	56.26	6	37.50	1	6.25	
31-40	3	100	0	0.00	0	0.00	
>40	41	18.06	159	70.04	27	11.89	
Distance to processing centre (km)							
0-10							
11-20	71	19.56	242	66.67	50	13.77	363
21-30	2	33.33	1	16.67	3	50.00	6
31-40	3	30.00	7	70.00	0	0.00	10
>40	2	66.67	1	33.33	0	0.00	3

Source: Field Survey, 2016.

4.1.3 Rice processors by size of operation

The major production systems based on size of operation in Nigeria are small scale, medium scale and large scale (O'Neill *et al.* 2006; Oniah *et al.* 2008; and Omoti, 2011). This sub-division is therefore adapted to this study. Although this study goes further to make use of another sub-division for rice processors. The new category introduced is the integrated category which is based on the outcome of Tanzania Assessment (2014). Therefore, the categorization of rice processors by size of operation as shown in Table 11 are small scale with processors the category (<100-900kg) or (<0.01-0.09 tons), medium scale with processors in category (1000-5000kg) or (1-5 tons), large scale with processors in category (6000-10,000kg) or (6-10tons) and integrated processors in category (>10,000kg) or (>10 tons).

More processors (55.15 percent) used the traditional method of processing and were found in the small scale category. 39.74 percent of the processors used the traditional techniques of processing and were in the medium scale category while 5.13 percent used the techniques to process rice in the large scale processing category. However, there were no processors who used the traditional processing techniques in the integrated category. Processors in the medium scale category (56.18 percent) were more who used the tradmodern technique of processing rice. Small scale processors (40.24 percent) used the tradmodern technique to process rice while processors who were in the large scale category (3.19 percent) used the tradmodern techniques of processing. However, there were only 0.40 percent of the processors in the integrated category that used the tradmodern techniques of processing rice. Processors (56.60 percent) in the medium scale category used the purely modern techniques of processing rice, 43.40 percent in the small scale category used the purely modern techniques while no processor in the large and integrated category that used the purely modern techniques of rice processing. This therefore suggests that more processors in the small scale and medium scale categories of rice processing used the traditional and tradmodern techniques of processing more than the purely modern techniques; similar to what was obtained in the researches of Uwaoma (2015) and Leonides (2015).

Table 12: Distribution by processors' category and size of operation

Variables (Percent)	Output in kg				
	(<100-900kg) (small)	**(1000-5000)kg (medium)**	**(>5000- >10,000kg) (large)**	**(>10,000kg (integrated)**	**Pooled (382)**
Traditional	43(55.15)	31(39.74)	4(5.13)	0(0.00)	78(100.00)
Tradmodern	101(40.24)	141(56.18)	8(3.19)	1(0.40)	251(100.00)
Purely modern	23(43.40)	30(56.60)	0(0.00)	0(0.00)	54(100.00)
Total	167(43.72)	202(52.88)	12(3.14)		

Source: Field Survey June-August, 2016. Figures in Parenthesis are in percentages.

***

Small Scale (<100-900kg),

Medium Scale (1000-5000kg),

Large Scale (>5000- >10,000kg),

Integrated Processor (>10,000kg).

4.1.4 Processing activities

Rice processing activities like parboiling, drying, milling and de-stoning could be done using traditional, traditional and modern (tradmodern) or purely modern techniques (Dandedjrohoun *et al.* 2015). This as shown in Table 13 reveals that rice processors involved in parboiling 17.9 percent used the traditional techniques, 31.3 percent used tradmodern techniques while 3.8 percent used purely modern techniques. Milling of rice was done using traditional techniques by 2.6 percent of the processors; 22.5 percent processors used the traditional and modern techniques while 37.7 percent used purely modern techniques.

De-stoning of rice was carried out traditionally by 1.3 percent processors; 2.6 percent used tradmodern techniques while 9.4 percent used pure modern techniques. The implication of this is that majority of the processors were not de-stoning their milled rice (Basorun, 2014). This result is a confirmation of the findings of Ogundele (2014) where more than 50 percent of the respondents sampled preferred imported rice to our locally processed rice. This situation will continue i.e. the preference for imported rice if our processors do not make use of techniques that will allow processed rice to be of quality both in look as well as in presentation (lustre). Processors (17.9 percent) used the traditional techniques for parboiling; 11.3 percent used tradmodern while 3.8 percent used purely modern techniques. Processors involved in parboiling and drying (57.7 percent) used traditional methods of processing. These parboilers still used old pots and drums in parboiling rice, which was as a result of available capital, paddy, etc; 26 percent used tradmodern equipment while 3.8 percent used purely modern equipment.

Processors involved in milling alone who used tradmodern techniques were 22.5 percent; those who used pure modern equipments were 37.7 percent while those who used the traditional equipment for milling were 2.6 percent. However when considering those involved in milling and parboiling, 21.2 percent use both traditional and modern equipment; 35.8 percent used pure modern equipment while 3.8 percent still used traditional equipment for milling and parboiling of rice paddy as presented in Table 11.

Table 13: Processing activity and technique used

	Processing Techniques Used			
Processing activity	**Traditional**	**Traditional and Modern**	**Purely Modern**	**Total**
Parboiling	18(17.90)	40(31.30)	2(3.80)	60(15.71)
Milling	2(2.60)	52(22.50)	20(37.70)	74(19.37)
De-stoning	1(1.33)	6(2.60)	5(9.40)	12(3.14)
Parboiling and Drying	45(57.70)	60(26.00)	2(3.80)	107(28.01)
Milling and parboiling	3(3.80)	49(21.20)	18(35.80)	71(18.60)
Harvesting Drying and Milling	-	7(3.0)	-	7(0.18)
Drying and Milling	-	4(1.70)	-	4(1.05)
Threshing, Parboiling, Drying and Milling	3(3.80)	14(6.10)	2(3.80)	19(4.97)
All the Above	10(12.80)	13(5.60)	3(5.70)	26(6.81)
Total	78(20.41)	251(65.71)	53(13.87)	382

Source: Field Survey, 2016. Figures in Parenthesis are in Percentages.

4.1.6 Activity and output of processed rice

This study also went ahead to investigate the output of processors based on the different rice processing activities carried out as shown in Table 14. It was discovered that not all the processors in the study area carry out all the processing activities at once. In parboiling for instance, those in the different output categories were found to be 64.44 percent, 31.11 and 2.22 percent for (100-1000), (1000-5000) and (5,000-10,000) kg, respectively. Processors engaged in milling of rice had 41.56, 50.65 and 7.79 percent, respectively for three of the output ranges. Those involved in parboiling and milling were 30.26 percent for processors in the output category (100-1000) kg and 69.74 percent for the output category (1000-5000) kg. Rice processors involved in parboiling and drying were 63.63 percent for processors in the output category (100-1000) kg and 35.46 percent for the output category (1000-5000) kg while those in output category (5000-10,000) kg were very negligible. Other aspect of rice processing does not have a representative number of respondents when compared to parboiling, milling, parboiling and de-stoning, however, this does not mean that processors were not engaged in them.

The classification of processors by output based on the different rice processing techniques used showed that more processors 62.34percent in the output category (100-1000) kg used the traditional processing techniques. Processors 36.36 percent in the output category 1000-5000kg used traditional techniques while 1.30 percent in the output category (5000-10,000) kg used traditional processing techniques. This is suggestive of the fact that processors, processing rice in lesser quantities still make use of the traditional techniques more than the modern techniques.

Processors (50.86 percent) in the category <100-1000 used the traditional methods of processing. 46.12percent in the output category 1000-5000kg used the traditional and modern techniques while 2.60 percent used the purely modern techniques in this category. The implication of this to rice processing is that processors in the output category 100-5000kg were found using more of the traditional and tradmodern techniques. Processors in the output category 5000-10,000kg (2.60percent) used the purely modern techniques.

Table 14: Distribution by processing activity and output of processed rice

Rice Processing Engaged in Processing	Output In Tons				
	(<100-900kg)	**(1000-5000kg)**	**(>5000>10,000kg)**	**(>10,000kg)**	**Total Pooled (382)**
Parboiling	29(64.44)	15(31.11)	1(2.22)	-	45(11.78)
Milling	32(41.56)	39(50.65)	6(7.79)	-	77(20.16)
De-stoning	1(7.70)	11(8)	1(7.70)	-	13(3.40)
Parboiling and Drying	70(63.63)	39(35.46)	1(0.91)	-	11028.80)
Parboiling and Milling	23(30.26)	53(69.74)	-	-	76(19.90)
Harvesting, Drying and Milling	5(71.43)	-	2(28.57)	-	7(1.83)
Drying and Milling	3(75.00)	1(25.00)	-	-	4(1.05)
Threshing, Parboiling, Drying, Winnowing, Milling	12(57.14)	9(42.86)	-	-	21(5.50)
All the Above	1(3.45)	25(86.21)	2(68.97)	1(3.45)	29(7.60)
Processing Technique Used					
Traditional	48(62.34)	28(36.36)	1(1.30)	-	78(20.42)
Traditional and Modern	136(54.18)	107(46.12)	6(2.59)	2(0.80)	251(65.71)
Purely Modern	6(12.5)	39(81.25)	3(6.25)	-	53(13.77)

Source: Field Survey, 2016. Figures in Parenthesis are in percentage

4.1.7 Constraints of rice processors

Rice processing is plagued with a number of constraints as discovered during the course of this survey and also attested to by outcomes of different researches conducted on rice (Dhanktar, 2014; Dandedjrohoun *et al.* 2015). It is shown in Table 15 that inadequacy of paddy is one of the major constraints to rice processing; 52.4 percent processors identified this as a very important problem. 35.1 percent processors identified inadequate access to paddy as an important problem while 12 percent processors did not see it as a problem. Lack of improved processing equipment, low storage capacity, high cost of labour, low pricing of locally processed rice compared to imported rice, lack of funds, high cost of spare parts for those involved in milling and de-stoning were some of the identified important and very important constraints affecting processing of rice in the study area, corroborating the research of Longtau (2003). Low storage capacity and high cost of labour accounted for 55.2 and 51.3 percent, respectively based on the responses of the processors as constraints to processing activities. Respondent 47.1 and 31.2 percent, respectively in the study area reported that transportation problems were very important and important constraints to their processing business while 66.5 percent of them gave reasons that lack of funds was a very important limitation of rice processing. High cost of spare parts of the processing equipment and lack of spare parts were reasons given by 48.2 and 49.2 percents of processors as limitations to rice processing. Other complaints and constraints categorised under weather conditions (as many of the respondents especially in Ebonyi, Ekiti and Ogun states who used sun as dryer but are disturbed regularly by rainfall), high cost of fuel, health conditions of rice processors (especially those involved in milling and parboiling) accounted for 95.8 percent. In other words, choice of rice processing is not only hampered by not having access to purely modern equipment but also by many other factors and determinants as considered based on the constraints and limitations facing rice processors in the study area.

Table 15: Constraints of rice processors

Constraints	Very Important	Important	Not Important
Inadequate Access to Paddy	200(52.4)	134(35.10)	46(12.0)
Lack of Improved Processing Equipment	153(40.1)	180(47.10)	48(12.60)
Low Storage Capacity	94(24.60)	211(55.20)	76(19.90)
High Cost of Labour	125(32.70)	196(51.3)	60(5.70)
Unavailability of Labour	83(21.70)	119(31.20)	179(46.90)
Transportation Problems	119(31.20)	180(47.10)	83(21.70)
Market Challenges	193(50.50)	150(39.30)	39(10.20)
Low Price of Processed rice	113(29.60)	215(56.30)	54(14.10)
Lack of Funds	254(66.50)	95(24.90)	33(8.60)
Lack of Processing Equipment	114(29.80)	222(58.10)	46(12.00)
Lack of Reliable Machine Operators	60(15.71)	115(30.10)	207(54.20)
High Cost of Spare Parts	100(26.18)	184(48.20)	98(25.70)
Lack of Spare Parts	89(23.30)	188(49.20)	105(27.50)
Other Constraints	10(2.62)	366(95.80)	6(1.60)

Source: Field Survey, 2016. (Figures in parenthesis are in percentage).

4.2 The Determinants of Choice of Processing Techniques.

4.2.1 Determinants of choice of processing techniques.

The Multinomial logit regression was used to estimate the correlates of the determinant of choice of processing techniques used by processors in this study. The results as shown in Tables 16 & 17 have a maximum likelihood of -334.01, LR chi^2 of 188.36, Prob>chi^2 (0.0000), which is significant at 1percent ($p<0.01$). This implies that the model is significant as a whole in explaining the explanatory variables when compared to a null model without predictors. The base category was the traditional and modern technique (tradmodern technique). The choice of which was to evaluate the outcomes of other rice processing techniques relative to it, and because processors had the highest frequency in this category. The relative risk ratio (Table 15) is also used in further explaining the results of the outcomes relative to the base category and comparison/reference group.

The coefficients of the explanatory variables (Marital status, sex of respondent, educational level, membership of processors' association, experience in processing, other income sources, distance from paddy source to processing unit/centre) were found to be significant determinants of the choice of processing techniques used,

Sex of processors

The result obtained from this study shows that male processors are more likely to make use of purely modern techniques of processing rice as seen by the positive and significant coefficient (1.44). The implication of this results is that relative to the base category (tradmodern techniques), the use of purely modern techniques in processing rice increases by 1.44 for male rice processors while the probability of the use of traditional techniques of processing increases for female rice processor. The outcome of this result is further explained by the outcome of the relative risk ratio (RRR) for sex of processors. The RRR of sex of processors shows a reduction in the probability of choice of traditional techniques (outcome category) of processing by 72.96 percent (since the outcome of the ratio is less than one); although the coefficient is not significant. While the RRR>1 for the purely modern techniques (reference category) of processing rice, it signifies that the probability that a male respondent will choose the purely modern techniques of processing rice increases by 42.30 percent relative to the base category (tradmodern techniques). This implies that the males are more involved in rice processing aspects which involve the use of purely modern techniques like de-stoning and milling as obtained from the research outcomes of Tekeshi *et al.* (2006), Dhanktar (2014) and Dandedjrohoun *et al.* (2015). The outcome of the research of Efon and Fonchi (2016), also showed that more males (62.7percent) were involved in more labour intensive aspects in rice markets in Cameroon.

Age

The age of processors, though not a significant variable, shows that an increase in ages of processors will increase the choice of traditional techniques (outcome category) of processing rice compared to the base category (tradmodern) and the reference category (purely modern techniques). This is as a result of the variable's RRR of 1.006 which is greater than 1. The coefficient of age is positive (0.0006), though not significant. This implies that as the age of processors increase, the choice of traditional techniques of processing rice relative to the purely modern and tradmodern techniques (reference and base category) increase. This result is similar to the outcome of Nasiru (2014) where age of rice farmers had a negative impact on the adoption of production technologies. It is however not similar to the research of Osanyanlusi and Adenegan (2015) where age of respondents was a positive determinant of productivity of farmers in Ekiti state, Nigeria. Similarly, the RRR of the age of processors obtained from this study shows a reduction in the probability of the choice of purely modern technique of processing (reference category) by 0.97. This implies that as the processors increase in age, the probability of choice of purely modern techniques of processing rice reduced by 0.03. A possible implication of this is that the responsibilities of older processors which will make them continue with the use of traditional methods rather than going for the purely modern techniques of rice processing which was adjudged more expensive. Another possible implication is that as the age of processors increase the unwillingness to take up new challenges increases as seen in the research of Nasiru (2014). However, in the research of Danso-Abbeam *et al.* (2014) age of respondents was significant with a negative coefficient ($p<0.05$), not supporting the choice of local rice in Temale metropolis in Ghana.

Marital Status

The probability of choice of traditional techniques of processing is found to increase significantly by 0.69 if a processor is married. This shows that being married is positive and significant ($p<0.05$) with the choice of traditional processing techniques (outcome category). However, it has no significance with choice of purely modern technique of processing rice (reference category). This suggests that married processors have responsibilities, and as a result of constraints of income and budget, they are more likely to choose traditional techniques of rice processing. The research of Ohajinaya (2012) confirms that being married is a major determinant of unemployment, which could be extrapolated to this research, favouring the use of traditional processing techniques. The RRR estimate shows a significant and positive outcome for being married. This implies that a married processor will increase the probability of choice of traditional techniques by 1.99. However, the RRR of 2.00, significant at 10 percent shows that a processor that is married will increase the probability of choice of purely modern technique (reference category). The possible implication of the RRR for the traditional technique of processing is that there are duties and responsibilities attached to being married. While as the dependents or children grows older, the burden on the respondents begin to lighten therefore more attention will be placed on the household means of generating income (Adepoju, 2012) thus, supporting the RRR outcome of 2.00 for the purely modern techniques of processing (reference category) against the tradmodern (base category) and the outcome category (traditional techniques).

Educational Level

The result shows that educational level though significant ($p<0.01$) have a negative relationship with the choice of traditional techniques of processing rice (outcome category). The probability of choice of traditional techniques of processing reduces by 0.4 for processors who had formal education of processors increases. This therefore suggests that educated processors know the full implication of making use of processing techniques that will increase the output and quality of the processed rice. This is however not similar to the outcome of the research of Tiamiyu *et al.* (2014) where respondents opted for the normal methods of processing rice due to the cost implication of the best option. Therefore, it suggests that having good education not backed with strong financial capacity will leave processors constrained and not able to improve and expand the processing business. The outcome of the RRR (0.67) at 1 percent level of significance confirms that being educated reduces the probability of choosing the traditional techniques (outcome category) of rice processing by 0.67 relative to the tradmodern (base category) and the purely modern techniques (reference category). This can further be explained that relative to the base category (tradmodern techniques), an educated processor will prefer the use of purely modern techniques (reference category) to the traditional technique of processing (outcome category). The research of Fakayode *et al.* (2010) shows that for household that were educated ($p<0.01$), there is an increase in the consumption of the combination of imported and local rice relative to local rice alone. However, in the research of Efon and Fonchi (2016) the educational status of respondents was found to be a major determinant of the consumption of locally processed rice relative to imported rice in Cameroon; since they believed their locally processed rice was healthier and more nutritious than the imported rice.

Other Income sources

Sources of income other than processing is significant ($p<0.01$) and positive in favour of purely modern techniques (reference category) relative to the base category (tradmodern) and the outcome category (traditional techniques). This implies that the probability of the choice of purely modern technique increased by 1.89 when additional income accrues to processors from other sources. This follows a priori the expectations that the more financially buoyant an individual is, the more likely to explore opportunities. This result is supported by the research of Olowa *et al.* (2012), although their research was on remittance receipts to households. This can be extrapolated to this study as remittance is a form of secondary source of income to households which is capable of increasing the financial capacity and reducing the burden placed on households from the diverse pressing needs. The estimates of the RRR show that the probability of the choice of purely modern techniques of rice increases by 6.61 and it is significant at 1percent. This therefore implies that the probability of the choice of purely modern techniques of rice (reference category) increases relative to the base category (tradmodern techniques). However, the RRR for the probability of the choice of traditional technique of processing (1.33) shows that processors will make use of the traditional technique (outcome category) of processing even though the RRR is not significant at any level. The possible implication of this for the users of traditional techniques is that although rice processors engage in other forms of income generating activities, this does not stop the use of traditional methods of processing. There is the possibility that funds generated from other sources are not enough or they are diverted to other activities apart from processing. This is similar to the outcome of Waqar *et al.* (2014) where other sources of funds generated are transferred to the other aspects rather than being used to generate more productive assets. Another possible implication of this research outcome is that processors who were involved in other income generating activities and still use the traditional techniques may be faced with a lot of distractions. This therefore makes them use the available techniques and focus more on these other sources of income.

Paddy Source

Source of paddy is another significant determinant of the choice of processing techniques. The source from which paddy is obtained was significant ($p<0.01$) and positive in favour of the choice of purely modern techniques (reference category) relative to the base category (tradmodern) and the outcome category (traditional techniques). It is however negative but significant ($p<0.05$) with the choice of traditional processing techniques. The negative relationship with the choice of traditional processing techniques therefore implies that processors who get paddy from their own farms have a higher probability of using the traditional methods of processing rice compared to processors who go long distances before paddy is obtained. This also suggests that the nearer the source of paddy is, the greater the probability of rice processors choosing the available techniques of processing. Moreover, processors who have to go through a little bit of stress before they can get paddy will count the cost and see to it that paddy rice is well processed. Therefore, it justifies the positive and significant coefficient ($p<0.01$) of the choice of purely modern techniques.

Membership of association

The result shows that processors are less likely to make use of the traditional techniques of processing when they are members of rice processing associations. The a priori expectation is that associations are expected to increase awareness, welfare and access to inputs of members (Martey *et al.* 2013). This result therefore follows a priori expectation. The research of Nasiru (2014) also shows that membership of association is significant with the adoption of modern technologies at 0.248. The RRR estimates also show that the probability of choosing the traditional techniques by a processor involved in processing association relative to the base category (tradmodern technique) reduces by 0.09 significant at 1percent.

Distance to processing centre

This research outcome shows that processors are more likely to continue with the use of traditional technique (outcome category) when the distance covered to get to a processing unit increases. The distance processors go before getting paddy to the processing unit is positive and significant ($p<0.05$) favouring the traditional techniques (outcome category) of rice processing relative to the base category (tradmodern) and the reference category (purely modern techniques). This implies that the lesser the distance, the lesser the cost of transportation and the greater the probability of the choice of traditional techniques of rice processing. However, the longer the distance covered in obtaining paddy, the less the probability of choice of traditional techniques of rice processing (it will be more difficult for processors to process paddy anyhow because they will want the best outcome in the long run after processing) (Dunstan *et al.,* 2009). The RRR estimate shows that the increase in the distance to the processing unit increases the probability of the choice of traditional techniques of processing (outcome category) by 1.0006 relative to the base category and the reference category. The implication of this is that longer distance will increase the processors' choice for the outcome category (traditional technique) relative to the base category (tradmodern techniques) and the reference category (purely modern technique). However, the probability of the choice of purely modern technique of processing, although it is positive, is not significant with the distance covered to the processing centre.

Table 16: Determinants of Choice of Rice Processing Techniques in Nigeria.

Characteristics of Processors	**Traditional Processing Technique**			**Purely Modern Techniques**		
Variables	**Coefficient**	**Standard Error**	**Z Statistics**	**Coefficient**	**Standard Error**	**Z Statistics**
SEX	-0.3152	0.3408	-0.92	1.4421***	0.3908	3.69
AGE	0.0006	0.0176	0.04	-0.0259	0.0196	-1.32
MARTSTA	0.6880**	0.3291	2.09	0.6979	0.4287	1.63
EDUSTA	-0.3990***	0.1302	-3.07	-0.2976**	0.1352	-2.20
HOUSSIZ	-0.0718	0.0652	-1.10	-0.0877	0.0745	-1.18
MAININC	0.1783	0.3190	0.56	0.3968	0.3310	1.20
OTHERINC	-0.5135	0.3512	-1.46	-0.5158	0.3952	-1.31
EXPPROC	0.2859	0.3506	0.82	1.8891*** .	0.60509	3.12
PADYSOU	-0.1106	0.1205	-0.92	-0.1061	0.1167	-0.91
LABO	0.3309	0.3589	0.92	0.0134	0.3768	0.04
CREDTSOU	-0.1434**	0.0639	-2.24	0.1876***	0.0684	2.74
MEMASS	0.0807	0.2302	0.35	-0.3326	0.2661	-1.25
DISTPROC	-2.3371***	0.4496	-5.20	3.1602***	0.7280	4.34
SEX	0.0556**	0.0217	2.55	0.0321	0.0421	0.76
Constant	-0.2362	1.2823	-0.18	-6.0531***	1.70751	-3.54
Number of Observations **382**	LR chi^2 (28) 188.36	Probe > chi^2 0.0000	Pseudo R^2 0.4089	Log likely hood - 334.01		

Source: Author's Compilation from Field Survey, 2016. Legend: (*p<0.01, **p<0.05, *p<0.10, respectively)**

Table 17: Relative risk ratio of choice of rice processing technique

Variable	Traditional technique			Purely modern		
	RRR	**Standard error**	**Z statistics**	**RRR**	**Standard error**	**Z statistics**
SEX	0.7296	0.2487	-0.92	4.2297***	1.6528	3.69
AGE	1.0006	0.1765	0.04	0.9744	0.0191	-1.32
MARTSTA	1.9896**	0.6549	2.09	2.0094*	0.8615	1.63
EDUSTA	0.6710***	0.0874	-3.07	0.7426**	0.1004	-2.20
HOUSSIZ	0.9307	0.0607	-1.10	0.9161	0.0683	-1.18
MAININC	0.5984*	0.2102	-1.46	0.5970	0.2359	-1.31
OTHERINC	1.3308	0.4666	0.82	6.6136***	4.0018	3.12
EXPPROC	0.8952	0.1079	-0.92	0.8993	0.1049	-0.91
PADYSOU	0.8664*	0.0554	-2.24	1.2063***	0.0825	2.74
LABO	1.084	0.2496	0.35	0.7170	0.1908	-1.25
CREDTSOU	1.3922	0.4997	0.92	1.0135	0.3819	0.04
MEMASS	0.0966***	0.0434	-5.20	2.5747***	1.1632	4.34
DISTPROC	1.0572**	0.0230	2.55	1.0326	0.04345	0.76
Constant	0.7896***	1.0124	-0.18	0.0024***	0.0040	-3.54

Number of Observations 382 LRchi^2 (26) 188.36 Probe> chi^2 0.0000 Psuedo R^2 0.4089 Log likely-hood -334.01.

Source: Field Survey, 2016. Legend: (*p<0.01, **p<0.05, *p<0.10, respectively)**

4.2.2 Marginal Effects of Choice of Processing Techniques

The marginal effect of the determinants of the correlates of the choice of processing technique is presented in Table 18. This shows how a unit change in any of the explanatory variables affected the choice of rice processing techniques used.

Sex

The result of the marginal effect estimates explains that being a male processor increases the probability of the choice of purely modern techniques by 0.073. The implication of this is that male processors involved in rice processing are also involved in aspects that involve the use of modern machines more than the females (Tanzania Assessment, 2014).

Marital Status

This result explains that the probability of the choice of traditional processing techniques increased by 0.077 if a processor was married while the marginal effect outcome of a processor's choice of tradmodern processing techniques reduces by 0.103 if the processor is married. This result is in line with the research outcome of Kagbu *et al.* (2016), wherein it is reported that the married are having more responsibilities which make them look for ways of providing for family needs; thereby the use and purchase of productive assets are reduced.

Educational Level

The marginal effect estimates for the choice of tradmodern techniques show that a processor who is educated increases the probability of the rice processors' choice of tradmodern techniques by 0.057. Furthermore, being educated reduces the choice of traditional techniques of processing rice by 0.045. This follows a priori that education is an added advantage and an eye opener. This is similar to the outcome of the study of Enwerem and Ohajianya (2013) where educational level is a major determinant of the adoption of and access to improved technology thereby improving technical efficiency of farmers in Imo state, Nigeria.

Main Income

The marginal effect estimates show that processors whose main income was rice processing increase the probability of their choice of tradmodern techniques by 0.077. This suggests that processors will have to engage in other activities to increase their income in order to move from the use of tradmodern techniques or in order to increase the probability of their choice of purely modern techniques relative to the tradmodern techniques of processing. This is in line with the research of Awoyemi (2011) where rural non farm income an additional form of income, reduced poverty in Nigeria. The possible explanation for this is that rice processors were strive to get the best out of processing, they are faced with challenges/constraints (Olaoye, 2014). The constraints/challenges make it less likely to purchase purely modern equipments, hence the choice of tradmodern techniques of processing rice as opposed to the outright choice of traditional processing techniques.

Other income

Processors who have other sources of income increases the probability of choice of the purely modern techniques by 0.062 as seen from the marginal effect estimates in Table 16. The probability that a processor will chose the tradmodern techniques however reduces by 0.085, significant at 5percent, while there is no significance with the choice of traditional techniques of processing rice.

Rice paddy Source

The marginal effect estimates shows that the purchase of paddy increases the processor's choice of purely modern techniques by 0.009. This implies that a processor who purchases paddy reduces the probability of choice of traditional processing techniques by 0.018. This therefore suggests that the longer it takes processors to get to the source of paddy, the more they count the cost and go for purely modern techniques of rice processing. The distance from which rice paddy is obtained according to Dunstan *et al.* (2009) is of utmost importance. This according to them could increase cost of incurred in transporting rice paddy thereby inhibiting cost minimization in the long run.

Membership of association

Membership of processors in rice processing association has a positive coefficient (0.139) and significant ($p<0.05$) with the choice of tradmodern technique. It is also significant ($p<0.05$) with a positive coefficient (0.181) with purely modern processing techniques based on the outcome of marginal effect estimates. However, it has a negative relationship with the choice of traditional techniques of rice processing. The outcome from these estimates implies that being a member of rice processing association increases the choice of tradmodern and purely modern processing techniques by 0.014 and 0.018, respectively, as opposed to the choice of traditional processing techniques. This therefore follows a priori expectation that associations are expected to increase the awareness, welfare and access to inputs of members (Martey *et al.,* 2013). When this is not the case, processors will be non-functioning, non participating members of these associations. The research of Nasiru (2014) supports the outcome from this research. Since membership of association is significant with the adoption of modern technologies at 0.248, therefore it further supports the positive outcome of this research.

Distance to processing unit

The result of the marginal effect estimates shows a positive and significant coefficient (0.040) with the choice of traditional processing techniques. The result, however, has a negative but significant coefficient (-0.007) with the choice of tradmodern techniques of rice processing. This implies that the nearer the processors are to the available processing techniques the better, since they will not want to incur extra cost of transporting paddy. Likewise, the further the distance the processors have to cover, the less likely that they will make use of tradmodern techniques of processing.

Table 18: Marginal Effects Estimates of the Determinants of Choice of Rice Processing Techniques in Nigeria.

Characteristics of Processors	Traditional Processing Technique		Tradmodern		Purely Modern	
Variables	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Sex (Base: Female)	-0.0464	0.0387	-0.0264	0.0453	0.0727***	0.0279
Age of Respondent	0.0002	0.0021	0.0009	0.0022	-0.0012	0.0001
Marital Status	0.0770**	0.0392	-0.1028**	0.0425	0.0258	0.0191
Educational status (years of schooling)	-0.0453*	0.0155	0.0557	0.0161***	-0.0103	0.0064
Household Size	-0.0079	0.0076	0.0113	0.0079	-0.0033	0.0033
Main income source	-0.0580	0.0425	0.0772**	0.0441	-0.0192	0.0181
Other income sources	0.0237	0.0384	-0.0854**	0.0421	0.0616***	0.0211
Experience in processing	-0.1242	0.0141	0.0163	0.0145	-0.0039	0.0051
Credit access	0.0403	0.0453	-0.0389	0.0463	-0.0015	0.0160
Paddy Source	-0.0181**	0.0074	0.0092	0.0078	0.0090 ***	0.0033
Labour used (man days)	0.0116	0.0271	0.0032	0.0286	-0.0148	0.0120
Membership of Association	-0.3204**	0.5381	0.1390**	0.0658	0.1813***	0.0392
Distance to processing centre	0.0404**	0.0453	-0.0074**	0.0034	0.0010	0.0018

Source: Author's Compilation from Field Survey, 2016. Legend: (*p<0.01, **p<0.05, *p<0.10, respectively).**

4.2.3 Test of Multi-collinearity

Test of multi-collinearity was carried out on the independent variables before using them in the Multinomial Logistic regression. This was necessary in order to determine the level at which each of the explanatory variables would affect the other variables/one another. The results as shown in Table 19 and 20 give the tolerance values and the variance inflation factors. Any variable with a VIF of more than 5 was removed from the regression analysis according to Akinwande *et al.*, (2015). The variable state with a VIF of 5.2 was removed from the model because it has a variance inflator factor which was 5 times more than what it should be, assuming there was no collinearity.

Table 19: Multi-collinearity all variables used

	Model	Collinearity Statistics	
S/N	**Variables**	**Tolerance**	**VIF**
1	Sex	0.286	3.497
2	Age	0.545	1.833
3	Processors category	0.299	3.340
4	Household Size	0.338	2.956
5	Level of Education	0.404	2.474
6	Years of Experience	0.363	2.752
7	Other Sources of Income	0.646	1.547
8	Main income source	0.331	3.018
9	Distance to processing centre	0.265	3.776
10	Credit access	0.334	2.995
11	Labour used	0.444	2.253
12	Paddy Source	0.665	1.503
13	State	0.192	5.217
14	Total Distance covered	0.001	100.00
15	Amount obtained after selling milled rice	0.0910	10.989
16	Type of rice processing engaged in	0.0410	24.390
17	Ownership of processing unit	0.0617	16.201
18	Frequency of processing	0.0587	17.036
19	Membership of association	0.277	3.613

Source: Field Survey, 2016.

Table 20: Test of Multi-collinearity

	Model	Collinearity Statistics	
S/N	**Variables**	**Tolerance**	**VIF**
1	Sex	0.286	3.497
2	Age	0.545	1.833
3	Processors category	0.299	3.340
4	Household Size	0.338	2.956
5	Level of Education	0.404	2.474
6	Years of Experience	0.363	2.752
7	Main sources of income	0.331	3.018
8	Other sources of income	0.646	1.547
9	Distance to processing centre	0.265	3.776
10	Credit access	0.334	2.995
11	Labour used	0.444	2.254
12	Paddy Source	0.665	1.503
13	Membership of association	0.277	3.613

Source: Field Survey, 2016. *independent Variable with VIF > 5 were not used in the model; according to Akinwande *et al.* (2015).

4.3 Technical Efficiency among Rice Processors in the Study Area

The Data Envelopment Analysis (DEA) was used to determine the efficiency of the sampled rice processors in the study area. The DEA evaluated a number of multiple inputs and single output of rice processing. Decision making units (DMUs) were individual processors who based on this study were found to consume varying amounts of inputs in order to produce different levels of processed rice. The output oriented DEA was used in estimating the technical efficiency of processors in order to reflect how processors actually combined the various inputs used in order to produce output (processed rice) while the input-oriented DEA was used in estimating the allocative efficiency of rice processors in order to show whether the inputs were efficiently utilized or not. The distribution of efficiency scores among rice processors is presented in Table 21. The results show the efficiency scores, output slacks, return to scale, etc. The efficiency scores of processors as estimated in this study are in the range of 0 and 1 (0-100) percent. The efficiency scores are further classified within the range of <0.5 and 1.0 or <50 to 100 percent. The mean processing efficiency is 0.3993 or 39.93 percent. This rather low efficiency indicates that rice processors are making use of techniques which cause them to record only 39.93 percent efficiency in rice processing (for the pooled data). The implication of this is that for an average rice processor, the observed output is 60.07 percent less than the frontier/maximum output. Thus, the 60.07 percent loss in output accounts for the low efficiency among rice processors in the study area. This result corroborates the research carried out in Tanzania (Tanzania Assessment, 2014) and that of Leonides (2015). Tanzania Assessment reported a very low efficiency among rice processors in Tanzania in the range 36-45 percent. Leonides whose research was on value addition (in general) and the outcome of processing also reported very low efficiency in the range 23-30 percent. The consequent of which was high losses during harvesting and processing of regular food crops like cassava, cereals, grains and legumes among small holder farmers.

Furthermore, Table 21 shows that 66 percent of the rice processors are in the category <0.5 efficiency score. This suggests that the observed output of processed rice is relatively low compared to the actual output of processed rice obtained. This can be attributed to the processing techniques opted for by majority of the processors, which are the tradmodern processing techniques. According to Dunstan *et al.* (2009) and Basorun (2013), distance to paddy source and high cost of variable inputs are factors enhancing the use of processing techniques lower in quality and form by processors. Thus, majority of the processors are therefore operating below the production frontier as regards processing of rice in the study area.

The outcome of this result is inconsistent with the research of Ogunniyi (2008) who researched on efficiency of farmers in Osun state, where majority of the farmers exhibited about 57.1 percent efficiency. Likewise, this result is not similar to the researches of Mloe *et al.* (2013) and Okoruwa and Ogundele (2006) where respondents had a technical efficiency of more than 80 percent. Enwerem and Ohajianya (2013) in their estimation of technical efficiency of rice farmers in Imo state Nigeria found out that the mean technical efficiencies for both large and small scale rice farmers were 0.65 and 0.69, respectively; higher than the technical efficiency of rice processors obtained from this study. The research of Umeh and Ataborh (2011) is also not similar to the outcome of this study. This is because the mean technical efficiency for rice farmers obtained in their study was 54 percent which is higher than the mean technical efficiency of approximately 40 percent obtained from this study.

Table 21: Technical efficiency of rice processors.

Efficiency Score	Frequency	Percentage
<0.50	248	65.00
0.50-0.59	33	8.64
0.60-0.69	21	5.50
0.70-0.79	27	7.07
0.80-0.89	18	4.71
090-1.0	35	9.16
Total	383	100
Mean	0.3993	39.93

Source: Field Survey, 2016.

4.3.1 Distribution of technical efficiency by processing technique used

The distribution of processors by technical efficiency based on the processing techniques used is presented in Table 22. The modern techniques of processing have more than 90 percent processors (96.22 percent) with efficiency scores in the category 0.80 and 1.00. This rather high degree of efficiency indicates that the paddy rice sacrificed to waste during processing is very small (3.78 percent). The mean technical efficiency for modern techniques of processing is 0.8994, implying that on the average; rice processors who used the purely modern techniques have an observed output of 10.06percent less than the maximum output. The observed output of 10.06 percent accounts for the low efficiency when the modern techniques are used in processing rice paddy.

The tradmodern techniques of processing rice have more than 50 percent (58.97 percent) in the efficiency score category 0.80 and 1.00. This suggests that the paddy sacrificed to waste during processing is 41.03 percent. This 41.03 percent loss is high, when compared to the maximum expectation of 100 percent. The mean technical efficiency for tradmodern processing technique is 0.5624 which suggests that the processors using the tradmodern technique have an observed output of 43.76 percent lesser than the frontier/maximum output. Therefore, the observed level of 43.76 percent accounted for the low efficiency obtained when processors used the tradmodern techniques.

The traditional techniques of processing have 33.21 percent processors in the efficiency score category 0.80 and 1.00. This means that over 60 percent processors (66.79 percent) are out of this efficiency score. The mean technical efficiency for the traditional processing technique is 0.4327 which means that the processors using this technique of processing have 56.73 percent observed output lesser than the maximum output. This therefore implies that the overall low technical efficiency (39.93 percent) can be attributed to traditional and tradmodern techniques of processing whenever paddy is processed. The outcome of the study of Elhendy and Alkahtani (2013) shows a technical efficiency of 0.54 for organic date farms in Saudi Arabia, which was close to the technical efficiency (0.56), obtained for tradmodern techniques in this study. The outcome from the study of Awerije and Rahman (2014) shows a mean technical efficiency of 0.41 which is a bit close to the mean technical efficiency obtained for the traditional technique of rice processing.

Table 22: Technical efficiency of rice processors by processing technique used.

Efficiency Scores	Traditional (N=78) Frequency	Percent	Traditional & Modern (N= 251) Frequency	Percent	Purely Modern (N=53)	Percent
<0.50	44	56.41	64	25.50	-	-
0.50-0.59	5	6.41	4	1.59	-	-
0.60-0.69	3	3.85	3	1.20	1	1.87
0.70-0.79	4	5.13	32	12.75	1	1.87
0.80-0.89	4	5.13	21	8.37	8	15.09
0.90-1.00	18	28.08	127	50.60	43	81.13
Mean	0.4327		0.5624		0.8994	
Standard Deviation	0.3950		0.4109		0.6713	
Minimum	0.2781		0.2685		0.0219	
Maximum	1.0000		1.0000		1.0000	

Source: Field Survey, 2016.

4.3.2 Input and output slacks among rice processors

Input and output slacks[23] arise in production, and in this case processing, when there is the possibility of reducing the amount of input used or increasing the amount of output obtainable without a significant or corresponding change in the amount of input used. This implies that in the processing process there is a lot of wastage or inefficiency as regards use of inputs in the production of outputs (Yusuf and Malomo, 2007).

The input and output slacks generated by processors in this study are presented in Table 23. Processors who used traditional techniques have an output slack of 46,227.15kg and an input slack of ₦25,326.14. Those who used the tradmodern techniques to process paddy have an output slack of 27,686.70kg and an input slack of ₦13,484.58. Processors who used the purely modern techniques of processing have an output slack of 1,939.37kg and an input slack of ₦6.289.40. Processors who used the purely modern technique have the least output and input slack. This minimal input waste for this technique of processing is similar to the results obtained from the research of Poopola *et al*. (2015) in Ekiti state, where farmers were able to minimize loss in the use of resources in cocoa production. However, processors who used the traditional techniques have very large output slacks. This implies that the output obtained is not optimal based on the estimated potential output; this can be avoided if the unit of processing are more efficient. Therefore, the use of purely modern techniques is found associated with the reduced input and output slacks more than the other techniques of processing rice.

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[23] Slacks can be defined as loose, easy going, not busy, relaxed, less active and reduced activity (Dictionary and Thesaurus, 1994).

Table 23: Distribution of Input and Output Slack for processing technique used.

Slack	Output traditional	Input traditional	Output Tradmodern	Input Ekiti Tradmodern	Output Modern	Input Modern
Mean	46,227.15	25,326.14	27,686.70	13,484.58	1,939.37	6,289.40
Std.Dev	92131.89	6011.51	61079.03	3012.21	1243.60	1881.00
Min	0.000073	13.25	0.000032	484.58	0.0005	225.64
Max	83,000.00	53,060.50	102,800.00	484.54	62,215.00	341.23

Source: Field Survey, 2016.

Note* Output from processed rice was standardized using the 25kg and 50kg**

4.3.3 Scale efficiency of rice processors

The scale efficiency in Table 24 gives an estimate of processors by the productive scale (size) based on the different processing techniques used. The scale efficiency score as estimated shows that 33.21 percent of the processors who used the traditional techniques are operating under a productive scale of 0.8-1.0 while 56.4 percent operated with a less productive scale of <0.50. This is similar to the result of Kirigia and Asbu (2013) where 58 percent of the respondents had a scale efficiency score of less than 0.5 and were termed scale inefficient. Processors who used traditional and modern techniques of processing (58.97 percent) have a scale efficiency of 0.8-1.0 which implies that 58.97 percent of the processors operate within the productive scale in this category, 25.50 percent of the processors operate at a low productive scale of less than 0.50, 14.34 percent of the processors operate within the productive scale of 0.50-0.79 and processors who used the modern techniques (81.13 percent) operate within the productive scale of 0.9-1.0. This result/outcome is close to the result of Watkins *et al.*, (2014) where the scale efficiency of farmers was 92 percent under the 0.9-1.0 efficiency range. However, the processors (15.09 percent) operate in the productive scale of less than 0.5 while 3.74 of them are in the productive scale of 0.60-0.79. The implication of this result is that 81.13 percent of the processors are at the optimal size of the input-output mix. This therefore implies that the processors who used the purely modern techniques to process are more scale efficient than processors who used traditional and tradmodern techniques.

Table 24: Scale efficiency of rice processors by processing techniques used

	Scale efficiency of processors in the study area					
Scale Efficiency Scores	**Traditional**	**Percent**	**Tradmodern**	**Percent**	**Purely Modern**	**Percent**
<0.50	44	56.41	64	25.50	8	15.09
0.50-0.59	5	6.41	4	1.59		
0.60-0.69	3	3.85	3	1.20	1	1.87
0.70-0.79	4	5.13	32	12.75	1	1.87
0.80-0.89	4	5.13	21	8.37	-	-
0.90-1.00	18	28.08	127	50.60	43	81.13

Source: Field Survey, 2016.

4.3.4 Returns to scale among processors in the study area

Returns to scale is a measure of the change in output when all inputs are changed proportionately. If a proportionate increase of all inputs gives rise to the same proportionate increase in output, there is a constant return to scale. If a proportionate increase in inputs used gives rise to more than proportionate increase in output, we have increasing returns to scale. However, if a proportionate increase in inputs brings about less than the proportionate increase in output, there is decreasing returns to scale. Therefore, Table 25 showed the returns to scale for different processors (DMUs) based on the results (outcome) obtained from the DEA.

It is observed that majority (90.58 percent) of processors experience increasing returns to scale, 3.2 percent experience constant returns to scale, while 6.38 percent experience decreasing returns to scale. The high increasing returns to scale (90.58 percent) obtained from this study shows that at the level of techniques and equipment used, a unit increase in input will bring about a more than proportionate increase in output of processed rice. This therefore implies that processors do not need to increase the amount of input used; thereby, suggesting that with better equipment and techniques, more than proportionate output of rice will be achieved. Therefore, it is better for processors to improve on the techniques and equipment used in order to improve on and achieve better productive scale and technical efficiency (Bielik and Rajcaniova, 2004). The return to scale outcome obtained from the research of Ismatul and Andriko (2013) is however not similar to that obtained from this research. In the research of Ismatul and Andriko, majority of the respondents (87.70 percent) operate with decreasing returns to scale, which implies that rice farmers in the area of Maluku in Indonesia had operated in the rational production area that was within the value obtained, hence they needed to re-allocate inputs and utilize them for more significant and effective production. The research of Ogundari and Ojo (2007) shows an outcome also not similar to the returns to scale results obtained from this research, since the technical efficiency of cassava farms in the study is greater (0.840) with decreasing returns to scale.

Furthermore, this study went ahead to estimate the returns to scale of processors based on processing techniques used. The results as shown in Table 26 implies that all the three techniques had increasing returns to scale, suggestive of the fact that rice processing output can be improved upon greatly with the available level of inputs if processors have access to quality equipment. Processors who used traditional techniques of processing (87.18percent) with a unit increase in the level of inputs process more than the proportionate level of output with the available inputs. Hence, there is a possibility of increasing output if the processing techniques used are much better than what they are using presently. Processors who used the tradmodern techniques (93.22 percent) also process with increase returns to scale, the significance of which is that with the available techniques used, processors need not to continue increasing the level of input since they will obtain more than the proportionate level of output with the inputs used and available equipment. Furthermore, 83.02 percent who used the purely modern techniques process with increasing returns to scale. The implication of this is that with the use of the purely modern techniques, if properly harnessed, a unit increase in input will give processors more than the proportionate level of output. However, 16.98 percent of the processors who used the purely modern techniques of processing were operating under decreasing returns to scale. This implies that with the use of the purely modern techniques, a unit increase in input gives the processors less than the proportionate level of output. This therefore means that any addition to the processing inputs will lead to less than the proportionate increase in output; thus, it is better for the processors to operate at this stage. This result for the decreasing returns to scale for processors got for purely modern techniques is similar to the research outcome of Awotide *et al.* (2005) where farmers in the humid forest zones of Nigeria had decreasing returns to scale in plantain production and the farmers were advised to continue at this stage of production. The outcome of this study is likewise similar to that of Madau (2011) where majority (77percent) of the citrus farmers in Italy were operating under increasing returns to scale.

Table 25: Returns to scale among processors in the study area

Returns to Scale	Frequency	Percentage	Processors with TE of 1	
			CRS	VRS
Increasing Returns to Scale (IRS)	346	90.58	7	16
Constant Returns to Scale (CRS)	12	3.20		
Decreasing Returns to Scale (DRS)	24	6.38		
Total	382			

Source: Field Survey, 2016.

Table 26: Returns to scale of rice processors by processing techniques used.

Returns to Scale	Traditional (78)		Tradmodern (251)		Purely modern (53)	
	Frequency	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
Increasing returns to Scale (IRS)	68	87.18	234	93.22	44	83.02
Constant Returns to Scale (CRS)	3	3.85	9	3.56	-	-
Decreasing Returns to Scale (DRS)	7	8.97	8	3.19	9	16.98
Total	78		251		53	

Source: Field Survey, 2016.

4.3.5 Allocative efficiency of rice processors in Nigeria

Allocative efficiency can be estimated using the DEA analysis or from the Marginal value product which is obtained by multiplying the marginal physical product (MPP) by the price of output (Watkins *et al.,* 2014; Izekor and Alufohai, 2014). The two methods was used and the discussion of the findings based on these analysis and methods is explained in the following section.

4.3.5.1 Allocative efficiency of rice processors estimated with DEA analysis

The data envelopment analysis was used in estimating the allocative efficiency among rice processors in the study area. The input orientation DEA was used on the following inputs fuel (₦), rice paddy (₦), labour (₦), transportation (₦) and maintenance and repairs (₦), all these variables were used together in the estimation in order to generate an efficiency score as shown in table 27. The allocative efficiency score was from the range of 0.000-1.000 with an overall mean of 0.2241. The highest allocative efficiency among the rice processors was 1.000 while the lowest was 0.0010. This result confirms that rice processors in the study area did not attain optimal allocative efficiency.

The allocative efficiency of rice processors by processing techniques used as shown in Table 27 shows that rice processors who used the traditional techniques of rice processing had a mean allocative efficiency of 0.2388, with a minimum allocative efficiency of 0.0160 and maximum allocative efficiency of 0.6210. The implication of this result is that compared the most efficient rice processor, rice processors who used the traditional techniques of rice processing are (1-0.2388) less efficient compared to the best or most efficient rice processor who is processing rice with an efficiency of 0.7612. The implication of this result further shows that rice processors are did not make optimal use of inputs hence they are not allocative efficient in the use of these inputs. More rice processors (71.79 percent) are in the efficiency score range of 0.100-0.5990 which is low when compared to the highest efficiency score of 1.000. The low mean allocative efficiency of 0.2399 obtained among rice processors who used the traditional techniques of rice processing is close to the 0.2900 allocative efficiency obtained for seed input by Adedoyin *et al.* (2016) although their own research was on rice production while this research is on rice processing.

Rice processors who used the tradmodern techniques are more in the efficiency score range of 0.1000-0.5990 (57.37 percent). The mean allocative efficiency for this technique of rice processing was 0.2195 with a minimum of 0.0010 and a maximum of 1.000. The implication of this result is that compared the most allocative efficient rice processor, rice processors who used the tradmodern techniques are (1-0.2195) less efficient, while the most efficient rice processors are 0.7805 more efficient than rice processors who used the tradmodern techniques. This further implies that compared to the most efficient processor, rice processors who used the tradmodern techniques will have been able to save 0.7805 units of inputs had they used a rice processing techniques that is more efficient.

However, more rice processors (71.70 percent) who used the purely modern techniques are in the 0.100-0.5990 allocative efficiency with a mean efficiency of 0.2242, minimum of 0.0020 and a maximum of 0.6880. The implication of this result is that a rice processor who used the purely modern techniques would have been able to save (1-0.2242 unit) of inputs compared to the beat or most efficient rice processor, while a rice processor that is most efficient would be able to save 0.7758 units of inputs had they used a processing techniques that would make them more allocative efficient.

Table 27: Allocative efficiency among rice processors

Allocative Efficiency Scores	Traditional (N=78) Frequency	Percent	Tradmodern (N= 251) Frequency	Percent	Purely Modern (N=53) Frequency	Percent
0.000-0.0090	0	0.000	15	5.98	2	3.77
0.100-0.0390	6	7.69	34	513.55	7	13.21
0.040-0.0690	11	14.10	27	10.76	3	5.66
0.070-0.0990	3	3.85	14	5.58	1	1.89
0.100-0.5990	56	71.79	144	57.37	38	71.70
0.600-1.000	2	2.56	17	6.77	2	3.77
Mean	0.2388		0.2195		0.2242	
Std. Deviation	0.1606		0.2078		0.1728	
Minimum	0.0160		0.0010		0.0020	
Maximum	0.6210		1.0000		0.6880	
Difference	(0.7612)		(0.7805)		(0.7758)	
Mean	0.2241					
Std. Deviation	0.1941					
Minimum	0.0010					
Maximum	1.0000					
Difference	(0.7759)					

Source: Filed Survey 2016

4.3.6 Allocative efficiency of rice processors by marginal value product

The Marginal value product which is obtained by multiplying the marginal physical product (MPP) by the price of output (Watkins *et al.,* 2014; Izekor and Alufohai, 2014). This section deals extensively with the allocative efficiency of the rice processors. It looks at how the rice processors were able to allocate inputs in order to maximize output based on the prices of output sold. Allocative efficiency can likewise be determined as a ratio of the marginal value product and the marginal factor cost which is the cost of inputs used in processing of rice Kadiri *et al.* (2014). The overall outcome obtained from allocative efficiency of the processors in this study further buttresses the assertion that processors were operating more on habits, experience and constraints while rationality and optimization were mostly neglected. This assertion is also confirmed in the research outcome of Ismatul and Andriko (2013) where majority of the rice producers 'threw caution into the air and' continued their production based on experience and habits. In order to further support this, the processors allocative efficiency are estimated by processing the techniques used.

The estimates of allocative efficiency of processors, as seen in Table 28 shows that the marginal value product of the processed rice is 28,077,620 (the sum total of the amount for processed rice for the different processors), the marginal cost of the inputs used was at various levels. There is no case where the MVP/MFC=1 among processors in the study area. Rice processors in the study area are close to being allocative efficient in the use of some inputs. It can be seen from the table that the fuel used has allocative efficiency scores close to the optimum allocative efficiency score of 1 percent at 0.88 percent. The implication of this based on the rule of thumb for allocative efficiency of the inputs used is that the inputs have been over-utilized (Fasasi, 2006; Tambo and Gbemu, 2010). Rice processors do not have optimal allocative efficiency in paddy (0.19 percent), operating space (0.21 percent), transportation (0.27 percent), other expenses (0.27 percent), labour (0.28 percent) and maintenance and repairs (0.47 percent). These are inputs used in the processing of rice which processors do not have authority over; they have to go through roads in order to bring paddy to the processing centres, they have to purchase paddy for those who process in large quantities, they have to pay for the use of their operating space. Maintenance and repairs of their processing equipment must be done regularly especially for those involved in milling and de-stoning or else, they will be out of business. This low outcome in allocative efficiency is in tandem with the research of Bifarin *et al.* (2010) and Watkins *et al.* (2013).

Table 28: Allocative efficiency among rice processors (pooled data)

Parameters (for 382 respondents)	Marginal Value Product (Cost of processed rice)	Marginal Input Cost (MFC)	AE= MVP/MFC	Percent AE Scores
Fuel	28,077,620	317,881	88.32	0.88
Paddy		1,521,020	18.45	0.18
Transportation		1,031,775	27.21	0.27
Labour		999,370	28.10	0.28
Maintenance & repairs		601,950	46.64	0.47
Operating space		1,363,350	20.60	0.21
Others		1,024,600	27.40	0.27

Source: Field Survey, 2016.

4.3.5.1 Allocative efficiency of traditional processing techniques

Processors who used traditional techniques of processing rice had an overall marginal value product of ₦19,475,630 and a different marginal factor cost for inputs used as shown in Table 29. The distribution shows that the processors who used the traditional techniques of rice processing are close to being allocative efficient in the use of operating space with an allocative efficiency of 0.91. The allocative efficiency score obtained is greater than what Watkins *et al.* (2013) obtained from the outcome of their research. A possible implication of this is that the processors do not have enough capita (paddy, need for hired labour, and other inputs) to make them demand for an operating space beyond their capacity. Therefore, the outcome from this results shows that the use of traditional techniques in processing rice makes rice processors in the study area less allocative efficient. The result of the allocative efficiency score for fuel (1.18), paddy (1.05), communication service (2.37), transportation (1.14) and amount spent on other things (1.41) shows that rice processors where under utilizing inputs. This research outcome according to the allocative efficiency rule of thumb of MVP>MFC signifies underutilization of the inputs used and therefore calls for more use of these inputs in order for the rice processors to be more allocative efficient. This result can also be explained based on the research of Izekor and Alufohai (2014) where when MVP>1 implied an under utilization of the inputs used; hence, the processors are not allocative efficient in the inputs used.

Table 29: Allocative efficiency of traditional techniques

Parameters	Marginal Value Product (Cost of processed rice)	Marginal Input Cost (MFC)	AE= MVP/MFC	Percent AE Scores
Fuel	19,475,630	174,168.4	111.82	1.18
Paddy		185,111.9	105.21	1.05
Transportation		170,095.4	114.50	1.14
Labour		603,988.6	32.25	0.32
Maintenance & repairs		493,384.1	39.47	0.39
Operating space		214,271.4	90.89	0.91
Others		138,521.7	140.59	1.41

Source: Field Survey, 2016.

4.3.5.2 Allocative efficiency of tradmodern techniques

The allocative efficiency of the processors who used both traditional and modern (tradmodern) techniques of rice processing shows a marginal value product (MVP) overall for the processed rice of ₦85,027,429. Individual cost of inputs when divided by the MVP gives the allocative efficiency outcomes as shown in Table 30. The processors who used the tradmodern techniques in processing have low allocative efficiency for the inputs used. There was an outcome of over utilization of fuel (0.58), paddy (0.56), operating space (0.99), maintenance and repairs (0.57) and transportation (0.29). However, the processors were allocative in-efficient in labour used, thereby underutilizing labour (1.17) and other expenses (1.02). This buttressed the fact that some infrastructures and social amenities should be provided by the government to reduce the cost incurred by the businesses (Oniah *et al.* 2008). The cost of fuel (diesel), transportation (to paddy source) and in cases when credit/loans are given, the interest rate should not be too high.

Table 30: Allocative efficiency for tradmodern technique

Parameters	Marginal Value Product (Cost of processed rice)	Marginal Input Cost (MFC)	AE= MVP/MFC	Percent AE Scores
Fuel	85,027,429	1,471,696	57.78	0.58
Paddy		1,504,905	56.50	0.56
Transportation		2,847,155,	29.86	0.29
Labour		721028.5	117.9	1.17
Maintenance & repairs		1,426,949	56.57	0.57
Operating space		852,240.5	99.77	0.99
Others		830.300	102.41	1.02

Source: Field Survey, 2016.

4.3.5.3 Allocative efficiency for purely modern techniques

Processors who used the purely modern techniques of rice processing as shown in Table 31 have an allocative efficiency between 0.44 and 0.86. Their marginal value product is ₦26, 371,748, with different levels of marginal factor cost or marginal input cost as used in the research of Kadiri *et al.* (2014). None of the processors has a case of MVP/MFC = 1 to indicate absolute or maximum allocative efficiency. The processors are however close to being allocative efficient in the use of fuel (0.86), paddy (0.84), labour (0.75), other expenses (0.63), operating space (0.53) and transportation (0.52). However, they have low allocative efficiency of maintenance and repairs of equipment. The allocative efficiency obtained for operating space, transportation and other expenses are 0.47, 0.48 and 0.37, respectively. Processors can improve on the fuel used, paddy source and labour used efficiency by 0.14, 0.16 and 0.25, respectively. The overall allocative efficiency obtained is similar to the outcome of Karimov (2013) whose highest AE were 0.89 and 0.90 for potatoes and water melon growers in Ubekistan. Awerije and Rahman (2014) also reported a mean AE of 0.84 for cassava farmers in Delta state Nigeria.

Table 31: Allocative efficiency for purely modern techniques

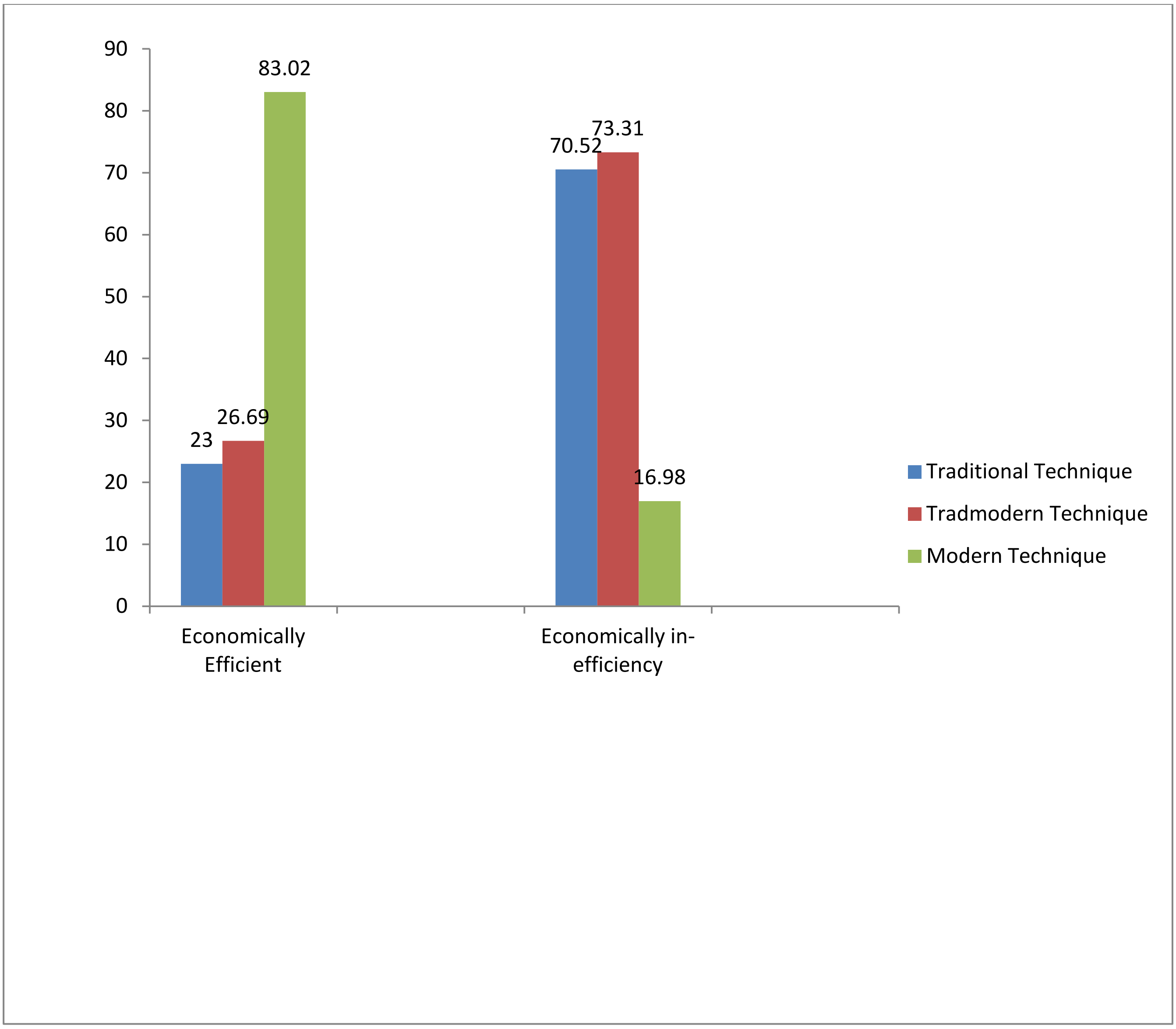
Parameters	Marginal Value Product (Cost of processed rice)	Marginal Input Cost (MFC)	AE= MVP/MFC	Percent AE Scores
Fuel	26,371,748	306,119.0	86.15	0.86
Paddy		313,058.9	84.24	0.84
Transportation		507,832.6	51.92	0.52
Labour		351,389.5	75.03	0.75
Maintenance & repairs		606,192.8	43.50	0.44
Operating space		500,433.2	52.70	0.53
Others		412,058.6	63.39	0.63

Source: Field Survey, 2016.

4.3.6 Economic efficiency of Rice processors

Economic efficiency can be defined as a product of the technical and allocative efficiencies Asogwa *et al.* (2011). Economic efficiency (EE) can be determined by the minimum total cost divided by the actual total cost as used by Watkins *et al.* (2014)[24] which is called the augmented formula method. In order to achieve this, the minimum total cost and the actual total cost of the inputs used are obtained from the cost of inputs used in the processing of rice. This definition of economic efficiency therefore suggests that processors have the ability of processing predetermined quantity of rice at minimum cost based on the available techniques or technologies (Cooper *et al.,* 2011). Furthermore, the augmented formulae method dividing the total cost of inputs by the actual cost of inputs is used in this study (Watkins *et al.,* 2014). The pooled economic efficiency of the processors is represented in Figure 3.

[24] Economic Efficiency (EE)= $\frac{\sum_{j=1}^{j} PnjXnj}{\sum_{j=1}^{j} PmjXmj}$ where $\sum_{j=1}^{j} PnjXnj$ is the minimum total cost obtained,while $\sum_{j=1}^{j} PmjXmj$ is the actual total cost observed.



Source: Field Survey, 2016

Figure 3: Economic efficiency of processors by processing technique used(pooled result)

4.3.6.1 Economic efficiency of rice processors by processing technique used

Economic efficiency of processors by the processing technique used as shown in Table 32 shows that an economic efficiency level of 23 percent for the processors who used the traditional techniques of processing. Processors who used the tradmodern techniques are 26.69 percent efficient while those who used the purely modern techniques of processing are 83.02 percent efficient. This outcome is not similar to the research of Biam *et al.* (2016) whose economic efficiency outcome for small scale soybean farmers in central agricultural zone of Nigeria is 52 percent. The outcome of the research of Ohajianya *et al.* (2013) is however close to the outcomes of the economic efficiency of traditional and tradmodern techniques at 21 percent for poultry production in Imo state Nigeria; although the stochastic production frontier was used (in the research of Ohajianya *et al.* (2013) and the activity under study was poultry production).

Table 32: Economic efficiency of rice processors by processing techniques

Variable $EE_p = \frac{\sum_{j-1}^{j} PnjX*nj}{\sum_{j-1}^{j} PnjXnj}$	Traditional (78)		Traditional and Modern (251)		Purely Modern (53)	
	Frequency	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Economic Efficiency	23	29.49	67	26.69	44	83.02
Economic inefficiency	55	70.52	184	73.31	9	16.98

Source: Field Survey, 2016.

4.4 Efficiency differentials

This section presents the efficiency differentials of rice the processors based the on rice processing techniques used in this study.

4.4.1 Efficiency differentials by processing techniques used

4.4.2 Difference in mean technical efficiency differentials among rice processors

The technical efficiency differential as shown in Table 33, shown the difference in means among rice processors by rice processing techniques used. Rice processors who used the purely modern techniques in processing rice had a mean technical efficiency of 0.8994 which is lower to the mean technical efficiency score of 0.63 obtained by Kadiri *et al.* (2014), while those who used the tradmodern techniques had a mean technical efficiency of 0.5624. The difference in means was 0.3370 which implies that rice processors who used the purely modern techniques of rice processing relative to the tradmodern techniques are 0.3370 units better than rice processors who used the tradmodern techniques in processing rice. The distribution in Table 33 also shows that rice processors who used the purely modern techniques relative to the traditional techniques had a mean technical efficiency difference of 0.4667 units. The implication of this is that rice processors who used the purely modern techniques had a mean technical efficiency of 0.8994 while rice processors who used the traditional techniques had a mean technical efficiency of 0.4327 hence, the purely modern techniques of rice processing is 0.4667 unit better relative the choice of tradmodern techniques.

Table 33: Technical efficiency difference in means

Processing Techniques	Technical Efficiency differential
Purely Modern Techniques	0.8994
Tradmodern techniques	0.5624
Difference in means	**0.3370**
Purely Modern Techniques	0.8994
Traditional techniques	0.4327
Difference in means	**0.4667**

Source: Field Survey 2016

4.4.3 Difference in means allocative efficiency differential among rice processors

Rice processors as who used the purely modern techniques had an average mean allocative efficiency of 0.2388 while those who used the tradmodern techniques had a mean of 0.2195 with a difference in mean of 0.0192. This allocative efficiency difference is not up to that obtained from Adedoyin *et al.* (2016) whose highest allocative efficiency was 0.29 for seed input used while fertilizer input had an allocative efficiency of 0.06 This implies that relative to the choice of tradmodern techniques, processors who used the purely modern techniques of rice processing where 0.0193 better than those who used the tradmodern techniques. The difference in means among rice processors that used the purely modern techniques relative to the traditional techniques of rice processing was 0.0146 as shown in Table 34; this implies that rice processors who used the purely modern techniques are 0.0146 more efficient that rice processors who used the traditional techniques in processing rice.

Table 34: Allocative efficiency differential of Rice processors

Processing Techniques	Allocative Efficiency differential
Purely Modern Techniques	0.2388
Tradmodern techniques	0.2195
Difference in means	**0.0193**
Purely Modern Techniques	0.2388
Traditional techniques	0.2242
Difference in means	**0.0146**

Source: Field Survey 2016

4.4.4 Difference in means economic efficiency differentials among rice processors

The difference in means of economic efficiency differentials among rice processors showed that processors who used the purely modern techniques of rice processing were 0.57 units better off than those who used the tradmodern techniques (0.44) with a difference of 0.13 units. Rice processors who used the purely modern techniques were 0.57 units better than rice processors who used the traditional techniques were 0.51 unit. The implies that for an average efficient processor who used the purely modern techniques in processing rice is 0.13 units better off than its counterparts who used the tradmodern techniques and 0.66 units better off than its counterparts who used the traditional techniques as shown in Table 35. This outcome can be explained extrapolating this research result to that obtained from Ogunniyi *et al.* (2012). The explanation is that relative to the most efficient processor, a processor who used the purely modern techniques of rice processing will be 0.1341 units better than a counterpart processor who used the tradmodern techniques; while a processor who used the purely modern techniques of rice processing is 0.0660 units better relative to the rice processor who used the traditional techniques of rice processing.

Table 35: Economic efficiency differential of Rice processors

Processing Techniques	Economic efficiency differential
Purely Modern Techniques	0.5723
Tradmodern techniques	0.4382
Difference in means	**0.1341**
Purely Modern Techniques	0.5723
Traditional techniques	0.5063
Difference in means	**0.0660**

Source: Field Survey 2016

4.5. Determinants of Efficiency among Processors in Nigeria

4.5.1 Tobit regression model

The aim of this section is to isolate the main determinants of efficiency among rice processors in the study area as shown in Table 36. The use of Tobit regression as against the ordinary least squares regression (OLS) model is favoured because, in reality, processors engage in processing activities at different levels. Furthermore, the use of Tobit regression will help in overcoming selectivity bias that may be introduced to the model being a second stage regression (Adenegan *et al.* 2013; Ijoku, 2016). Hence, the Tobit regression results for the determinants of efficiency as shown in Table 35 was an estimates of the second stage regression of economic efficiency scores regressed/predicted against some socioeconomic and processing characteristics. The number of observations was 382 for which all the response and predictor variables were none missing. The sigma (σ) is 0.012 with a t-value of 12.925; hence sigma is statistically significant (P <0.01). This indicates that the model has a good fit to the data. The LR chi2(12) test indicates that at least one of the predictors' regression coefficient is not equal to zero and the number 12 in parenthesis indicates the degree of freedom of the Chi-square distribution used to test the LR Chi-square statistics and is defined as the number of predictors in the model. The log likelihood of the fitted model was -105.99 shows that all predictors' regression coefficients in the model are simultaneously zero. In the analysis, six of the twelve (12) variables, estimated in the model were statistically significant at different levels between one percent (P < 0.01) and ten percent (P < 0.1) level of significance. The significant coefficients constituted 50.0 percent; which implies that multi-colinearity is not significant in the model. The variables found to have significant contribution to efficiency are educational level, paddy source, membership of processing association, experience in processing, access to credit and distance to processing centre.

4.5.2 Significant variables with efficiency of rice processors

Age of rice processors

Age is a not a significant determinant of the efficiency of processors although it is positively related to economic efficiency of processors, suggesting that a unit increase in the age of processors increases the likelihood of being economically efficient. This therefore implies that the likelihood of economic efficiency of respondents increasing for a unit increase in age is 0.0009. Thus it means that as processors increase in age, there is a higher level of understanding and desire for quality; hence, following a prior expectations. The outcome from this study is however not contrary to a priori that the older the processors the greater the likelihood of making use of processing techniques that will be more economically efficient. This outcome for age is however not similar to the result obtained by Nasiru (2014) where age of respondent though significant had a negative relationship with the adoption of improved rice production technologies in Jigawa state, Nigeria. Therefore, it implies that the older the respondents the less likely they easily adopt or accept changes. The research outcome of Tiamiyu *et al.* (2010) is also not similar to the age of processors obtained from this research. The age of respondent has a negative coefficient (-0.0044) and is not a significant determinant of the technology use. However, the research outcome of Asante *et al.* (2013) showed a positive significance ($p<0.05$) with preference for improved variety of rice in Ghana and age of respondent. The implication of this research result is that household heads preferred an improved variety of rice as their ages increase. The research of Onyeneke (2017) is also not similar to the research outcome obtained for the age of processors, i.e. the result is a variance with the age of processors obtained in this study. The research outcome of Onyeneke (2017) showed that the age of respondent was a negative determinant of the adoption of new technologies, therefore implying that a unit increase in age decreases the likelihood of adoption of new technologies by rice farmers in the study.

Marital Status of rice processors

Marital status of respondent although not significant as a determinant of the economic efficiency of processors has a negative co-efficient (-0.0029). However, this can be explained as the married who incidentally were the majority in this study (88.48percent) the likelihood of not making use of the processing techniques that will make them economically efficient. This therefore suggests that those who are married, because of diverse responsibilities, may find it difficult making use of processing techniques that will make them economically efficient. This outcome obtained is not similar to the study of Asogwa *et al.* (2012) where the dependency ratio (significant at 5 percent) had a significant impact (and a positive relationship) with the severity of poverty among rural the households in Nigeria. If this outcome is extended to the outcome obtained in this study, it therefore confirms that being married will not enhance processors' economic efficiency. The implication of this research outcome therefore is that respondents have to take care of the needs and requirements of their families; and a possible reason to use the resources available to them to cater for family needs. This therefore implies that the opportunity cost of purchasing productive assets or getting paddy processed in an economically efficient way is taking care of their family. This result is at variance with the research outcome of Onyeneke (2017) whose research identified being married as a positive advantage to farmers and a possible determinant of adopting improved technologies as spouse(s) were be an additional source of labour to the farmers.

Household size of rice processors

Household size is not a significant determinant of the efficiency of processors. It has a negative sign (-0.0010) which can be explained as a unit increase in the household size would reduces the probability of processors' economic efficiency by 0.001. This implied that the larger the size of processors' household, the more likely those processors spend on the upkeep of their household members more than on rice processing. This will reduce the quality of processing and the likelihood of not being economically efficient; thus they will continue with the use of available techniques and equipment. This further suggests that family needs have increased (Asogwa *et al.* 2012). This is supported by the findings of Awotide *et al.* (2010) whose research on poverty and household livelihood diversification in southwest Nigeria was able to show that increase in size of households would increase the probability of being poor. The reverse is however the outcome from the research of Nazaki *et al.* (2013) where respondents' mean household size was 8 persons and this was described as a factor that enabled them to cultivate bigger rice plots (1.53) and therefore harvested larger volumes of rice (982 kg).

Consequently, in the research of Obaniyi *et al.* (2014), although a positive outcome (0.262) for household size was obtained it was not a significant factor determining the participation of rice farmers in capacity building programmes of the agricultural development programme in Kwara state, Nigeria. Likewise, Nasiru (2014) obtained a research outcome where household size was not a significant socio-economic factor determining the adoption of improved rice processing technologies in Jigawa state, Nigeria. However, the research of Oyinbo (2014) was however similar to the outcome obtained from this research, where household size was found to be negative and although significant ($p<0.01$). This implies that a unit increase in the size of households reduces the preference of household members in the consumption of foreign rice. Effiong *et al.* (2015) from their research outcome showed that household size was a positive determinant of women farmers' participation in rice production in Bende local government area of Abia state, Nigeria. They argued that being a member of a large family could predispose family members to potential source of information on agricultural technologies. This research outcome from Effiong *et al.* (2015) is however contrary to the research of Oyinbo (2014) and Olaleye (2016) where household size was significant at 1percent, having a positive relationship with the risk of being poor in Kaduna state, Nigeria. This outcome further confirms the outcome from this study that large household increases the probability of processors not being economically efficient.

Educational level of rice processors

Educational level of processors is a significant (0.0098) determinant of efficiency of processing ($p<0.01$). A unit increase in processor's educational level increases efficiency of rice processors by 0.0098. This outcome is similar to Kadiri *et al.* (2014) whose respondents' educational attainment helped in the adoption of new technologies in the Niger Delta region of Nigeria. Adenegan *et al.* (2013) also obtained an outcome similar to the outcome from this study, where education was a significant factor influencing market orientation of cassava farmers in Nigeria. This was however at variance with the research outcome of Uwaoma (2015) who focused on soybean processors. The research outcome from Uwaoma showed that the educational level of respondents, although significant at 1 percent, had a negative relationship with the efficiency of processing soybeans. The implication of this is that although processors may be educated, are many other factors affecting the output and quality of processing. This results when other conditions and situations are more overwhelming than what the processors can handle; therefore they will continue with available processing techniques. Mendola (2006) had a result that was not similar to the outcome obtained for educational level and the economic efficiency of processors in this study. According to Mendola, the educational level of household heads is un-correlated with the adoption of agricultural technology in rural Bangladesh.

Paddy source

Source of paddy is a significant (p<0.01) determinant (0.0141) of the efficiency of processing. This implies that purchasing paddy increases the probability of being economically efficient by 0.0141. The implication of this is that processors who purchase paddy are less likely to process their paddy anyhow. They are more likely to make use of the processing techniques that will make them more economically efficient. However, processors who got paddy[25] from own farms have a likelihood of not being economically efficient. There is tendency of using readily available rice processing techniques, thereby reducing their efficiency. This however is at variant with the study of Nazaki *et al.* (2013) where many rice millers who had to travel very far distances before they got paddy were constrained by the long distances travelled; they either sold their paddy after returning from such distance or they milled with the available equipment. The implication of this is that the source where processors get paddy was an important determinant of the processing techniques used. A processor that gets paddy from a long distance to the nearest processing centre or facility will prefer to make use of the processing techniques that will make them economically efficient, in order to cover up for the cost incurred in transporting paddy. The outcome obtained from Coker and Ninalowo (2016) is in variant with the outcome from this study; their research showed that bad roads and transportation costs increased post harvest losses in rice production and processing in Niger state, Nigeria, therefore implying that getting paddy from a source nearby would increase the likelihood of farmers reducing post harvest loss in Niger state, more than is obtained in this research, where nearness to source of paddy increases the likelihood of not being economically efficient.

Membership of processing association

Membership of rice processing association is a positive determinant (0.0890) of the efficiency of processing and significant at (p<0.01). Processors involved in rice processing association had the likelihood of increasing their economic efficiency by 0.0890. The implication of this following a-prior is that processors who are members of an association are expected to be impacted positively. Obaniyi *et al.* (2014) had a similar result where there was a positive relationship with the participation levels of farmers involved in capacity building programmes and the years of involvement in farming association. The research outcome of

[25] Basorun (2014) obtained two major sources of paddy, this where processors' own farm, or purchased from other farms around.

Nasiru (2014) is similar to that obtained in this study where membership of rice processing association was a significant socio-economic (0.248) factor affecting the adoption of improved processing technologies in Jigawa state, Nigeria. Furthermore, the research outcome of Effiong *et al.* (2015) identified membership of a cooperative society as a factor that positively improved the participation of women in rice production activities in Abia state, Nigeria. Membership of cooperative society can also be seen as a productive and proactive group initiative which will affect welfare, dissemination of information as it is in a rice processing association.

Experience in processing

Experience in processing is a positive determinant (0.0164) of efficiency of processors as obtained from this research. A unit increase in years of processing increases processors' economic efficiency by 0.0164. The number of years a particular rice processor has been in the rice processing business, positively influenced the efficiency of processors at ($p<0.01$) level of significance, thereby implying that the level of experience will make the desire to make use of best methods of processing rice of paramount importance; in order to increase output as well as quality. This is similar to the outcome of the study of Nwalieji (2016) who found out that increase in years of experience in rice farming in Ebonyi and Anambra states, Nigeria increased the profitability of farmers. Nasiru (2014) also found out that processing experience was a positive and significant (0.069) factor determining how improved rice processing technologies were adopted in Jigawa state. This is however contrary to the research of Osanyanlusi and Adeneagan (2016), where rice farmers' experience was negatively related to productivity of farmers in Ekiti state.

Other source of income

Other source of income is positive (0.0238) though not statistically significant determinant of economic efficiency of rice processors. This outcome however can be explained that additional source of income other than rice processing, will make rice processors better off than when they have no other income sources. This inference is similar to the research of Obaniyi *et al.* (2014) in which the most significant variables among others was secondary occupation (called other source of income in this study). Asogwa *et al.* (2012) also obtained an outcome similar to what is obtained in this study, therefore confirming that other sources of income reduce respondents' poverty incidence. Rahman and Chima (2016) also confirmed in the outcome obtained from their research that diversification is an important profit generating approach when applied to food crops in southern Nigerian. Awoyemi (2011) found out that non farm income (other sources of income) were significant determinant of poverty reduction among Nigerian rural farmers. This result is therefore similar to the outcome obtained from this study where other source of income was positive and a significant determinant of economic efficiency of processors. The research outcome of Oyinbo and Olaleye (2016) found out that livelihood diversification which was significant at 1percent had negative relation with farmers' status and poverty in Kaduna state of Nigeria. This research outcome is similar to the positive relation other sources of income have on the efficiency of processors in this study. The implication of this result is that the risk of low income associated with single investment is reduced.

Access to credit

Credit-access is positively significant (0.0549) as determinant of the efficiency of processing ($p<0.01$). The implication of this research outcome is that processors' access to credit increased the probability of being economically efficient by (0.0549). This outcome is similar to the outcome of Nasiru (2014) were access to credit was a positive socio-economic factor of the adoption of improved rice processing technology. Likewise, the research outcome of Effiong *et al.* (2015) is similar to the research outcome from this study, where access to credit was a significant factor determining the involvement of women in rice production activities in Bende, Abia state, Nigeria. Oyinbo and Olaleye (2016) in their finding also showed negative relationship of access to credit significant at 5 percent to poverty status of farming households. The research outcome of Shrestha *et al.* (2016) is however at variance with this research outcome, where access to credit was negative and was not a significant determinant of efficiency. This further suggests that when the processors have access to credit, the use of such funds for other activities other than what they specifically got the loans or cash for is inevitable, as obtained from the research of (Akinbode 2013; Waqar *et al.* 2013; Awotide *et al.* 2014). Furthermore, the research of Ayeomoni and Aladejana (2016); observed that agricultural funds have the tendency of being subjected to personal-use, these will not have significance on productive or economic growth.

Distance to processing centre

Distance taken to process rice is significant but negative as a determinant of the efficiency of processing ($p<0.01$). A unit increase in the distance processors have to cover before they get to processing centres reduces the efficiency of rice processors by 0.0059. The implication of this is that when processors have to go a long distance before they can have access to processing centres with purely modern equipments, their use of purely modern techniques will reduce. This suggests that the distance of the processing centre affects the processing technique used and ultimately the efficiency of processing. The probability that a processor will process rice efficiently is 0.059 given that the distance to the processing centre is near. This is similar to the research of Adenegan *et al.* (2013) where education, gender, age and distance were factors influencing market orientation of cassava farmers significantly in Nigeria.

Table 36: Determinants of Efficiency among Processors in Nigeria.

Tobit Regression Results for the determinants of Efficiency among Rice Processors.

Variables	**Coefficients**	**Standard Error**
Sex of processor	-0.0416	0.0365
Age of processor (years)	0.0009	0.0109
Marital status of processor	-0.0029	0.0382
Household size of processor	-0.0010	0.0042
Educational level of processor (years)	0.0098***	0.0127
Paddy source	0.0141***	0.0061
Membership of processor association	0.0890***	0.0460
Experience in processing (years)	0.0164***	0.0112
Other income	0.0238	0.0390
Access to credit	0.0549***	0.0368
Processing centre distance	-0.0059***	0.002
Constant	0.432	0.280
/ Sigma	0.3177	0.012
Number of Observations	382	
Psuedo R^2	0.1606	
Log likelihood	-105.9876	
LR Chi^2 (12)	26.36	
t-value	12.925	
Prob > Chi^2	0.0092	

Source: Field Survey, 2016.

Legend: (*, **, * indicates 1%, 5% and 10%, respectively).**

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This is the concluding chapter of this thesis. It consists of summary of major findings, implications of results of all analysis and conclusions. The contributions of the work to knowledge were documented; appropriate policy recommendations are made from the findings and areas of further research are suggested.

5.1 Summary of Major Findings

This study examined the determinants of the choice of processing techniques among rice processors and the efficiency that resulted based on the choices made. The study also examined the determinants of efficiency of processors and the efficiency differentials of rice processors in Nigeria.

Processors' mean age was 47.84±9.87, with mean household size of 6.64±4.18, mean years of experience was 16.40±9.26. More processors were married (>80 percent). Majority of the respondents were females (66.26 percent). More processors (~66 percent) used the tradmodern techniques of rice processing. Marital status, sex, experience in processing; other income sources, paddy source, membership of association as well as distance to processing centre were found to be significant determinants of choice of traditional and purely modern processing techniques. Main determinants of efficiency of processors were: educational level, paddy source, credit sources, experience in processing and membership of association.

The mean technical efficiency was 39.39; implying there is a possibility of improving on efficiency of rice processing by 60.10 percent. Traditional technique of processing had a mean technical efficiency of 43.27 percent; tradmodern had technical efficiency of 56.24 percent; while the purely modern technique of processing had mean technical efficiency of 89.94 percent. Processors who used traditional methods of processing were least scale efficient (28.08percent), followed by tradmodern (50.60percent) while processors who used purely modern techniques were more scale efficient with a scale efficiency value of 81.13percent.

Processors had high allocative efficiency in fuel used (88.32percent), communication service (93.11percent), while there was a record of low allocative efficiency in paddy (18.45percent), transportation (27.21percent), labour use (28.10percent), maintenance and repairs

(46.64percent), operating space (20.60percent) and other expenses (27.30percent). Efficiency differentials of processors showed that more processors relative to the purely modern techniques were found using the tradmodern techniques. However, the efficiencies (technical, allocative and economic) of purely modern techniques were higher compared to the tradmodern and traditional techniques. Furthermore, the efficiency differentials for the tradmodern techniques of processing relative to the purely modern techniques were higher. Likewise that of the traditional techniques of processing rice was also higher than that of the purely modern techniques.

This implies that relative to the choice of purely modern techniques, rice processors (65.71 percent) were found using the tradmodern techniques while 20.48 percent used the traditional techniques. This therefore confirms the overall essence of this research that the choice of rice processing techniques is an important determinant of the efficiency of rice processing and this is affected by the processors' socio-economic as well as processing characteristics.

5.2 Conclusions

The study has been able to establish the following:

i) Majority of rice processors (~66 percent) used the tradmodern techniques than the traditional and purely modern techniques

ii) The main determinants of choice of processing techniques are Educational status, marital status, paddy source and membership of association

iii) Choice of traditional and tradmodern techniques used resulted in TE scores < 0.5 (Mean 39.93 ~ 40.0 percent)

iv) The choice of tradmodern and traditional techniques of processing rice resulted in inputs not being optimally allocated (Allocative efficiency (AE) $\neq$ 1)

v) Therefore the combinations of low TE and AE resulted in low EE for tradmodern and traditional techniques

vi) The differential was higher for purely modern techniques and traditional techniques, compared to the purely modern techniques and tradmodern techniques of rice processing

vii) The main determinants of economic efficiency of rice processors are sex of processors, marital status, educational status, credit access, other income sources, experience of processors and membership of association.

5.3 Policy Implications of the Findings

i) It was found out in this study that, experience of processors is a positive determinant of efficient rice processing; hence the need for the Federal Ministry of Agriculture, State Ministries of Agriculture and Local government Agricultural Units to focus on existing players in the rice processing industry.

ii) There should be more focus on processors' education by State and Local government Agricultural agencies in order to empower rice processors on formal and business education since it is a significant determinant of choice and efficiency of processing.

iii) The distance processors have to cover before they get to the processing centers was a significant determinant of efficiency and choice of processing techniques. This therefore necessitates the provision of good motorable roads by the federal, state and local governments in order to reduce drudgery faced in transporting paddy and milled rice.

iv) The above recommendation (iii) further suggests that when processors have access to purely modern equipments of processing close by, there will be an increase in the probability of choice of techniques that will increase economic efficiency.

v) The outcome of this study identified traditional and tradmodern techniques with low efficiencies, hence rice processors should be empowered and encouraged in accessing modern techniques for enhanced rice processing efficiency.

vi) Furthermore, despite the low efficiency recorded by processors who used the traditional and modern techniques, they were still found to be in the majority as obtained from this study. This therefore suggests that focusing on processors who used the techniques (traditional and modern) will encourage an outright shift of processors from using these techniques to the use of purely modern techniques which will ultimately increase efficiency.

5.4 Recommendations

i. The rice processors' association should be enhanced and supported with input supply and credit by Presidential Initiatives on rice production, since the study was able to find out that processing association is a positive determinant of choice of techniques.

ii. The female respondent should be empowered with input supply, access to credit and proper monitoring in order to ensure the use of purely modern techniques, since it was discovered based on the outcome of this study that they are more likely to use the traditional techniques of processing rice than the males.

iii. Based on the outcome of this study, the further away the processing centre was the less likely that processors will use the purely modern techniques of processing; hence, governments at the state and local levels are advised to invest in processing equipment and situate them close to rice processors with good accessible roads.

iv. Government (state and local) should focus on existing players in the rice processing industry, since it was found out in this study that experience of processors is a positive determinant of efficient processing of rice;

v. A large number of processors experienced increasing returns to scale; therefore, with the right processing facilities and techniques, inputs used will be justified[26].

vi. In this study, it was discovered that the distance processors have to cover before they get to the processing centers is a significant determinant of efficiency and the choice of processing techniques. This therefore necessitates the provision of good motorable roads at the federal, state and local levels to reduce processors' cost of transportation.

vii. There should be a genuine focus on traditional and modern techniques used by processors and seeking for ways of upgrading processors to use the purely modern techniques of processing rice by the ministry of Agriculture, Presidential Initiatives on Rice, State and Local governments.

5.5 Contribution to knowledge

i. This study investigated the different processing techniques available to rice processors in Nigeria paying attention to factors that determine choice of these techniques and efficiency derivable as a result of the choice of these techniques.

ii. This study went further to establish the Efficiency differentials among rice processors as a result of the choice of rice processing techniques used.

iii. Previous studies on rice processing efficiency had focused mainly on technical efficiency differentials of rice production. This study has been able to improve on this by estimating not only the Technical Efficiency differentials, but also the Allocative and Economic Efficiency differentials of rice processing techniques as well.

[26] This is already bringing out fruitful results, based on the collaboration witnessed by states and other stakeholders, which has greatly increased the output of rice to 5.8 million tons in 2017.

iv. In this study, it is established that adequate access to credit, better participation in processors' associations, access to purely modern techniques and improving on processors' education will enhance economic efficiency of processors in Nigeria.

5.6 Limitations of the study

i). This study could not be conducted in all the states in Nigeria, as it was restricted to only 4 states in 3 geo-political zones of the country. Therefore, this research cannot report what obtains as regards rice processing activities in the six geo-political zones as well as in all the states of the federation.

ii). The survey does not capture the rice farming practices of the different processors surveyed in the research as it was discovered that some processors interviewed during the course of these survey got paddy from their own farms.

iii). This survey was not able to properly investigate the other sources of paddy to processors. Majority of the processors attested to the fact that they got rice paddy from neighbouring villages and towns in order to augment the amount of paddy obtained from their rice farms.

iv) Processors were fully aware of the importance of processing the same varieties of rice paddy, however because the paddy was obtained or bought from different sources, processors were not able to ascertain the varieties processed. It was discovered based on this study that they obtained paddy at random and processed. It was only the processors who plant and process at the same time that had an idea of the rice variety they processed. Hence, varieties of rice were not used in estimating efficiency and determinants of choice of processors in the study.

v) Due to the lack of uniformity of measurement standards used in the different rice processing states visited, there was a lot of multiplication, conversion, re-calculation and cross-checking of the data obtained.

5.7 Suggestions for further research

i). There is a need for a survey of the six-geopolitical zones to address the processing efficiency and capacities of rice processors in the country.

ii). More attention should be paid to the rice processors and rice producing states in the country as regards their capacity of production and capacity of the equipment used.
iii) It was discovered based on the interview conducted in this survey that processors were not having adequate access to same varieties of paddy. Thus linkage to paddy by processors calls for further investigations.

iii). Further studies on rice farming practices of the surveyed processors, who were involved in rice cultivation (as a form of backward integration) should be done. In this research, it was discovered that some processors obtained paddy from personal rice farms, thus, implying that some processors are also rice paddy farmers, this could be a possible reason for inefficiency in the processing business.

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APPENDIX

Table 37: Analysis of Objectives.

	Objectives	Meaning of Objective	Required Data	Analytical Tool
1	To describe the characteristics of processors with processing techniques available to them	This gave insight to the different rice processing techniques available/accessible to the processors.	i) Rice processor's socioeconomic characteristics	Descriptive Statistics mean, standard deviation, tables, cross tabulations.
2	To examine determinants of choice of processing techniques by processors.	This provided information on the choice of rice processing and the factors that inform these choices as it relates to different processors.	Information on different rice processing techniques readily available to rice processors which includes: parboiling alone, parboiling and drying, milling alone, milling and drying, de-stoning etc.	Multinomial Logistic regression model.
3	To determine the efficiency of rice processors.	Evaluating technical, allocative and economic efficiency among rice processors	Information on the efficiency of processing based on output of processed rice in kg and inputs used Information on unit price of inputs, marginal variable product, marginal factor cost, total unit cost and total cost.	Data Envelopment Analysis/Augmented formula method
4	Determine the efficiency differential of rice processors	Estimating the differences based on processing techniques used	Test of difference among the different processing techniques used.	Difference of means
5	Estimate the determinants of efficiency among the processors.	To determine the determinants of efficiency.	Efficiency-scores generated from DEA to estimate main determinants of efficiency of rice processors.	Tobit Regression model.

Source: Compiled by the Author, 2016.

Table 38: Distribution of processors by socio-demographic characteristics

Variables (Percent)	Ogun	Ekiti	Ebonyi	Nasarawa	Pooled (N=382)
Gender					
Male	38 (38.00)	62(68.90)	39(41.49)	33(33.67)	172 (45.03)
Female	62(62.00)	28(31.11)	55(58.51)	65(66.33)	210 (54.97)
Age (years)					
0-20	-	-	-	3(3.06)	3 (0.79)
20-40	20(20.00)	20(22.22)	22(23.66)	32(32.65)	94 (24.61)
41-60	60(60.00)	66(73.33)	66(70.97)	55(56.12)	247 (64.66)
61-80	20(20.00)	4(4.44)	4(4.31)	7(7.14)	35 (9.16)
>80	-	-	1(1.08)	1(1.02)	2 (0.52)
Mean Age in years					50.45
Standard Deviation					(38.93)
Marital Status					
Single	2(2.02)	1(1.11)	3(3.33)	10(11.36)	16 (4.19)
Married	81(81.81)	85(94.44)	90(95.74)	82(93.18)	338 (88.48)
Divorced/Separated	9(9.09)	1(1.11)	-	1(1.14)	11 (2.88)
Widowed	7(7.07)	3(3.33)	1(1.06)	5(5.68)	16 (4.19)

Source: Field Survey, 2016.

Table 39: Distribution by socio-demographic characteristics

Variables (Percent)	Ogun	Ekiti	Ebonyi	Nassarawa	Pooled (N=382)
Household size					
1-5	29(29.29)	33(36.67)	43(49.43)	29(29.90)	134 (35.07)
6-10	63(63.64)	55(61.11)	42(48.28)	50(51.55)	210 (54.97)
>10	7(7.07)	2(2.22)	2(2.30)	18(18.56)	29 (7.59)
Mean					6.63
Standard Deviation					(4.22)
Educational Level					
No Formal Education	32(32.00)	7(7.87)	29(32.22)	15(15.46)	83(21.73)
Primary Education	51(51.00)	27(30.34)	15(16.67)	12(12.37)	105(27.49)
Quaranic Education	-	3(3.37)	-	9(9.28)	12 (3.14)
Secondary Education	15(15.00)	47(52.81)	34(37.78)	28(28.87)	124 (32.46)
Tertiary Education	2(2.00)	5(5.62)	12(13.33)	33(34.02)	52 (13.61)
Area of operation					
Rural	86(86.00)	86(95.60)	43(45.70)	39(39.80)	254(66.50)
Urban	14(14.00)	4(4.40)	51(59.00)	59(60.20)	128(33.50)

Source: Field Survey, 2016.

Table 40: Processors' socio-economic characteristics

Variables (Percent)	Ogun (100)	Ekiti (90)	Ebonyi (94)	Nasarawa (98)	Pooled (N=382)
Experience in processing (Years)					
0-5	9(9.18)	2(2.22)	17(18.48)	9(9.28)	37(9.69)
6-10	23(23.47)	42(46.67)	15(16.34)	15(15.46)	95(24.89)
11-15	22(22.45)	17(18.89)	9(9.78)	15(15.46)	63(16.49)
16-20	28(28.57)	21(23.33)	19(20.65)	31(31.96)	99(25.92)
21-25	11(11.22)	12(13.33)	4(4.35)	10(10.30)	37(9.69)
26-30	3(3.06)	1(1.11)	14(15.22)	15(15.46)	33(8.64)
>30	2(2.04)	-	14(15.22)	2(2.06)	18(4.71)
Mean					16.40
Standard Deviation					(9.26)

Source: Field Survey, 2016.

Table 41: Economic efficiency among rice processors

Economic Efficiency Scores	Traditional (N=78) Frequency	Percent	Tradmodern (N= 251) Frequency	Percent	Purely Modern (N= 53) Frequency	Percent
<0.50	38	48.72	151	60.16	21	39.62
0.50-0.59	9	11.54	19	7.57	6	11.32
0.60-0.69	3	3.85	2	0.80	2	3.77
0.70-0.79	9	11.54	20	7.89	4	7.55
0.80-0.89	10	12.82	31	12.35	9	16.98
0.90-1.00	9	11.54	28	11.16	11	20.75
Mean	0.5063		0.4382		0.5723	
Std. Deviation	0.3096		0.3280		0.3339	
Minimum	0.3515		0.0101		0.0085	
Maximum	0.9985		0.9985		0.9985	
Difference	(0.4937)		(0.5618)		(0.4277)	
Mean	0.4707					
Std. Deviation	0.3279					
Minimum	0.0085					
Maximum	0.9984					
	(0.5293)					

Source: Field Survey 2016

Table 42: Efficiency differentials of rice processors by the processing techniques used

Efficiency scores	Technical Efficiency			Allocative Efficiency			Economic Efficiency		
	Traditional	**Trad Modern**	**Purely Modern**	**Traditional**	**Trad Modern**	**Purely Modern**	**Traditional**	**Trad Modern**	**Purely Modern**
<0.2	10(13.33)	55(73.33)	10(13.33)	17(15.89)	78(72.90)	12(11.21)	54(20.34)	184(69.17)	28(10.53)
0.2-0.39	46 (26.29)	111(63.43)	18(10.29)	17(19.54)	64(73.56)	6(47.12)	18(25.00)	43(59.72)	11(15.28)
0.40-0.59	13(26.00)	27(54.00)	10(20.00)	13(26.00)	28(56.00)	9(18.00)	6(28.57)	8(38.10)	7(33.33)
0.60-0.79	5(16.13)	19(61.29)	7(22.58)	12(30.00)	22(55.00)	6(15.00)	0(0.00)	12(70.59)	5(29.41)
>0.79	4(7.84)	39(15.69)	8(15.69)	19(19.39)	59(60.20)	20(20.41)	0(0.00)	4(66.67)	2(33.33)
Pooled	78(20.48)	251(65.71)	53(13.87)	78(20.48)	251(65.71)	53(13.87)	78(20.48)	251(65.71)	53(13.87)

Source: Field Survey, 2016. (Figures in parenthesis are in percentage)

UNIVERSITY OF IBADAN

DEPARTMENT OF AGRICULTURAL ECONOMICS

FACULTY OF AGRICULTURE AND FORESTRY

RESEARCH QUESTIONNAIRE

Dear Respondent,

This Questionnaire of the Department of Agricultural Economics, University of Ibadan, is to collect information on Choice of Processing Techniques and Efficiency Differential among Rice Processors in Nigeria, Response will be confidential and will be used strictly for research purpose. Thank You.

Identification of State/LGA/ Processing Hub/Centre/Cluster type

A1	**Year of Survey** **Date of Survey**	
A2	**Respondent Category: Type of rice processing engaged in:**	
A3	**State**	
A4	**LGA** **Village/Town**	
A5	**Name of Interviewer & GSM No.**	
A6	**Name of Respondent & GSM No.**	

A. Socio-economic Characteristics of Respondents. (Tick the one that applies)

1. Gender of Household head Male ( ) Female ( )

2. Status of Household head Male Head of family ( ) Female Head of family ( ) Spouse ( ) Others specify ( )

3. Age of Household head in years____________________

4. Marital Status Single ( ) Married ( ) Divorced/Separated ( ) Widowed ( )

5. Household size (in numbers)__________________________

7. Level of Education of household head: No formal Education ( ) Primary Education ( ) Quaranic Education ( ) Secondary Education ( ) Tertiary Education ( )

8. Level of education of household members No formal education ( ) Primary Education ( ), Quaranic Education ( )

Secondary Education ( ) Tertiary Education ( ).

9. Years of Experience in Processing (in Years)___________________________

10. Main source of income ____

11. Other source of income: Rice farming ( ), Cultivation of other crops ( ), Artisan ( ), Trading ( ), Government worker ( ), Agro Processing ( ), Factory employee ( ), Others specify ______

11b. How will you classify your other source of income? Farming ( ), Non-farm ( ) off farm ( )

12. Do you belong to a rice processing association? Yes ( ) No ( )

13. How long have been a member ___________________________

14. If Yes, what are the roles of the association? Sourcing of paddy ( ), Pricing of Paddy ( )

Information on paddy ( ), Source of credit ( ), Source of inputs ( ), All the above ( ),

None of the above ( ), Others Specify ____.

15. If no who owns the processing unit Co-operative society ( ), Rent ( ) Others Specify _____________________-

16. How often do you process? Weekly ( ), twice weekly ( ), monthly ( ) Others Specify________________

17. Do you carry out all rice processing stages yourself? Or do you subcontract some stages Yes ( )No ( )

18. If No, why ____

19. If No, which stages do you subcontract? ____

B. Characteristics of Processing Firm (Please Tick as Appropriate)

1. How many tonnes do you process at a time?________________________

2. What is the source of your paddy? Own farm ( ), Purchase ( ), Other farms around ( ), neighbouring towns ( ), import ( )

3. What is your processing capacity per day/week (in kg) ?______________________________________.

4. What is the range of output per unit of processing per time? Less than 10 kg ( ), 10-20 kg ( ), 20-30 kg ( ), 30-40 kg ( ), 50-60 kg ( ), 60-70 kg ( ), 70-80 kg ( ), 80-90 tons ( ), 90-100 kg ( ) Over 100kg ( )

5 . What processing techniques do you use? Traditional ( ), Traditional and modern ( ), purely modern ( )

Others specify ( ).

6. What determines your choice of a rice processing techniques?___________________________

7. What factors determine how you process your rice?____

____

8. What determines the amount of paddy you process per time?_______________________________

____

9. What percentage of your total income comes from your processing activities? %___________________-

10. What amount do you get each time you process (₦)_________________________

11. Are you the owner of the processing unit? Yes ( ) No ( )

12. What processing equipments do you have?____

13. What processing equipments are available to you?_______________________________________

C. Financing of Processing Business (Per Processing Period)

S/N	Source of Credit	Amount Gotten (₦)	Amount Repaid (₦)	Interest rate
1				
2				
3				
4				
5				
6				
7				

D. Overhead Cost in Processing (₦)

S/N	Cost Items	Expenditure/week (₦)	S/N	Cost Items	Expenditure/week (₦)
1	Fuelling		7	Legal Charges	
2	Electricity		8	Transport from paddy source	
3	Maintenance and repairs		9	Transport to point of sale	
4	Communication Services		10	Cost of operating space	
5	Duties and Taxes		11	Others	
6	Interest on loans				

E. Marketing and Distribution Cost for Processed Rice (Cost/Week) (₦)

S/N	Marketing Activities	Cost /Week (₦)	S/N	Marketing Activities	Cost/ Week(₦)
1	Bagging		5	Storage	
2	Packaging		6	Transportation/haulage	
3	Labelling		7	Unofficial payments (gifts to security men, agents on the road)	
4	Ad-hoc workers		8	Communication	

F. Employment and Labour use for your processing Operation (per day/week/month)

Category	Hired Casual Worker	Hired Admin/ Management	Hired Technical/ skilled	Family Member used
Number of Adult males used				
Number of hrs worked/adult male				
Number of days worked/adult male				
Number of month worked				
Amount paid (₦) per day				
Amount paid per week (₦)				
Amount paid per month (₦)				
Number of Adult Female used				
Number of hrs worked				
Number of days worked per adult female				
Amount paid per day (₦)				
Amount paid per week (₦)				
Amount paid per month (₦)				
Number of days worked for children				
Amount paid per day (₦)				
Amount paid per week (₦)				
Amount paid per month (₦)				

G. Processing Constraints: What are the main constraints you face in your rice processing activities? Classify them from the most important to the least important.

S/N	Complaint	Very Important	Important	Not Important
1	In adequate access to rice paddy			
2	Lack of improved processing equipment			
3	Low storage capacity			
4	High Labour cost			
5	Unavailability of Labour			
6	Transportation problems			
7	Market Challenges			
8	Low price of processed rice			
9	Lack of funds (Cash/capital)			
10	Lack of reliable processing equipments			
11	Lack of reliable machine operators			
12	High cost of spare parts			
13	Lack of spare parts			
14	Others			

H. Kindly indicate the type of processing equipment you use for processing rice?

Equipment	Tick	How many	Year bought	Own/Rent	If Owner (Cost of Purchase)	If Rent-age (Amount paid for use)	Expected life Span	Capacity/ Output (kg, tonnes or other measure, specify)	Maintenance Cost			Residual Value*** (Current Market Price) (₦)
									Description	Year	Cost(₦)	
Threshing												
Winnowing												
Drying first stage												
Hulling												
Parboiling												
Milling												
Drying												
Destoning												
Packaging												

***** Value at which owner is willing to sell the equipment after life span**

I Other Overview Questions

S/N	Product	Size of Operation (10-100 tons, 100-1000 tons, >1000 tons)	Output (kg, tons, other measure Specify).	Source of Paddy rice (self produced, Another farmer, Retailer, Middleman Wholesaler)	Distance(km) from source of paddy to processing unit	Length of time paddy stays in store before processing	Distance (km) from processing centre to store	Means of Transport (Foot, Wheel Barrow, Bicycle, Car, Keke--Napep, Motor Van, Lorry, Carmel/donkey, Others specify)	Type of Packaging Used for Processed rice (Basket, Sacks, Bags (Kg), Others specify)	Length of stay of rice in store before sale	How do you store processed rice (Crib, Open Space, Warehouse, Others specify)	Reason for length of stay of rice in store (Lack of customers, Quality of grains, Distance from processing unit to market, High transportation cost, Waiting for buyers, Want to have a large amount before selling, Others specify).	Who you sell your processed rice to	Direct sales to consumers (Amount generated) (Qty/ton/(₦) (Food stores, Supermarket, Wholesalers, Retailers)
1	Broken grains													
2	Processed rice													