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ANALYSIS OF PRODUCTION EFFICIENCY OF POULTRY FEED INDUSTRIES IN NIGERIA.

BY

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(PhD / AGRIC / 4329 / 2009-10)

DEPARMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY

FACULTY OF AGRICULTURE

AHMADU BELLO UNIVERSITY

ZARIA – KADUNA STATE

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY DEGREE IN AGRICULTURAL ECONOMICS

DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY

FACULTY OF AGRICULTURE

AHMADU BELLO UNIVERSITY

ZARIA – KADUNA STATE

NIGERIA.

NOVEMBER, 2015.

DECLARATION

I hereby declare that this thesis titled **"Analysis of Production Efficiency of Poultry Feed Industries in Nigeria"** has been written by me and it is a record of my research work. No part of this thesis has been presented in any previous application for another degree or diploma in this or any other institution. All borrowed information have been duly acknowledged in the text and a list of references provided.

______________________ ________________

Isiaku **SANI** **Date**

Student

CERTIFICATION

This thesis titled **"AnalysisProduction Efficiency of Poultry Feed Industries in Nigeria"** by Isiaku **Sani** meets the regulations governing the award of the degree of Doctor of Philosophy in Agricultural Economics of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This Thesis is dedicated to my late parents.

ACKNOWLEDGEMENTS

All praise is to Allah, Lord of the world, Who taught man by the pen. May the mercy and blessing of Allah be on his Prophet Muhammad (S.A.W). My profound gratitude goes to my able supervisors ProfessorS. A. Rahman, Chairman Supervisory Committee and Dr. M. A. Damisa and Professor T. K. Atala, Members of the Supervisory Committee for reading this work and making useful suggestions, the result of which brings this work to its present status.

I am grateful to my wife Fatima A. H; my children Amina, Maryam, Sa'adatu, Ahmad, Aliyu and Fatima Zahra for their cooperation, prayers and understanding throughout the length of this study. My appreciation also goes to all my brothers and sisters who have contributed immensely towards the successful completion of this study.

My special appreciation goes to the Executive Director and the entire staff of the National Agricultural Extension Research and Liaison Services (NAERLS) for their assistance and company during the study. The Zonal office Staff of NAERLS are worthy of mention especially Mr. A. Adeshina (South West), Mr. O. Basil (South East), Mal. S. Abudu (South South), Mal Y. Sakpe (North Central) Dr. G. Muhammed (North East) and Dr. U. Bala (North West) for their assistance in data collection.

I would like to thank my friends and colleagues especially Mal S. K. Haruna, Mal. J. A. Abdullahi, Mal. D. Baba, Mal. I. J. Sambo, Mal. A. Yari, Dr. A .A. Hassan, Dr. O. Yusuf, , Mr. O. Oyinbo, Prof. S. Z. Abubakar, Prof. C.K.Daudu, Prof. S. J. Auta and Prof. E. Ikanni for taking time to go through the work and offer useful suggestions. Others worthy of mention are Professor Z. Abdulsalam, Prof. H. Mani, Engr. A. A. Fagge, Mal. S. Beli, Mal. S. Usman, Mal. A. A. Amman, Miss J. Yakub and Mal. A. Mohammed all of the ABU Zaria. My appreciation also goes to my former colleagues in the Kaduna Polytechnic, such as Mal. M.A. Biu, Mal. I. B. Bashir, Mal. M. U Sunusi, Dr. N. Abdullahi, Mal. A. A. Mohammed, Engr. M. S. Liman, Engr. M. T. Musa, Dr. M. S. Yahaya, Mal. H. A. Zakari, Engr. U. A. Garba, Mal. A. Liadi and Engr. B. A. Abdul for their prayers and support during this study. This acknowledgement will not be complete without the mention of Mal. S. H. Webmaster of Duniyar Computer, Mal. M. Abdullahi, S. Danmaliki, Abdullahi mai NAPEP, A. Alhassan and Mal. T. Khalid for their support and prayers.

Lastly, I would like to thank the Ahmadu Bello University and NAERLS Management for giving me the opportunity to undertake this study.

ABSTRACT

The study determined the production efficiency of poultry feed industries in Nigeria. It specifically examined the characteristics of poultry feed industries; the level and efficiency of input used; the level of production; the profitability level; technical, allocative and economic efficiency levels and the constraints to profitable feed production. Primary data were collected using a set of structured questionnaire from a sample of 279 mills from 12 states across the 6 geo-political zones of Nigeria. The data collected were analysed using descriptive statistics, Net Income Analysis and the stochastic frontier analysis. The findings indicated that the poultry feed industry was characterized by the presence of commercial, toll and on farm mills with an average of 15 years milling experience, with an average capacity 10 tonnes per day operating on average of 5days/week using 1-2shifts in a day. The mills produced mainly feed in mash form for broilers (starter and finisher), pullets, layers and cockerels (chick, grower and layer). The commercial mills made an average profit of ₦16, 855.98, the toll mills made ₦14, 277.07 profit, while the on farm had ₦13, 082.11and the pooled data for all the mills showed an average profit of₦14, 090.75 from the production of 1000Kg of poultry feed. The test of hypothesis on profitability confirmed that all the mill categories were making profit, with a return to Naira invested ranging from ₦0.15 to ₦0.28 for the three category of mills. The feed mills were found to be technical and cost inefficient. The mean technical efficiency of the commercial mills was 0.88; the toll mills had 0.82; while the on farm mills had 0.79 and 0.82 for the pooled data. All the mean technical efficiency values were below the ones specified by the frontier. To attain full technical efficiency, the average mills have to increase their output by 11% with the current level of resources or reduce costs by 11% at the current level of output. The mean allocative efficiency for the commercial mills was 1.145, for the toll mills it was 1.132, while the on farm mills had 1.152 and 1.143 was the mean for all the mills pooled together. All the allocative efficiency values were above the ones specified by the frontier. To attain full cost efficiency, an average mill has to reduce cost of production by about 14% at the current level of output. The test of hypothesis for the presence of technical and cost inefficiency further confirmed the presence of inefficiency at 1% level. The variables that were found to increase technical and cost inefficiency include, distance to ingredient sources, source of power, number of months ingredients are available, access to credit, mill size. Some of the constraints to more efficient and profitable poultry feed production identified include: adulteration of feed ingredients, fluctuation in prices and seasonal nature of the ingredients. There was also inadequacy of electricity and high cost of diesel to power generators. Taxes were equally high and multiple in nature. Based on the findings it can be concluded that feed production was profitable despite the technical and cost inefficiency of the mills. It was therefore, recommended that the mills should have access to more credit facilities as this will ensure expansion of the business and reduction of costs through bulk purchase and storage of feed ingredients, adulteration of ingredients could be checked through enforced regulations in the sector, adequate supply of electricity to the industries can reduce costs and improve cost efficiency.

TABLE OF CONTENTS

Contents **Pages**

LIST OF TABLES

Tables Pages

LIST OF FIGURES

Figures **pages**

LIST OF ACRONYMS AND ABBREVIATIONS

ATA:	Agricultural Transformation Agenda
PTAP:	Poultry Transformation Action Plan
FLD:	Federal Livestock Department
FMARD:	Federal Ministry of Agriculture and Rural Development
NPC:	National Population Commission
CIA:	Central Intelligence Agency
NAERLS:	National Agricultural Extension Research And Liaison Services
PAN:	Poultry Association of Nigeria
ADP:	Agricultural Development Programme
GNC:	Groundnut Cake
PKC:	Palm Kernel Cake
SBM:	Soybean Meal
SBC:	Soybean Cake
OFN:	Operation Feed the Nation
NIAS:	Nigerian Institute of Animal Science
SMEDAN:	Small and Medium Enterprises Development Agency of Nigeria
SFA:	Stochastic Frontier Analysis
DEA:	Data Envelopment Analysis
TE:	Technical Efficiency
AE:	Allocative Efficiency

EE:	Economic Efficiency
TOA:	Technology Option Analysis
LP:	Linear Programming
USDA	United State Department of Agriculture
MT	Metric Tonne
MMT	Million Metric Tonne
SON	Standards Organisation of Nigerai
FCR	Feed Conversion Ratio
SAP	Structural Adjustment Programme
MILCOPAL	Milk Cooperative Producer Association Limited

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The downturn in the Nigerian economy in the early eighties coupled with the massive devaluation of the Naira caused many workers to lose their jobs in both the public and private sectors. According to Tinuke (2013), Nigeria's economic condition escalated to a crisis during the 1983-84 period when government in the Federation could not meet its financial obligations.About 256,150 workers were retrenched in the public sector during the period, which compounded the problems of an already bad economy as unemployment increased. This has forced many people to seek investment in Crops and livestock sectors including Agro processing through feed milling activities (Oyediji, 2006).

This was also the time the poultry industry began to recover from the effects of the ban on maize importation in 1983 which affected the poultry feed milling industry. Traditionally, the bulk of maize being used at that time was being imported as local supplies continued to be inadequate as a result of drought and diseases and lack of adequate administration of the strategic reserves (Oyediji,2006). Local sources of protein ingredients also collapsed leading to an acute shortage of groundnut and soybean cakes. Feed milling activities and poultry production business almost collapsed at that time. To save the situation, Livestock Feeds Company Limited a subsidiary of Pfizer Company embarked on a project of teaching farmers how to compound poultry feeds through the use of concentrate or 5% premixes if concentrates or finished feeds were not available (Oyediji, 2006). This was a major turning point in local or indigenous poultry feed production as local fabricators of feed mills sprang up especially in Ibadan and Lagos, leading many farms to own feed mills using concentrates, premixes or basic ingredients.

Although livestockproduction has risen steadily over recent years, a major constraint to its expansion is inadequate feed supply. The poor quality of feeds currently available in the industry generates high poultry mortalities, low productivity and as a consequence, leads to a low rate of return on investment (Fagbenro and Adebayo 2005). An efficient feed mill industry that can supply quality feeds in adequate quantity is therefore crucial to the sustainability of viable livestock and poultry production enterprises.

In recent years, rate and level of performance in the livestock industry has fallen below expectation due to high feed cost arising from fluctuations in feed supplies, rising prices of feed ingredients, high capital outlay in purchase and storage of ingredients over time, poor feed quality (adulterated feed) and most importantly inefficiency in feed production (Eruvbetine,2009).This fallen trend according to Bello (2008), started around 1998-2000 when feed production figures dropped from 2.4MMt in 1995 to 1.6MMt in 2000 with subsequent decline up to 1.00MMt in the year 2008. This low capacity feed resources utilization could be linked to inadequate information based on location and localization of feed resources, processing, storage and quality enhancement. The net effect of all these are capacity under-utilization, curtailment of planned expansion programs and in extreme cases liquidation (Eruvbetine, 2009). However, according Oyediji (2015), there was a rise in the quantity of poultry feed produced in Nigeria from 2.2Mt in 2010 to about 3.3MMt in 2014. This was as a result of the ban imposed on the importation of frozen chicken and other livestock products which made poultry production more attractive. The rise in the number and size of poultry business has led to more demand for feeds and subsequent pressure on feed production ingredients. Thus, the rise in the number of feed mills to meet this demand become inevitable, according to Mbanasor and Jonas (2006), local feed industries without any standard procedure for quality dominated the feed market.

Feed being a major input in poultry enterprise constituting about 70% of total poultry production cost (Aduku, 1993 and Hassan, 2002), any major change in its composition, quality and availability will have a direct effect on the productive performance of the birds. Since the advent of balanced feed formulation, feeds have been prepared scientifically and economically to meet the specific requirements of the particular class of birds being produced. Compounded feeds are feedstuffs that are blended from various raw materials and additives. These blends are formulated according to the specific requirements of the targetanimal, by feed compounders as meal, pellets or crumb types.

In Nigeria, the first commercial feed millwas established in 1963 by Pfizer, now Livestock feeds Plc (Bello, 2008). In 1970 Ladokun Feeds produced poultry feed as a franchise of Pfizer,became autonomous 1976 until they fold up activities in the 90"s (Eruvbetine, 2009). In between 1980-1983 with the implementation of the "Operation Feed the Nation" it was obvious that the country needed to expand feed production, as the programme aimed at encouraging agricultural activities including poultry and livestock feed production. Thus, the number of feed mills grew to 303 in 1983 with a combined installed capacity of 1039tonnes/hr and feed production rose from 640,000tonnes/annum in 1980 to 2.4 million tonnes in 1985. Within 3 years, poultry population was at its peak from 12 million to 40 million commercial chickens (Eruvbetine, 2009).

Since then there has been a constant decline in poultry population and consequently feed productionespecially as a result of the avian influenza which affected many countries including Nigeria. This low turn in the performance of the poultry feed industry reachedits lowest in the year 2008 according to Bello (2008) and Eruvbetine(2009). The industry recovered from the shock decline of 2008 with increase in the number of feed mills and poultry farms across the country after the avian influenza scare. This has increased feed production according to Oyediji (2015), from 2.2Million tonnes in 2010 to about 3.3Million tonnes in 2014. There are plans according to the Poultry Association of Nigeria, PAN (2015), to expand these figures to 5.00Million tonnes by 2017 which will make Nigeria an exporter of poultry feeds. This has also placed Nigeria 51st in the rank of the world 130 leading feed manufacturers (Oyediji, 2015).Fromthe total output of feed annually produced in Nigeria, commercial feed millsaccount for about 50% while the remaining 50% is produced by toll and farm own mills without any quality control procedures or regulatory mechanism in place (Eruvbetine, 2009).

The poultry feed business in Nigeria employs a significant estimate of over 100,000 people with the upsurge in toll milling which accounts for over two-thirds of all the manufactured animal feeds (Oyediji, 2006). The industry offers quick return to investment with a guaranteed market due to increase in demand for feed by the ever increasing poultry farms in the country. According to the Nigerian Institute of Animal Science (NIAS), the current demand for poultry feed is about 4.5Million tonnes (Kannike, 2015) which is more than its supply of about 3.5MMt thus, making many people to venture into the business.

However, the industry has witnessed many feed mills who are operating sub optimally due to limited knowledge of innovations in the feed milling industry. The monitoring body for regulating feed production, the Standards Organization of Nigeria (SON), started an active program in 2006 to monitor and standardize all feed operations in the country as a result of the rising concerns about avian flu. This important function however, did not cover the toll mills who hardly follow laid down standards in the manufacture of poultry feeds (Eruvbetine, 2009). In the absence of adequate reference material or text specifically for managing a feed mill for efficiency and the potential hazards of operating commercial feed mills without prerequisite knowledge of managing the mills for efficiency, this study hoped to provide information that will bridge the gap in knowledge. The broad objective of this study is to examine the production efficiency of poultry feed mill business in Nigeria. The study will serve as a guideto operators, potential investors and other stakeholders in the feed industry on the major elements and challenges of managing feed mills for profitability.

1.2 Problem Statement

Global consumption of poultry products, especially poultry meat and egg, has consistently increased over the years as a result of increase in population, urbanization and income.This trend is expected to continueas forecasted by the Food and Agriculture Organization FAO (2013),which put growing populations, economies and incomes are fuelling an ongoing trend towards higher consumption of animal protein in developing countries, with Nigerians expected to consume two-thirds more animal protein, with meat consumption rising nearly 73%.

Such growth in the poultry industry is having a profound effect on the demand for feed and feed raw materials. Previous studies have shown that the high cost of compounded feeds for poultry is derived largely from the exorbitant prices of feed ingredients, increasing competitive demand for them and scarcity of the conventional ingredients

(Ojewola, 2004). According to FAO (2013), the growth in protein consumption is expected to drive the demand for maize and soybeans which form the main components of poultry feeds. Hence any attempt to improve efficiency in the sector can go a long way in reducing the high costs of the feed ingredients and consequently sustain the current level of growth. Feeding and nutrition are important aspects of poultry production enterprise, hence a good understanding of proper nutrition and feeding is essential for successful poultry production. Feed is a complex material which is composed of several indistinctively different groups of substances called nutrients, with definite functions which are fed to animals for the purpose of sustaining them.

In commercial poultry production the main constraint to successful production, is the feed cost which accounts for about 75 to 80% of the total cost of production (Hassan, 2002). The cost of feed ingredients has been increasing steadily as a result of growing number of poultry farms due to high demand for poultry products; increase in human population which increases competition for the feed ingredients and rise in the number of poultry feed compounding mills in Nigeria. This has posed a serious challenge to the poultry feed industries, leading to increase in prices and in some cases compromising the required standard and feed adulteration (Mbanasor and Jonas, 2006). The inability of the feed mills to meet the demand of the ever increasing poultry farms and the incessant increase in prices of the feed could be attributed to decrease productivity and inefficiency in the use of resources by the feed industries (Mbanasor and Jonas, 2006).

The poultry industry consumes about 90% of the total commercially produced feeds in Nigeria which can be put at 763,000 tonnes per year (FLD, 2005). Poultry population estimates as given by FLD (cited by Oyediji, 2006) shows a population estimate of poultry over the years to be on the increase. Current and estimated poultry population are about 166 million for 2008 and 249 million for 2011 (Njoku, 2007; Federal Ministry of Agriculture and Water Resources FMAWR, 2008). For this projected population, a total of 6.25 million tonnes of feed is required in Nigeria. If it is assumed that 50% of this is corn, then, approximately 3.125 million tonnes of corn is required while approximately 1.56 million tonnes of soybeans is also required to produce the projected 249 million was projected for poultry in 2011.

The high demand for feeds and low productivity in the feed industry indicates that Nigeria is faced with a great challenge as far as the inadequacy of the livestock sub-sector is concerned. Thus, it then becomes imperative to quantitatively measure the current level of and determinants of efficiency in poultry feed production in Nigeria and policy options available to raise the present level of sub-optimal efficiency in poultry feed production.Efficiency of production is directly related to the overall productivity in any sector, especially in the agricultural sector vis-a-vis the poultry sub-sector. From the foregoing, there is a crucial need to raise the productivity of the feed mill industries as such growth is the most efficient means of achieving food security and alleviating poverty. This study therefore, answered the following research questions:

i. What are the characteristics of poultry feed industries in Nigeria?
ii. What are the levelsand efficiency of inputs used in the poultry feed production?
iii. What is the level and efficiency of production of poultry feed by the industries?
iv. How profitable is poultry feed production?
v. What is the level of economic efficiencyof the poultry feed industries?
vi. What are the constraints of poultry feed production?

1.3 Objectives of the Study

The broad objective of this study was to determine the efficiency of Poultry feed industries in Nigeria.

The specific objectives were to:

i) describe the characteristics of poultry feed industries in Nigeria;

ii) determine the level and efficiency of input used for poultry feed production;

iii) determine the level and efficiency of production of poultry feed by the industries;

iv) evaluate the profitability of the poultry feed industries;

v) determine the economic efficiency of the poultry feed industries and

vi) identify the constraints of poultry feed production in the study area.

1.4 Justification of the Study

In Nigeria, feed production was in the past dominated by few large commercial feed industries usually based in Europe or America who run local franchised industries. The composition of their rations is not purely based on indigenous feed ingredients. The industry depends much on importation of major feed ingredients. The erratic supply of feeds by these franchised industries and the associated increase in feed prices, enhanced the increase in the number of the indigenous feed enterprises (Adene and Oguntade, 2006). These indigenous feed production enterprises according to Mbanasor and Jonas (2006), are classified as commercial(large), toll (small to medium) and farm own (small) feed mills operate without any laid down regulation or regulatory body to enforce compliance with standard production practice. The operations of such mills were reported to be inefficient in the utilization of expensive resources of production in studies on feed mill efficiency by Mbanasor and Jonas (2006), Oladejo (2012) and Munkaila *et al.* (2012). The result of this inefficiency is being shifted to the end users of the feed (farmers) in form of extra charges for the feed they purchase. This according to Bamiro *et al.* (2001), has added an extra burden on the poultry farmers to the already 65% to 80%cost of production which feed alone accounts for. Atteh (2002), further suggested private feed production using locally available unconventional feed resources that are relatively cheap as a solution to the rising costs of commercial feed.

The rising demand for poultry products on the other hand, has led to a tremendous increase in the number of poultry farms all over the country. However, the advancement in the poultry sector is currently being undermined by the escalating cost of feeds. Previous studies have shown that the high cost of poultry feeds is derived largely from the exorbitant prices of feed ingredients, increasing competitive demand for them for human consumption and scarcity of the conventional ingredients (Ojewola, 2004 and Oladejo, 2012). In order to reduce the high cost of feed emanating from inefficient resource utilization, it becomes necessary to study the efficiency of the feed milling industry. Increase in their level of efficiency will reduce cost and consequently increase the level of profits enjoyed by both the mills and the poultry farmers (Eruvbetine, 2009).

Currently in Nigeria, emphasis has been placed on the Agricultural Transformation Agenda (ATA). The Poultry Transformation Action Plan (PTAP) of the ATA document has projected doubling the annual production of eggs, spent layers and broilers, increase competitiveness and innovation and generate 182,300 new jobs. The areas for transformation are: breeder stock and day old chicks provision; feed availability, affordability and of high quality; poultry health coverage; marketing, processing and value addition; and research and innovation (ATA, 2011). To achieve this, the ATA is encouraging indigenous feed enterprises that make use of local ingredients in formulating feeds for the poultry industry. The PTAP document however, identified that low production efficiency and poor development of the poultry value chain wereas a result of frequent problems of increase in feed prices occasioned by low supply of feed ingredients, disease outbreaks and product gluts. Therefore findings of this study on economic efficiency wouldprovide some suggestions to help achieve some of the ATA targets through recommendations for policy formulation for the PTAP.

Due to the foregoing, it has therefore become necessary to examine the efficiency of the feed producing enterprises in order to ensure sustainability, higher profits through efficient use of resources and the need to meet the requirements of the fast growing poultry enterprises. Efficiency study is very important for provision of information on how to improve poultry feed output and enhances productivity of resources used. Resources are usually scarce, efficiency study can show whether it is possible to raise their productivity without increasing the resource base of the mills in the study area. The findings of this study being one of the few of its kind would provide empirical evidence on technical, allocative and economic efficiencies in poultry feed production in Nigeria. The information from this study would also contribute to knowledge relevant to the needs of the current Agricultural Transformation Agenda (ATA) of the federal government for policy formulation that creates enabling environment for sustainable poultry feed and poultry production in Nigeria.

1.5 Scope of the Study

This thesis covers the feed mills in Nigeria. In order to reduce the level of errors and inconsistencies in the data, the study consider information on a particular period of feed production. According to Hassan (2002), this was the festive period of Easter, Fasting and *Sallah* celebrations where most of the commercial poultry farmers produce broiler birds for sale and layers for egg. This also marks the time when most feed mills operate fully in order to meet the increase in demand for feed from the farms (USDA, 2008). The study was therefore conducted between April to October, 2014.

1.6 Research Hypotheses

The hypotheses that were tested include:

i) Poultry feed production is not profitable.

ii) Poultry feed mills are technically and cost inefficient in the allocation of their resources

iii) There is no significant relationship between the production attributes of the mills and their technical and allocative efficiency.

1.7 Organisation of the Thesis

The remaining sections of the thesis were structured as follows:

Chapter two provides the literature or the theoretical and empirical basis for the study while chapter three provides a description of the study area and the data collection and analytical technique employed in the study. The methods used in the empirical analysis are also discussed in chapter three. Results or findings of the study are discussed in chapter four. Chapter five contains summary of major findings, conclusion, recommendations and contribution to knowledge based on the empirical results of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Framework

2.1.1 Modeling Production

The estimation of production and cost functions has been an exercise among econometricians. The frontier production function is an extension of the regression model based on the theoretical premise that a production function, or its dual, the cost function, or the convex conjugate of the two, the profit function, represents an ideal, the maximum output attainable given a set of inputs, the minimum cost of producing that output given the prices of the inputs or the maximum profit attainable given the inputs, outputs, and prices of the inputs (Green, 2008). The estimation of frontier functions involves making its empirical implementation consistent with the underlying theoretical proposition that no observed firm can exceed the ideal values set up by the frontier. In practice, the frontier function model is a regression model that is fit with the recognition of the theoretical constraint that all observations lie within the theoretical extreme. Measurement of in efficiency is, then, the empirical estimation of the extent to which observed firms fail to achieve the theoretical ideal.

The empirical estimation of production functions had begun long before Farrell's work, arguably with the papers of Cobb and Douglas (1928). However, until the 1950s, production functions were largely used as devices for studying the functional distribution of income between capital and labor at the macroeconomic level. The celebrated contribution of Arrow et al. (1961), marks a milestone in this literature. The origins of empirical analysis of microeconomic production structures can be more reasonably identified with the work of Dean (1951, a leather belt shop), Johnston (1959, electricity generation) and, in seminal work on electric power generation, Nerlove (1963). It is noteworthy that all three of these focus on costs rather than production, though Nerlove (1963), following Samuelson (1938) and Shephard (1953), highlighted the dual relationship between cost and production.Empirical attention to production functions at a disaggregated level is a literature that began to emerge in earnest in the 1960s (Hildebrand and Liu (1965) and Zellner and Revankar (1969).

2.1.2 Production and Production Functions

2.1.2.1 *Producer*

To have a good understanding of production, we begin by defining a producer as an economic agent that takes a set of inputs and transforms them either in form or in location into a set of outputs. This definition according to Greene (2008), encompass service organizations such as travel agents or law or medical offices.

2.1.2.2 *Production*

Production is the process of transforming inputs into economically useful output. According to Greene (2008), the economic concept of production generalizes from a simple, well defined engineering relationship to higher levels of aggregation such as farms, plants, firms, industries, or, for some purposes, whole economies that engage in the process of transforming labor and capital into GDPby some pre-defined production process. Although this interpretation of production is broad, it is worth noting that the first empirical analyses of production functions, by Cobb and Douglas (1928), were studies of the functional distribution of income between capital and labour in the context of a macroeconomic production function.

2.1.2.3 *Production function*

The function, is a relationship between inputs and outputs, as of the time of the observation. It is simply a body of knowledge about the relationship between inputs and outputs. The various technical aspects of production, such as factor substitution, economies of scale, or input demand elasticities can be shown as a relationship to the extent that a particular specification, Cobb-Douglas or translog, for example, can be used to express their functional form. Cobb-Douglas, constant elasticity of substitution and trans-log production functions are the most common functional forms used in frontier analysis (Bhasin, 2002).

The Cobb-Douglas and translog models overwhelmingly dominate the applications literature in stochastic frontier and econometric inefficiency estimation. There have been a number of studies specifically focused on the functional form of the model. Caves-Christensen and Trethaway (1980), employed a Box-Cox functional form in the translog model to accommodate zero values for some of the outputs. The same consideration motivated Martinez-Budria, Jara-Diaz and Ramos-Real (2003), in their choice of a quadratic cost function to study the Spanish electricity industry. Another proposal to generalize the functional form of the frontier model is the Fourier flexible function used by Huang and Wang (2004) and Tsionas (2004).

In a production (or cost) model, the choice of functional form brings a series of implications with respect to the shape of the implied isoquants and the values of elasticities of factor demand and factor substitution. In particular, the Cobb-Douglas production function has universally smooth and convex isoquants. The implied cost function is likewise well behaved. The price to be paid for this good behavior is the strong assumption that demand elasticities and factor shares are constant for given input prices (for all outputs), Cost functions are often used in efficiency analysis because they allow the analyst to specify a model with multiple inputs. The Cobb-Douglas multiple output cost function has the unfortunate implication that in output space, the output possibility frontiers are all convex instead of concave – thus implying output specialization.

2.2 Stochastic Frontier Production Model

The stochastic production frontier proposed by Aigner, Lovell, Schmidt (1977) and Meeusen and van den Broeck (1977),is motivated by the idea that deviations from the production ‘frontier’ might not be entirely under the control of the firm being studied. Under the interpretation of the deterministic frontier, for example, an unusually high number of random equipment failures, or even bad weather, might ultimately appear to the analyst as inefficiency. A more appealing formulation holds that any particular firm faces its own production frontier, and that frontier is randomly placed by the whole collection of stochastic elements which might enter the model outside the control of the firm as viewed by Forsund and Jansen (1977). Cobb-Douglas, constant elasticity of substitution and trans-log production functions are the most common functional forms (Bhasin, 2002).

The main feature of the stochastic production frontier is that the disturbance term is a composite error consisting of two parts: a symmetric and a one-sided component. The symmetric component, Vi, captures the random effects due to measurement error,statistical noise and other influences outside the control of the firm and it is assumed tobe normally distributed (Udoh and Etim, 2007). They added that the one-sided (nonnegative)component Ui, with Ui $\geq$ 0 captures the technical inefficiency relative to thestochastic frontier. This randomness is under the control of the firm; its distribution isassumed to be half – normally distributed or exponential. The Vi, is assumed to beindependently and identically distributed as; N $(0,\delta^2V)$ random variables, independentof Uis. The Uis are also assumed to be independently and identically distributed asexponential (Meeusen and Vanden-Broeck, 1977), half normal (Aigner *et al.*, 1977),truncated and gamma (Greene, 1990).The stochastic frontier function model is estimated using the Maximum LikelihoodEstimation procedure (MLE) (Olowofeso and Ajibefun, 1999; Amos, 2007).

2.5.1 The stochastic production frontier function

By definition, stochastic frontier production function is:

Yi = f (Xi, β) exp (VI – Ui) i = 1, 2 … n ……………………………………………..(1)

Where:

Yi = Output of the ith firm

Xi = Vector of the quantities of input used by the ith firm

β = Vector of unknown parameters to be estimated

F(.) = denotes an appropriate functional form

exp = Exponential base of natural logarithms

Vi = Error term associated with random factors outside thecontrol of firm or management

Ui = non-negative (one-sided) error term which captures theeffects of technical inefficiency (Bhasin, 2002).

In the context of stochastic frontier production function, the technical efficiency (TE) ofthe individual firm is defined as the ratio of the observed output to the correspondingfrontier output, conditional on the levels of inputs used by the firm. Therefore,technical efficiency of an individual firm can be obtained as:

TE = exp (-Ui)………………………………………………………………………(2)

That is,

$TEi = Yi = F(Xi\beta) \exp(Vi - Ui) = \exp(-Ui)$……………………………………………..(3)

$Yi^* F(Xi\beta) \exp(Vi)$

Where:

TE = Technical efficiency of ith firm

Yi = Observed output from ith firm

Yi* = Frontier output

This is such that $0 \leq TE \leq 1$ (Farell, 1957)

Maximum efficiency has a value of 1.0, lower value represents less than maximumefficiency in production. According to Idiong (2006), the difference between Yi and Yi*is embedded in Ui when U = 0, then production is in the frontier (that is, Y = Y*) and thefirm is technically efficient. However, if Vi > 0, the firm is inefficient since productionwill be below the frontier.

2.3 Stochastic Frontier Cost Functions

Under a set of regularity conditions Shephard (1953) and Nerlove (1963), proposed an alternative representation of the production technology using the cost function,

$C(y,w) = \min\{w^T x: f(x) \geq y\}$

Where **w** is the vector of exogenously determined input prices. The cost function gives the minimum expenditure needed to produce a given output, y. If a producer is technically inefficient, then their costs of production must exceed the theoretical minimum. On the cost side, however, any errors in optimization, technical or allocative, must show up as higher costs. As such, a producer that we might assess as operating technically efficiently by a production function measure might still appear inefficient viz-a-viz a cost function. The corresponding cost frontier of Cobb-Douglas functional form which is the basis for estimating the allocative efficiencies of the farmers is specified as follows:

C_i= g (Pi, ɑ) exp (Vi + Ui); ………………………………………………………….. 4

Where;

C_i represent the total input cost of thei-th firm;

g = suitable function such as the Cobb-Douglas function;

P = represent input prices employed by the i-th firm in production and measured in naira; a = the parameter to be estimated,

Vis and Uis = random errors which are assumed to be independent and identically distributed truncations (at zero) of the N (μ, σ^2) distribution. Ui provides information on level of the allocative efficiency of the i-th firm.

The allocative efficiency of individual firms is defined in terms of the ratio of the predicted minimum cost (Ci*) to observed cost (Ci).

That is AE = Ci*/Ci = exp (Ui)…………………………………………………………..5

Hence, allocative efficiency ranges between zero and one that is $0 \leq AE \leq 1$. The inefficient firms are expected to operate above the frontier level of 1

2.4 Deterministic Frontier Production Models

Frontier functions, in which the deviation of an observation from the theoretical maximum is attributed solely to the inefficiency of the firm, are labeled deterministic frontier functions. This is in contrast to the specification of the frontier in which the maximum output that a producer can obtain is assumed to be determined both by the production function and by random external factors such as luck or unexpected disturbances in a related market. Under this second interpretation, the model is recast as a stochastic frontier production function.

2.5 Deterministic Cost Frontiers

Forsund and Jansen (1977), formulated a hybrid of the linear programming approaches and the parametric model above to extend the analysis to costs of production. The Forsund and Jansen specification departs from a homothetic production function because the parameters of the production function are obtained by using linear programming to minimize ΣiNi=lnCsubject to the constraints that observed costs lie on or above the cost frontier.

2.6 Data Envelopment Analysis (DEA)

This consist of a body of techniques for analyzing production, cost, revenue, and profit data, essentially, without parameterizing the technology. Built on the premise that there exists a production frontier which acts to constrain the producers in an industry. With heterogeneity across producers, they will be observed to array themselves at varying distances from the efficient frontier. By wrapping a hull around the observed data, we can reveal which among the set of observed producers are closest to that frontier (or farthest from it) (Greene, 2008). Presumably, the larger is the sample, the more precisely will this information be revealed. In principle, the DEA procedure constructs a piecewise linear, quasi-convex hull around the data points in the input space. The technical efficiency requires production on the frontier, which in this case is the observed best practice. Thus, DEA is based fundamentally on a comparison of observed producers to each other. Each producer strives to achieve that goal of attaining the ideal situation.

DEA method of measuring efficiency is atheoretical. Its main strength may be its lack of parameterization; it requires no assumptions about the form of the technology. The piecewise linearity of the efficient isoquant might be problematic from a theoretical viewpoint, but that is the price for the lack of parameterization. The main drawback is that shared with the other deterministic frontier estimators. Any deviation of an observation from the frontier must be attributed to inefficiency.There is no provision for statistical noise or measurement error in the model. The problem is compounded in this setting by the absence of a definable set of statistical properties. Recent explorations in the use of bootstrapping methods has begun to suggest solutions to this particular shortcoming. (Xue and Harker (1999), Simar and Wilson (1999) and Tsionas (2004). The last of these used efficiency measures produced by a DEA as priors for inefficiency in a hierarchical Bayes estimation of a stochastic frontier.

2.7 Comparison between SFA and DEA

Comparison been made between (nonparametric) DEA and statistical based frontier methods, both deterministic and stochastic. There have been several studies that have analyzed data with both DEA and parametric, deterministic frontier estimators. For example, Bjurek, Hjalmarsson and Forsund (1990), used the techniques described above to study the Swedish social insurance system. Forsund (1992), did a similar analysis of Swedish ferries. In both studies, the authors do not observe radical differences in the results with the various procedures. That is perhaps not surprising since the main differences in their specifications concerned functional form – Cobb-Douglas for the parametric models, piecewise linear for the nonparametric ones. The differences in the inferences one draws often differ more sharply when the statistical underpinnings are made more detailed in the stochastic frontier model. But, even here, the evidence is mixed. Ray and Mukherjee (1995), using the Christensen and Greene (1976), data on U.S. electricity generation find a good agreement between DEA and stochastic frontier based estimates. Murillo-Zamorano and Vega-Cervera (2001), find similar results for a later (1990) sample of U.S. electricity generators. Cummins and Zi (1998), also found concordance in their analysis of the U.S. insurance industry. Finally, Chakraborty, Biswas and Lewis (2001), find in analyzing public education in Utah that the empirical results using the various techniques are largely similar. These studies do stand in contrast to Ferrier and Lovell (1990), who found major differences between DEA and stochastic frontier based inefficiency estimates in a multiple out distance function fit in a large sample of American banks. Bauer *et al.* (1998), likewise found substantial differences between parametric and nonparametric efficiency estimates for a sample of U.S. banks. In sum, the evidence is mixed, but it does appear that quite frequently, the overall picture drawn by DEA and statistical frontier based techniques are similar. That the two broad classes of techniques fail to produce the same pictures of inefficiencies poses a dilemma for regulators hoping to use the methods to evaluate their constituents (and, since they have the same theoretical underpinning, casts suspicion on both methods). As noted above, this has arisen in more than one study of the banking industry. Bauer, et al. (1998) discuss specific conditions that should appear in efficiency methods to be used for evaluating financial institutions, with exactly this consideration in mind.

2.8 Conceptual Framework

2.8.1 **The conceptof efficiency**

There are basically two broad paradigms for measuring efficiency as discussed in the previous section, one based on an essentially nonparametric, programming approach to analysis of observed outcomes, and one based on an econometric approach to estimation of theory based models of production, cost or profit (Greene, 2008). This section presents an overview of the application of the techniques for econometric analysis of technical (production) and economic (cost) efficiency in various fields. The stochastic frontier model of Aigner, Lovell and Schmidt (1977),which is the standard econometric platform for this type of analysis was reviewed.

The literature on frontier production and cost functions and the calculation of efficiency measures begins with Debreu (1951) and Farrell (1957). Farrell (1957), suggested that one could usefully analyze technical efficiency in terms of realized deviations from an idealized frontier isoquant. This approach falls naturally into an econometric approach in which the inefficiencyis identified with disturbances in a regression model. He proposed that the efficiency of a firm consist of technical and allocative components and the combination of these two components provide a measure of total economic efficiency (Overall efficiency).

Greene (2008), defined technical efficiency (TE), which is one of the focus of this study, as the firm's ability to produce a maximum level of output from a given level of inputs and allocative efficiency (AE) as the ability of a firm to use inputs in optimal proportions, given their respective prices and available technology. Odii (1998),added that, a firm is said to be more technically efficient than another if given the same quantities of measurable inputs; it consistently produces a larger output.

Efficiency of resource-use is therefore, the ratio of useful output to the total input that gives a maximum value of output from any given total of inputs (Shepherd, l985). Helfand (2003), reiterated that the analysis of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given bundle of resources, or certain level of output at least cost. According to him, Productive efficiency is the attainment of production goal without waste.

2.8.2 **Empirical Application of Stochastic Frontier Production in Agriculture**

The crucial role of efficiency in increasing agricultural output has been widely recognized by researchers and policy makers. It has remained an area of important research both in developed and developing countries. This is particularly so in developing economies where resources are meager and opportunity for developing and adapting better technology are dwindling (Ali and Chaudhary, l990). The reason behind measure of efficiency is that if farmers are not making efficient use of existing technologies, then efforts designed to improve efficiency would be more cost effective than introducing a new technology as a means of increasing output (Shapiro, 1983). Efficiency measurement is important because it leads to a sustainable resource savings, which have important implications for both policy formulations and farm management (Bravo-Ureta and Evenson, 1994).

Ojo (2003), stated that efficiency measurement is important for the following reasons: firstly, it is a success indicator and performance measure by which production units are evaluated. Secondly, it is in only measuring efficiency and separating its effects from the effects of the production environment that one can explore hypothesis concerning the sources of efficiency differential. Thirdly; identification of sources of inefficiency is important to the formulation of public and private policies designed to improve performance, as this will provide the mechanism for monitoring the performance of a production system or unit.

The problem of measuring the productive efficiency of an industry is important to both the economic theorists and the economic policy maker. If the theoretical arguments as to the relative efficiency of different economic systems are to be subjected to empirical testing, it is essential to be able to make some actual measurements of efficiency. Equally, if economic planning is to concern itself with particular industries, it is important to know how far a given industry can be expected to increase its output by simply increasing its efficiency, without absorbing further resources (Farrel, 1957).

The crux of the problem of growth in agriculture in developing countries is how to increase output per unit input (Singh, 1981). One way of approaching the problem of increasing production is to examine how efficient the farmers are using their resources, if resources use is inefficient, production can be increased by making adjustment in the use of factors of production in optimal direction. In case it is efficient, the only way for increasing production would be the adoption of modern inputs and improved technology of production (Singh, 1981).

The measurement of farm efficiency is an important area of research both in the developed and developing world (Tadessea and Krishnamoorthy, 1997). It has been shown that efforts designed to improve efficiency as a means of increasing agricultural output are more cost-effective than introducing new technology if farmers are not making efficient use of existing technology (Belbase and Grabowski, 1985 and Shapiro, 1983). If farmers are reasonably efficient, then increases in productivity would require new inputs and technology to shift the enterprise frontier upward. Given the availability of indigenous poultry feed enterprises, it is important to know whether the operators are efficient users of this local technology. The task of meeting the increasing demand for poultry feed can best be realized through increased availability of indigenous feed production (Mbanasor, 2002). The challenge of this study is to estimate the current level of technical efficiency as well as the factors that influence the level of efficiency of these indigenous enterprises.

The stochastic frontier production function has been applied in a considerable number of studies in the field of agriculture locally and internationally. Early applications of stochastic frontier production function to economic analysis include those of Aigner *et al.* (1977), in which they applied the stochastic frontier production function in the analysis of the U.S agricultural data. Battese and Corra (1977), applied the technique to the pastoral zone of Eastern Australia. And more recently, empirical applications of the technique in efficiency analysis have been reported by Battese *et al.* (1997); Ajibefun and Abdulkadri (1999); Ojo (2003).

Also Battesse and Corra (1977), used stochastic frontier function to determine whether there is significant difference in the technical efficiencies of small, large crop and mixed-enterprise farms in West Tennesse. His findings indicated that variability of farm effect was highly significant and the mean technical efficiency of mixed enterprises (0.76) was smaller than that of crop farms (0.85). Battesse and Corra(1997), investigated the technical efficiencies of two samples of maize producers in Eastern Nepal, one involved in the Sasakawa Project and the other sample outside the project. The results indicate that the Sasakawa Global Project sampled farmers were more technically efficient than those outside the project relative to their respective technologies (0.94 and 0.79 respectively).

There are also several efficiency studies conducted locally using the stochastic frontier production function. They include Ojo (2003), in a study on Productivity and Technical Efficiency of Poultry Egg Production in Nigeria. He found the Technical Efficiencies of the farmers varied widely between 0.239 and 0.933 with a mean of 0.763 and about seventy nine percent of the farmers had Technical Efficiency exceeding 0.70. Udo and Etim (2009), determine farm level efficiency of rice production in Uyo, Nigeria using the stochastic frontier production model. The result showed mean efficiency of 62%, implying that output from broiler production could be increased by 38%.

2.9 Efficiency of Poultry Feed Production

The rising demand for poultry products has led a large increase in the number of poultry farms in Nigeria. However, this advancement in the sector according to Mbanasor and Jonas (2006) and Oladoja and Olusanya, (2009), is undermined by the escalating cost of feeds which accounts for about 65% to 80% of the total cost of raising livestock depending on the species, breeds and environment. Studies such as that of Njoroge, Bett and Njehia (2015), found high cost of ingredients and low quality of feeds as the major impediment to profitability of commercial livestock production in Kenya. Therefore, for profit to be enhanced and poultry owners to remain in business, a feed cost reduction strategy is inevitable.

During the early stage of its development, the Nigeria feed industry is dominated by a few large commercial feed mills based in Europe and America who run local franchised industries. The ban on the importation of maize and other cereals coupled with the protein crises of the early eighties and the structural adjustment programme put a lot of pressure on the livestock industry, (Oyediji, 2006 and Bello, 2008). This led to the closure of many feed mills and capacity underutilization in the few operating ones (Erubvitine, 2009). The situation affected many poultry farms leading to closure and consequent decline in the population of commercial poultry in Nigeria. This decline happened in the few years before and after the structural adjustment programme (SAP) according to (Oyediji, 2006).

With emphasis on the use of locally available materials for industrial development, the number of such local feed industries is on the increase. These millers according to Mbanasor and Jonas (2006), operate without the requisite knowledge of the standards required in poultry feed milling. They are also associated with inefficient utilization of resources as a result of several factors. These factors as found in studies by Mbanasor and Jonas (2006), Oladejo (2012) and Mukaila *et al.* (2012),were use of poor technology, profit margin and inefficiency in the use of available resources.

Mbanasor and Jonas (2006), studied the Efficiency of Indigenous Poultry Feed Production Enterprises in Abia State, Nigeria. They found the estimated mean technical efficiency of the 120 enterprises in the sample was 78% and the outstanding variable affecting Technical efficiency of the enterprise is years of experience. This implies that output from feed production could be raised by 22% to attain full efficiency in the study area. In another study on the economic analysis of feed mill industry in Lagos State, Oladejo (2012), found some of the factors affecting efficiency to include inadequate capital, irregular supply of electricity, unavailability of feed ingredients and transportation cost. Munkaila *et al.* (2012), in their study of feed mills in Ogun and Oyo States, Southwest Nigeria found the mills enjoying some profits but are highly inefficient. Some of the inefficiency variables in their study were inadequacy of production ingredients, high prices and inadequate power supply.

The outcome of the study would serve as a guide to public policy design and implementation to enhance the poultry feed enterprises.This study attempted to provide additional knowledge and literature in this area of poultry feed production where little information is available and few studies conducted especially in Nigeria.

2.10 An Overview of the Nigerian Livestock Industry

The livestock and poultry production industries are well developed in Nigeria. The livestock resources include cattle, goats, sheep, donkeys, horses, pigs, giant rats, camels rats, guinea pigs and rabbits. The poultry resources include indigenous and imported chickens, guinea fowls, turkeys, ducks and geese. The majority of the ruminants (cattle, sheep and goats) are supplied with fodder feeds harvested from rangelands and grazing reserves. Cattle production systems are largely pastoral, with the vast majority of cattle being maintained in transhumance and agro pastoralist systems. Most of the other livestock resources are reared under the traditional extensive systems. These comprise pastoral, village and urban smallholder farms. Over 90 percent of the country's pig and rabbit production is managed under traditional husbandry systems(Sani, 2007). Commercial production techniques are only used extensively in the poultry and aquaculture sectors, where they account for 27% and 19% of livestock production, respectively (Simonya, 2006).

The Nigerian poultry industry is estimated at ₦80 billion and is comprised of approximately 165 million birds, which produced 650,000 tonnes of eggs and 290,000 tonnes of poultry meat in 2013 using approximately 3.5 million tonnes of feed (USDA, 2013 and Oyediji, 2015). From a market size perspective, Nigeria’s egg production is the largest in Africa ahead of South Africa at 540,000 tonnes of eggs and it has the second largest chicken population after South Africa’s 200 million birds (USDA, 2013). This growth started during the oil boom era which later declined during the austerity and the structural adjustment programme periods of the early eighties and nineties.

Chicken importation (with the exception of day-old-chicks and hatchable eggs) was banned by Nigeria in 2003, which spurred growth in domestic poultry production. Statistics Information from the Poultry Association of Nigeria, PAN(2015), however, highlighted that between 2009 and 2011 over 3 million tonnes worth of poultry products were imported into the Republic of Benin, with the preponderance of these products ending up in the Nigerian market. If this is reflected in overall assumptions, estimated poultry meat consumption in Nigeria is approximately 1.2 million tonnes (Oyediji, 2015).

One of the reasons is that smuggled chicken costs about ₦500- ₦700/kg while locally produced frozen chicken costs between ₦1,000- ₦1,300/kg at retail locations, and approximately ₦850/kg at the farm gate (Oyediji, 2015; Sahel, 2015 and PAN, 2015). The price differential between imported and locally produced poultry is driven primarily by the high cost of feed production ingredients such as maize and soybeans in Nigeria, and wide fluctuations in these commodity prices. In 2013 in particular, high maize prices impacted on the margins of both poultry and animal feed companies, while the first quarter of 2015 has seen the poultry sector squeezed by a combination of high soybean prices (₦ 150,000/tonne in May versus ₦110,000/tonne during the same period in 2014) and incidences of Avian Flu (Sahel, 2015). Even with these challenges, analysts have projected a 20% annual growth in the poultry industry between 2010-2020 driven by Nigeria's large population and rapidly growing middle class (FAO, 2014).

2.11 Poultry Feed Production

The beginning of world industrial scale production of animal feeds can be traced back to the late 1800's. This was around the time that advances in human and animal nutrition were able to identify the benefit of a balanced diet and the importance of the role that the processing of certain raw materials played in the composition of feed. Corn gluten feed was first manufactured in 1882 while leading world feed producer, Purina was established in 1894 by William Danforth Cargill, mainly dealing with grains in 1865. They started making livestock feeds in 1884. By the 1900's the feed industry expanded rapidly and in 1927 the first feed mill was opened in Canada by Purina (Eruvbetine, 2009). Today there are about 3800 feed mills worldwide manufacturing more than 80%

of the World's industrial feed requirement (Eruvbetine, 2009). Global consumption of poultry products, especially poultry meat, has consistently increased over the years, and this trend is expected to continue. Such growth in demand for livestock products suggests that there will be a consequent rise in demand for animal feed, not only of cereals but of other feeds and particularly proteins. Data on feed production and consumption are much harder to assemble, the projected world demand for poultry and other feeds according to FAO will reach 1.4billion tonnes by the year 2020 (Akintoye, 2010).

In Nigeria, commercial feed milling commenced in 1963 by Pfizer, now Livestock feed Plc (Bello, 2008). The number of feed mills grew to 303 as at 1983 with a combined installed capacity of 1039tonnes/hr. Feed production rose from 640,000mt in 1980 to 2.4 million tonnes in 1985. Within 3 years, poultry population was at its peak from 12 million to 40 million commercial chickens (Eruvbetine,2009).

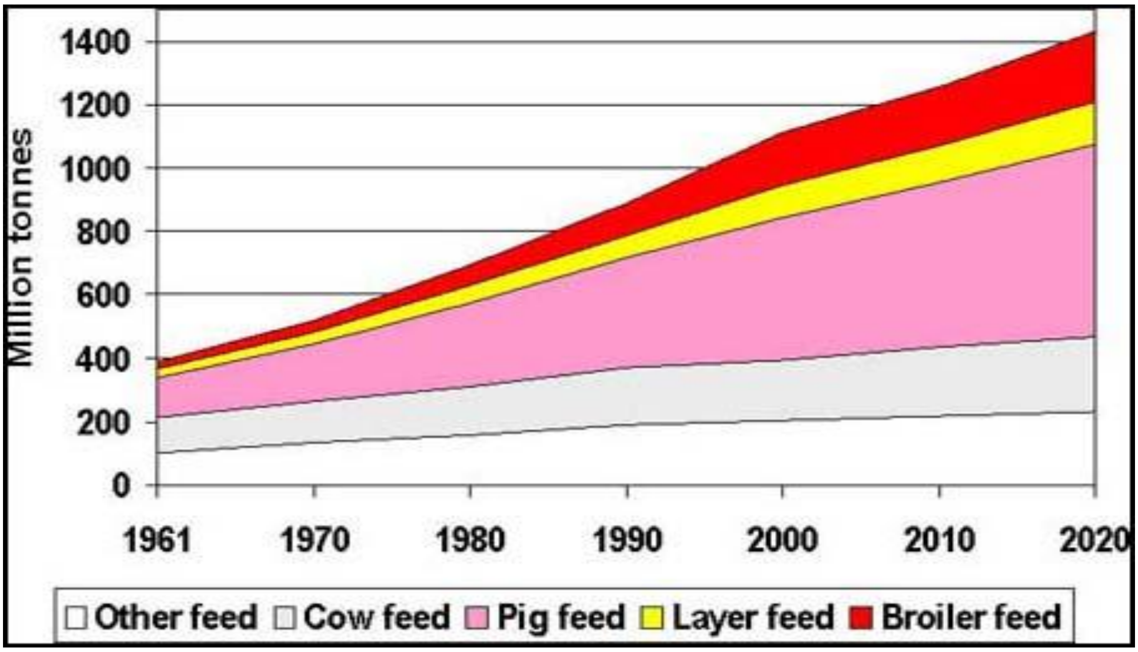

Figure: 1: Projected world growth in demand for animal feed

Poultry meat and eggs have become very important means of bridging the protein supply gap in Nigeria. Thus, many Nigerians in recent times, have developed interest in poultry production as a result of awareness of the nutritional value and the great opportunities for making profits. The rising demand for poultry products has led to a tremendous increase in the number of poultry farms all over the country. However, the advancement in the sector is currently being undermined by the escalating cost of feeds. Previous studies have shown that the high cost of compounded feeds for poultry is derived largely from the exhorbitant prices of feed ingredients, increasing competitive demand for them for human and other industrial uses and scarcity of the conventional ingredients (Ojewola, 2004).

A typical poultry diet, contains approximately 70% cereal grains (maize, wheat, sorghum, millet) and 25% protein sources from plants (soyabeans, groundnut cake, palm kernel cake, cotton seed cake) and animal sources (fishmeal, blood meal, meat meal. The remaining 5% is for fixed or micronutrients such as salt, vitamin/mineral premix, enzymes, limestone and bone meal. Formulated feeds account for the major operating costs in the semi-intensive and intensive pig and poultry (monogastrics) industry. These costs may account for as much as 60 - 80 percent of total production costs. Although the production of conventional livestock has risen steadily over recent years, a major constraint to its expansion is an inadequate feed supply. The poor quality of the feeds currently available to the industry generates high mortalities, stimulates low productivity and as a consequence, produces a low rate of return on investment (Fagbenro and Adebayo, 2005).

Given the fact that Nigeria is faced with a great challenge as far as the inadequacy of the livestock sub-sector is concerned, it then becomes important to quantitatively measure the current level of and determinants of efficiency and policy options available for raising the present level of efficiency given the fact that efficiency of production is directly related to the overall productivity of the agricultural sector.

2.12 Poultry Feed Industries in Nigeria

In Nigeria, commercial feed milling commenced in 1963 by Pfizer, (Now Livestock feed Plc). The number of feed mills in the country has been increasing since then. The number of feed millers grew to 303 as at 1983 with a combined installed capacity of 1039 tonnes per hour. Feed production rose from 640,000 tonnes in 1980 to 2.4 million tonnes in 1985, this then declined to about 1.0 million tonnes by 2008 (Eruvbetine, 2009).

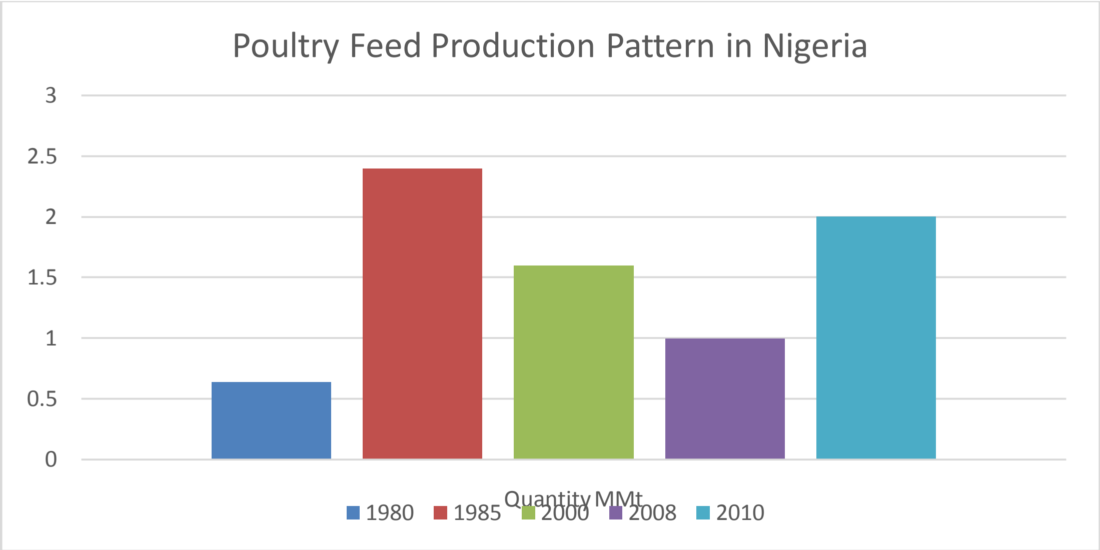

Figure: 2: Feed production in Nigeria over the years
(Adapted fromEruvbetine, 2009)

An efficient feed mill industry is therefore crucial to the sustainability of viable livestock and poultry production enterprises. The poultry feed industry (broiler and layer industry) according to Fagbenro and Adebayo (2005), dominates the animal feed industry, and accounted for approximately two-thirds (68.2 percent) of the national feed production while the remaining 31.8% is for livestock such as pig, rabbits and fish. The industry comprises two sectors: the small-scale and the commercial sectors. The commercial sector manufactured nearly 1.7 million tonnes or 65.4 percent of the country's poultry feed - this included feeds offered to chickens, guinea fowls, ducks, geese and turkeys (Fagbenro and Adebayo, 2005).The Toll millers and farm mixed feed constitute the remaining 35% of the total poultry feed produced in the country. The ingredient composition used in poultry feeds is derived using least cost formulation techniques. It should be noted that although these feeds are formulated for poultry, some are commonly and widely used as general livestock and fish feeds. The Tables below shows the total feed production in Nigeria over the years

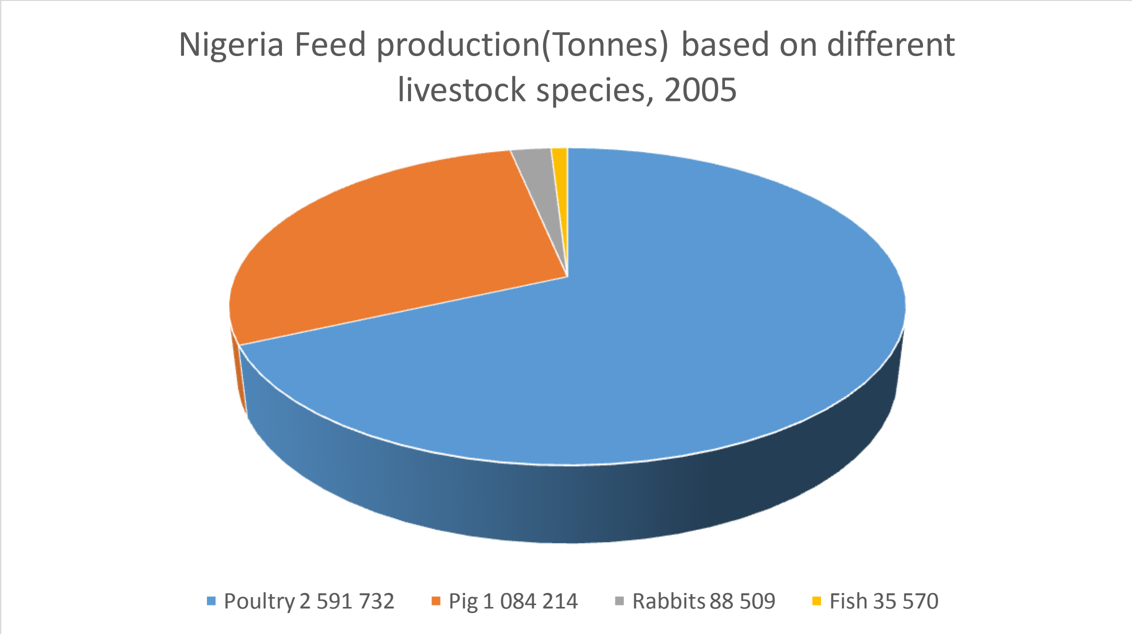

Figure: 3: Nigeria Feed production (Tonnes) based on different livestock species, 2005 (Adated from Fagbenro and Adebayo, 2005)

2.13 Characteristics of Poultry Feed Industries

Livestock feed industries or mills are found all over the country, with the largest concentration in the south-west zone of the country. These range from small, medium to large scale operators. Currently there are only six (6) well established reputable feed milling companies in Nigeria. The major commercial feed millers include, Top feeds, Vital feeds, Livestock feeds, Boar feeds, Animal care, Amo byng, and Feed Masters producing more than 50% of feed requirement of the country while the remaining is balanced by the medium, small scale,toll millers and on farm/ self-mixed feed that can be found all over the country(Bello, 2008). According to Oyediji (2006), increase in demand for feed has led to the emergence of additional feed mills whose size and nature of business differentiate them from one another. According to Munkaila *et al.* (2012), thereexist large scale commercial feed mills whose hourly output ranges from 5tonnes and above, medium scale mills with an output range of 2-4 tonnes and the small scale with an hourly output of 0.5 to 2 tonnes per hour. In the study 56% of the sample were small scale, 29% medium scale and only 4% were large scale mills.

Table2. 3: Commercial/Self mix poultry feed market production 2006 (MMt)

Company	Avg. Monthly Production	Avg. Annual Production	Market Share %
Top Feeds	11,000	130,000	13
Vital Feeds	8,500	102,000	10.2
Livestock Feeds	4,000	48,000	4.8
Boar feeds	4,000	48,000	4.8
Animal care	4,000	48,000	4.8
Amo Byng	2,500	30,000	3.0
Regional Compounders	8,000	96,000	9.6
Toll millers	25,000	300,000	30
On farm/Self mixed	16,470	198,000	19.8
Total	83,000	1,000,000	100

Adapted from Bello (2008)

2.14 Classes of Poultry Feeds

Common classes of poultry feed produced according to Aduku (1993), depending on the type of poultry in question are: Broiler starter and broiler finisher feeds for meat type of chickens.The chick, grower and the layer feeds are prepared for the egg type poultry. The last category of feed is the breeder ration formulated specifically for feeding breeding or parent stocks owned by hatcheries. The major difference between the feed types is in the varying inclusion rates of the various feed ingredients that supply energy, protein and vitamins to the poultry bird in question.

Poultry diets are formulated from a mixture of ingredients, including cereal grains, cereal by-products, fats, plant protein sources, animal byproducts, vitamin and mineral supplements, crystalline amino acids and feed additives. These are assembled on a least-cost basis, taking into consideration their nutrient contents as well as their unit prices. According to Eruvbetine (2009), Compounded feeds are feedstuffs that are blended from various raw materials and additives. These blends are formulated according to the specific requirements of the target animal and presented in form of a mash or pellet. The mash feed is prepared from ground feed ingredients that are well mixed to provide a balanced diet to the bird. On the other hand pelletized feeds go a step further in processing where the mash is converted to pellets using s suitable binding material under moderate heat. It is usually preferred to mash feeding for the avoidance of selective feeding by the chickens.

2.14.1 **Broiler starter feed**

The broiler starter is a feed type that is usually fed to birds for meat production from 0 – 4 weeks of age. The feed is usually high in energy and protein to support rapid growth of the birds. The minimum metabolisable energy (ME) and crude protein (CP) for broiler starter feed according to Moreson (1998) and Oladokun and Johnson (2012), are 2,860 Kcal/Kg and 23% respectively. Other dietary considerations for this type of feed are high fat content (4.0% min.), low fiber and high level amino acids methionine (0.40%) and lysine (1.12%). This makes the broiler starter the most nutritious and expensive chicken feed in Nigeria. Different combinations of ingredients are used in order to achieve this fast rate of growth in this class of poultry. According to Aduku (1993), broiler starter is in the small granule size which makes easy for the chicks to pick up the feed faster. It is designed in a very precise manner for healthy growth of the chick to face possible stresses like diseases, climate variation, vaccinations and handling. A broiler bird requires approximately 1 Kg. of starter feed to shift to broiler finisher feed.

The average inclusion rate for ingredients in the broiler starter diet which will supply the needed nutrient requirements for the bird according to Aduku (1993) and Oladokun and Johnson (2012) is 535, 175, 75, 30, 50, 75, 25, 20, 10, 2 and 3 Kg/tonne of maize, groundnut cake, palm kernel cake, soybean cake, fish meal, wheat offal, maize offal, bone meal, oyster shell, salt, and vitamin/mineral premix. The average dietary requirements for different classes of poultry birds is shown in Table 2.3

Table 4.2: Ingredients used for poultry feed production in Nigeria

Feedstuff	**Quantity - kg per tonne**				
	Chicks	Growers	Layers	Broiler	
				Starter	Finisher
Maize	575	510	500	535	545

Groundnut cake	175	100	125	175	100
Palm kernel cake	50	50	70	75	80
Blood meal	30	30	10	30	40
Fishmeal	40	15	30	50	125
Wheat offal	75	200	100	75	50
Brewer's grain	25	60	50	25	20
Bone meal	15	20	10	20	25
Oyster shell	10	10	100	10	10
Salt	2	3	2	3	3
Vitamin/Mineral premix	3	2	3	2	2

Oladokun and Johnson (2012)

2.14.2 **Broiler finisher feed**

This is the type of feed given to broiler birds immediately they finished consuming broiler starter (recommended 1Kg) or at about 3-4 weeks of age till the point of disposal of the birds. According to Oyediji (2006), this feed is designed at a very high energy level with well-balanced protein, energy ratio to get faster, and maximum weight gain with lowest Feed Conversion Ratio (F. C. R.). The minimum recommended metabolisable energy and crude protein for broiler finisher is 3,080 Kcal/Kg and 19.5% respectively with high methionine (0.40%), lysine (1.10%), crude fat (3.5%) and low fibre for complete digestion Moreson (1998). The broilers are fed this type of feed on a free choice basis until they attain required weight or at most 8 weeks of age.

The average inclusion rate for ingredients in the broiler finisher diet which supply the needed nutrient requirements for the bird according to Aduku (1993) and Oladokun and Johnson (2012) is 545, 100, 80, 40, 125, 50, 20, 20, 10, 3 and 2 Kg/tonne of maize, groundnut cake, palm kernel cake, soybean cake, fish meal, wheat offal, maize offal, bone meal, oyster shell, salt, and vitamin/mineral premix.

2.14.3 **Chick feed**

This is the type of feed given to pullets and cockerels from day old to about 8th to 10th week of age. It is in the form of small granule size feed which makes easy for the chicks to pick up the feed. It is formulated to satisfy all the requirements for the healthy growth of the chick in the presence stresses like diseases, climate variations and handling.The recommended minimum metabolisable energy and crude protein for chick mash is 2,640 Kcal/Kg and 20.0% respectively with high fibre (5.0%), methionine (0.40%), lysine (1.0%) and crude fat (3.5%) for proper growth and development of the egg machine (layer) Moreson (1998).

The average inclusion rate for ingredients in the chick diet that supplies the needed nutrient requirements for the bird according to Aduku (1993) and Oladokun and Johnson (2012) is 575, 175, 50, 30, 40, 75, 25, 15, 10, 2 and 3 Kg/Tonne of maize, groundnut cake, palm kernel cake, soybean cake, fish meal, wheat offal, maize offal, bone meal, oyster shell, salt, and vitamin/mineral premix.

2.14.4 **Grower feed**

This is the most important type of feed where the precautions are taken while formulating to ensure best performance during the layer stage. This is recommended from 8th week to20th week or when the birds start dropping (laying). The minimum meabolisable energy for this category of feed is 2,475 Kcal/Kg to 2,650Kcal/Kg and crude protein of 16.0%. Other minimum dietary requirements are high fiber (7.5%), fat

(3.5%), lysine (0.80%) and methionine (0.27%). The lower crude protein and energy of the growers' diet compared to that of chick diet is an attempt to slow down their growth to attain full sexual maturity and also to avoid fat deposition (Moreson 1998).

The average ingredients inclusion rate for grower diet which will supply the needed nutrient requirements for the bird according to Aduku (1993) and Oladokun and Johnson (2012) is 510, 100, 50, 30, 15, 200, 60, 20, 10, 3 and 2 Kg/Tonne of maize, groundnut cake, palm kernel cake, soybean cake, fish meal, wheat offal, maize offal, bone meal, oyster shell, salt, and vitamin/mineral premix.

2.14.5 **Layer feed**

This type of feed is recommended from 19th week till the culling of birds. At the onset of sexual maturity defined as the age at first egg drop, a layer ration containing an adequate level of calcium as well as other nutrients need to be made available to the birds. Extra care is taken while formulating to ensure maximum hen housed production with good quality egg with minimum possible feed consumption. The minimum energy requirement for layer is 2,530 to 2600Kcal/Kg and a crude protein of 16.5%, while the calcium, fibre and crude fat requirements are pegged at 3.5% (highest for any bird category), 6.5% and 3.5% respectively for optimum performance of the birds Aduku (1993) and Moreson (1998).

The average inclusion rate for ingredients in Layer diet which supplies the needed nutrient requirements for the bird according to Aduku (1993) and Oladokun and Johnson (2012) is 500, 125, 70, 10, 30, 100, 50, 10, 100, 2 and 3 Kg/Tonne of maize, groundnut cake, palm kernel cake, soybean cake, fish meal, wheat offal, maize offal, bone meal, oyster shell, salt, and vitamin/mineral premix.

Table: 2. 3: Recommended nutrient requirements of various classes and species of poultry

Feed type	Age of birds (wks)	Crude Protein Min %	Fat Min %	Fibre Min %	Calcium Exact	Phosphorus Available	Lysine Min%	Methionine Min.%	M.E Kcal/kg
Chick Ration	0-8	20	3.5	5	1	0.45	1	0.4	2640
Growers Ration	9-20	16	3.5	7.5	1	0.35	0.8	0.27	2475
Layers Ration	21-end of lay	16.5	3.7	6.5	3.5	0.45	0.7	0.27	2530
Broiler Starter	0-4	23.5	4	3.5	1	0.45	1.12	0.45	2860
Broiler Finisher	5-8	20	3.5	3.5	0.9	0.4	1.1	0.4	3080
Breeder	21-end of lay	16	3	5	3	0.45	0.7	0.3	2420

Adapted from Aduku (1993) and Moreson (1998).

2.15 Inputs Requirement in Poultry Feed Production

In any production process, inputs are converted into intermediate products or final output ready for use by the consumer. In the poultry industry these inputs comprises of both the fixed or capital equipment and the variable inputs. The machines include: the mill, mixer, conveyors, and electric motors, pelleting machine, bags, sealer, weighing scale, metal containers, electricity supply, generator set, truck, warehouse, wheel barrows, manual and technical labour. Other inputs are the feed ingredients such as maize, maize bran, sorghum, wheat, wheat bran, groundnut cake, soybeans cake, fish meal, palm kernel meal, bone meal, limestone, vitamin/mineral premix, essential amino acids and blood meal (Eruvbetine, 2009).

Poultry diets are made from feedstuffs that are classed into two broad categories: conventional and non-conventional. The conventional feed ingredients are those occurring naturally and whose quality parameters have been recognized and standardized by the animal feed industry. According to Aduku (1993), feedstuffs such as maize, soybean, wheat bran, groundnut cake, fish meal, palm kernel cake, bone meal, limestone and salt are in this category. The non-conventional feedstuffs on the other hand include many farm wastes and agro-industrial by products. They can partially or fully substitute for the conventional feedstuffs in some rations, for the supply of some nutrients (Aduku, 1993).

Poultry feed is made primarily from a mixture of several conventional (in some cases non-conventional) feedstuffs such as cereal grains, soybean meal or cake, groundnut cake, fish meal, .and vitamin and mineral premixes (Alimon and Hair-Bejo, 1995). The diet is expected to contain three essential nutrients that provide metabolizable energy, Protein, vitamins, and minerals. Different species, strains or classes of animals have different requirements for energy, proteins, minerals, and vitamins in order to maintain its various functions like body maintenance, reproduction, egg, milk and meat production.

Energy is very critical in poultry feed for the metabolic activities of the bird. The most easily available energy sources are cereal grains such as maize, sorghum and grain by-products, however, suitable quantities of fat may be added to increase energy concentrations and palatability (Aduku, 1993). According to F.A.O. (2012), the predominant feed grain used in poultry feeds worldwide is maize. This is mainly because its energy source is starch, which is highly digestible for poultry. In addition, it is highly palatable, is a high-density source of readily available energy, and is free of anti-nutritional factors. The metabolizable energy value of maize is generally considered the standard with which other energy sources are compared while formulating poultry feed.

Table: 2. 4: Conventional and alternative feedstuffs in non-ruminant dietary formulations

Nutrient	Conventional feedstuffs	Percent ration	Alternative feedstuffs	Maximum inclusion rate
Protein	Groundnut cake	15	Palm kernel cake	15
	Soybean meal	15	Cottonseed cake	10
			Jackbean	10
			Poultry offal	10
Energy	Maize	55	Sorghum	55
			Cassava	45
			Sweet potato	15
Fibre	Brewer's dry grains	15	Maize offal	10
	Rice bran	15	Wheat offal	2.5
			Sorghum offal	10
			Rice husk/bran	5
			Cassava peel	10
Minerals	Oyster shell	7.5	Periwinkle shell	7.5
	Bone meal	2.5	Limestone	5
	Dicalcium phosphate	2.5	Malt dust	2
			Common salt	2
Additives	Vitamin premix	1		
	Salt	0.25		
	Others	0.75		

Adapted from Aduku (1993) and Moreson (1998).

While considerable quantities of maize are cultivated for human consumption, the wet milling of maize for oil and starch produces by-products that are available to the animal feed industry. In addition, the production of sorghum beer produces waste products that may be used in feed formulations. In 2000, the total grain production was recorded at a little over 25 million tonnes, and comprised maize, sorghum, millet, rice and wheat (Fagbenro and Adebayo, 2005)

In the Asian and African regions, however, maize yield per hectare is low, and in most countries, production has never been sufficient to meet the needs of the growing human population. The net result is a continuing shortage of maize for feed use in these regions. The other energy source that meets most of the same criteria as maize is low-tannin sorghum. Sorghum can be grown in low-rainfall areas and is a popular crop in hot, drought-prone regions. The high tannin content of many older sorghum varieties limits their use in poultry diets, but low-tannin varieties are now available and can be used in poultry diets without any limitation. The energy value of low-tannin sorghum is 90 to 95 percent that of maize (Aduku, 1993).

Protein is essential in the development of muscles, feathers, flesh, beak, skin, and internal organs of animals. It is also needed for growth, reproduction, milk and egg production. Most of the protein requirements of poultry is supplied by soybean, groundnut cake (Plant protein), fish, meat and blood meal (animal protein). The dietary protein requirement for protein in poultry is the actual requirement for amino acids which must be provided in proper amounts. For poultry, the most limiting amino acids are methionine and lysine (Oladokun and Johnson, 2012).

Fishmeal is an exceptionally good source of high-quality protein, and its price usually reflects this. It also provides abundant amounts of minerals (calcium, phosphorus and trace minerals), B vitamins and essential fatty acids. The presence of unidentified growth factors is another feature of fishmeal. Feed formulations therefore seek to ensure minimum levels of fishmeal in diets (Aduku, 1993).

While considerable quantities of groundnut, soybeans, and cotton seeds are cultivated for industrial use, human competition for use of these protein sources has drastically reduced their availability for the feed industry.Adulteration of cakes with haulms, hays and other impurities affect the availability and utilization of most locally available cakes.

Minerals are essential in the development of bones and egg shells in poultry some sources of minerals include oyster shell and limestone which are rich in calcium. Bone meal is a rich source of both calcium and phosphorus, while common salt provide the poultry bird with sodium and chloride requirements. Other trace minerals and vitamins which are essential in the absorption of other nutrients and maintenance of healthy condition in birds are usually supplemented through the use of vitamin/mineral premix (Scheideler, 2008).

2.16 Factors Affecting Poultry Feed Production

Poultry feed production involves the interaction of several factors which affect the performance and profitability of the business. According to Mbanasor and Jonas (2006), several factors have been identified as the causes of low performance. Some of these are poor technology, profit margin and inefficiency in the use of available resources. Other factors affecting poultry feed production include; Variability (or lack of consistency) in nutrient quality, Limited information on the availability of nutrients, High fibre content, Presence of anti-nutritional factor, Need for nutrient supplementation (added cost), Seasonal and unreliable supply, Bulkiness, physical characteristics, Need for de-hulling and/or processing (drying, detoxification), Limited research and development facilities for determining nutrient composition, inclusion levels in poultry diets, Competition with use as human food, Poor prices relative to other arable crops (farmer), Cost per unit of energy or limiting amino acids, relative to traditional feedstuffs (feed manufacturer) and Cost of processing.

2.16.1 **Feedstuff availability and prices**

Commodity prices are generally subject to market forces and the effects of supply and demand. Nevertheless, a number of locally produced items are subject to protective quotas and tariffs that are raised on their imported equivalents. The dependence on imported concentrates in the past stimulates wide price fluctuations. The prices of feedstuffs also vary with inflation, official regulation of the commodity markets through government import controls and price support through subsidies or direct government purchases. At present, retail of feedstuffs is widespread, and it is estimated that close to 50 percent of all feeds produced are mixed/made on the farms (Oladokun and Johnson, 2012). Furthermore, an efficient road system will ensure that the general availability of most feedstuffs throughout Nigeria is good.

The food processing industry is an important, yet inexpensive source of raw materials. Oil mills, breweries and distilleries produce an assortment of protein-rich by products that have use as feeds for livestock, poultry and fish. For example, sludge from the palm oil industry, has a high nutrient value that has the potential to be developed into a major raw material for the animal feed industry.

The current level of feedstuff availability is below the demand for it by the feed mill industry which rely on local production. Seasonality in production and over reliance on natural precipitation are some of the factors that affect prices and feedstuff availability in Nigeria (Olukosi and Isitor, 1990).

Energy sources constitute the largest component of poultry diets, followed by plant protein sources and animal protein sources. Globally, maize (corn) is the most commonly used energy source, and soybean meal is a common plant protein source.

However, other grains such as wheat and sorghum, and plant protein meals such as groundnut cake, and sunflower meal are also widely used.. The main animal protein ingredients are fishmeal and meat meal. Almost all developing countries including Nigeria are importers of these ingredients; the poultry feed industries in Africa and Asia depend on imports, which are a drain on their foreign exchange reserves. Quite often, the semi-commercial and commercial sectors in these countries are forced to limit their output of compounded feeds.

The diversion of grains, particularly maize, from the animal feed market to other uses has caused severe grain supply problems in the world market, with dramatic price increases. Despite record prices, the import demand for main ingredients in developing countries continues to increase to meet the feed demands of an expanding poultry sector, putting further pressure on prices.

After energy-yielding raw materials, protein supplements constitute the largest component of poultry diets. Plant protein sources supply the major portion of dietary protein (or nitrogen) requirements. The plant protein source traditionally used for feed manufacture is soybean meal, which is the preferred source for poultry feed. Soybean meal contains 40 to 48 percent crude protein, depending on the amount of hulls removed and the oil extraction procedure. Relative to other oilseed meals, soybean protein has a good balance of essential amino acids, which can complement most cereal-based diets (Aduku, 1993). The amino acid availability in soybean meal is higher than those for other oilseed meals. The metabolizable energy content is also substantially higher than in other oilseed meals (FAO, 2012). However, raw soybeans contain several anti-nutritional factors, including protease inhibitors, which can negatively affect protein digestion and bird performance. However, these inhibitors are destroyed by heat during the processing of soybean meal (Aduku, 1993). Properly processed soybean meal is an excellent protein source for all classes of poultry, with no restrictions on its use. Soybean production has increased substantially over the past two decades to meet the rising demands for oil for the human food market and meal for the animal feed market. The major producers of soybeans are the United States, Brazil and Argentina, which are also the major exporters.

With the exception of soybean meal, plant protein sources are generally nutritionally imbalanced in terms of essential amino acids, particularly lysine, the first limiting amino acid in cereals (Aduku, 1993). Unless supplemented with animal protein sources and crystalline amino acids, plant-based diets may not meet the requirements for critical amino acids for egg and meat production. Owing to their high prices, animal protein ingredients are normally used to balance the amino acid contents of diets rather than as major sources of protein (Oladokun and Johnson, 2012). In many countries, feed manufacturers ensure that animal protein ingredients do not fall below minimum levels in poultry diets, especially for young birds whose amino acid requirements are high. The requirements for essential amino acids are progressively reduced as the birds grow older, and it is possible to meet the needs of older birds with diets containing lower levels of animal protein and relatively higher levels of plant protein. Fishmeal and meat meal in developed countries) are the animal protein sources most widely used in poultry diets

Fishmeal consists essentially of dried, ground carcasses of fish. Good-quality fishmeal is brown, but the colour varies according to the type of fish used and the processing conditions. A very dark colour is indicative of overheating, which can destroy amino acids, reduce amino acid availability and substantially lower the protein quality.

Fishmeal is an important – sometimes the only – source of animal protein ingredients in most developing countries. It is either imported or locally produced. Local fishmeals typically contain between 40 and 50 percent crude protein, compared with more than 60 percent protein in imported fishmealsAduku (1993) and Moreson (1998).

2.16.2 **Feedstuff quality**

Feedstuff quality varies depending upon their ingredients, sources and production methods. The quality of imported ingredients tends to be good - they have to meet the demands of a sophisticated feed milling industry. Prices are fairly consistent with product quality, and for some items, pegged to those specifications that are most likely to vary, e.g. the moisture levels for grains or crude protein levels for fishmeals.

However, lack of quality control in the processing and supply of locally available feedstuff is a source of concern for most millers. High level of ingredients adulteration occur at various stages of the commodity exchange. This ranges from mixing ingredients such as soybean cake with yellow maize, fish meal with sand and other debris (PAN, 2015). This lack of quality control is affecting the performance of the animals fed with those feeds.The larger feed mills maintain laboratories that check on raw material quality and monitor the feed manufacturing process. The involvement of the larger feed mills in commodity trading also helps to maintain the quality of feedstuffs.

2.16.3 **Feedstuff supplies**

The demand for feedstuffs in Nigeria is derived predominantly from the livestock and poultry feed industries, and is met either by domestic production and/or imports. Domestic supplies to the feed industry is dependent upon the overall agricultural production, the degree of industrialization and the demand for refined food products. Recently, the livestock and poultry industries in Nigeria went through a phase of rapid expansion. The expansion placed a severe strain on the supplies of feedstuffs traditionally sourced from Nigeria's grain and oilseed crops. At present, the total supply of all the locally produced feedstuffs does not appear to be sufficient to meet demands - especially with respect to the animal protein supplements that are currently imported (PAN, 2015). To assist in the

2.17 Poultry Feed or Ration Formulation

Ration (or feed) formulation does not merely involve mathematical calculations to meet the requirement of the birds, since the result of the calculation may turn out to be impractical and not ideal for feeding of poultry (Aduku, 1993 and Adediji, 2006). An experienced Poultry nutritionist, therefore, needs to evaluate the feed formulation before it can be given to the birds. Factors to be considered in making good feed according to literatures as cited by Aduku (1993), Adediji (2006),Onwurah (2010), and Afolayan and Afolayan (2008), are:

i. **Acceptability to the birds:** The ration being formulated has to be palatable enough to stimulate intake by the birds. Feed refused by the birds is worthless, since feed has to be consumed and utilized.
ii. **Digestibility of the feed**: The nutrients in the feed have to be digested and released into the gastrointestinal tract to be utilized by the birds. Rations with high fiber content cannot be tolerated.

iii. **Cost of feed ingredients:** The requirement of the birds can be met through several combinations of feed ingredients. However, when the cost of these ingredients are considered, there can only be one least-cost formulation. The least-cost ration should ensure that the requirements of the birds are met.

iv. **Presence of anti-nutritional factors and toxins:** The presence of anti-nutritional factors in the feed, such as anti-trypsin factor in soybean meal, affects the digestion of some nutrients by making them unavailable to the animal. Some feed ingredients may also contain toxic substances, which may be detrimental to the animal when given in excessive amounts. The inclusion of these feed ingredients should therefore be limited or eliminated from the formulation. There are several methods in formulating rations. All of them have the same objectives of providing the required balanced nutrients at the least possible cost.

v. **Ingredients availability:** When undertaking complete feed formulation, one should note that many ingredient types are usually needed to produce a single feed type. To assure the availability of enough quantity of each ingredient could be such onerous task that the producer and his agents may have to be constantly on their toes. The absence of one ingredient may cause unwanted delays in production or a change in formulation. Raw material procurement and quality assurance of procured materials should therefore be placed under the control of an experienced and diligent staff.

2.18 Methods of Formulating Feed:

There are several methods involved in formulating rations; all of them have the same objectives of providing the required balanced nutrients at the least possible cost. Some of these methods are according to Aduku (1993), Afolayan and Afolayan (2008) include:

2.18.1 **Pearson Square Method**

This the simplest method of feed formulation using two ingredients that supply energy and protein with some fixed ingredients for the provision of minerals and vitamins to the animal in question. Expert users of Pearson square usually modify it to accommodate more than a single energy and protein sources. It has the advantage of being relatively simple direct and easy to follow and useful in balancing for the protein requirements. Some of its limitations are the use of only two feed ingredients and less consideration is given to other nutritive requirements, vitamins and minerals (Ogundipe, 2002).

2.18.2 **Simultaneous Equation Method:**

This is an alternative method for the Pearson Square method using a simple algebraic equation. The ingredients to be included in the feed formulation equations are arranged in form of simultaneous to solve the values of the unknown. It allows the use of several ingredients and one can balance for both the protein and the energy.

2.18.3 **Linear - Programming (LP)**

This is the common method of Least Cost Feed Formulation. It is used in determining the least-cost combination of ingredients using a series of mathematical equations. A standard linear programming model, in matrix form, may be stated as follows.

$$Minimise \sum_{j-1}^{n} c_j x_j \rightarrow (j = 1, 2, 3, \ldots\ldots n)$$

$$\sum_{j-1}^{n} a_{ij} x_j \geq b_i \quad \sum_{j-1}^{n} a_{ij} x_j \geq b_i \quad \sum_{j-1}^{n} x_j = 1 \quad x_j \geq 0$$

……………………………………………….6

Where

c_j = Cost per unit for jth ingredient

x_j = Quantity of jth ingredient

a_{ij} = Quantity of ith nutrient per unit of jth ingredient

b_i = Requirement for ith nutrient in the diet

There are many possible solutions to the equations, but when the factor of cost is applied, there can only be one least cost combination. LP is very useful for poultry feed formulation, the reason been that feed ingredient are not expected to change property because of mixing, that is every unit of a least cost feed formulated ration has the same productivity regardless of ingredients sources (Allison and Baird, 1974).

2.18.4 **Stochastic Method**

This is a windows based method of feed formulation unlike the Linear programming which involves the use of some programme codes. In real life nutrient composition is highly variable. This variation is associated with variety of factors which include variation of nutrient content of ingredients coming from different batches and sources and variation attributed to the laboratory procedure and human error. For example if same sample of soybean is analyzed multiple times for protein content, it is very likely that every time a slightly different value will be obtained. In Linear Programming method a mean value of these analytical values is used for formulation. Statistically, these mean values are associated with only 50% confidence of meeting the requirements in prepared formula. Most feed manufacturers want to minimize the risk of not meeting the nutrient requirements of the animal. The application of safety margin in linear formulation and use of Stochastic Programming minimize this risk.

2.18.4.1 ***Application of safety margin in linear formulation***

In the first solution diets are formulated at 5-10% higher than requirement. This is an unsatisfactory solution from quality control and economic points of view because it does not account for variation level. Nutrient variation could be higher enough to exceed safety margin level. In case where variation level is low, the formulated diet will be unnecessarily expensive. This will result in economic loss of the Feed manufacturer or livestock farmer.

2.18.4.2 ***Use of Stochastic Programming***

The second solution, Stochastic Programming has been widely recommended for feed formulation. In modern terms, stochastic has become a statistical word referring to variables that are random or uncertain.

The standard form of constraints in linear programming is as follows

$$Minimise \sum_{j-1}^{n} c_j x_j \rightarrow (j=1,2,3,.......n) \quad ....7$$

$$\sum_{j-1}^{n} a_{ij} x_j \geq b_i \qquad \sum_{j-1}^{n} a_{ij} x_j \geq b_i$$

Subject to:

$$P\left(\sum_{j-1}^{n} a_{ij} x_j \leq b_i\right) \geq \varphi_i \qquad P\left(\sum_{j-1}^{n} a_{ij} x_j \geq b_i\right) \geq \varphi_i$$

Because the above constraints are nonlinear so they could not be solved using software that formulates least cost diets by linear programming. This form of constraint is solved by stochastic programming, which provides assurance of meeting the requirement of animals to a greater probability – statistically at a value greater than 90%.

The use of computer in feed formulation minimizes the cost of ration, given a certain set of ingredients and their nutritional content, is convenient and saves manpower, allows large ingredients handling at a time and eliminates human error both in calculation and in speed. Examples of Software That Use Linear Programming for Feed Formulation include: MIXIT (various version exist), Winpas, Feedlive, EGGPRO Version 2.0, and Feed Mania, while those that use Stochastic Method are:Winfeed and WUFFDA.

2.19 Costs and Returns in Poultry Feed Production

The fact that total poultry feed production costs vary from mill to mill makes it somewhat difficult to make accurate generalizations about the costs associated with establishing a feed mill or cost producing a certain quantity of feed. However, in all cases, the major cost items in feed production are the mill and the mixers which constitute a huge amount of investment in the fixed cost items. The other cost items of importance are the feed production ingredients which are classified in to the energy, protein, vitamins, minerals and feed additives (Aduku, 1993; Oyediji, 2006 and Oladejo, 2012). The fixed and variable costs depend on the type of mill and size of operation. According to Munkaila *et al.* (2012), total capital investment determine the firm's ability to acquire necessary equipment such as delivery van, quality milling and mixing machine, storage facility and the right quantity of qualitative feed ingredients. Their study also revealed that for a small scale feed mill require about ₦1,000,000 to invest in fixed assets while the medium scale mill require about ₦4,000,000 and the large scale feed mills have to invest about ₦20,000,000. The study further revealed that the variable cost components which include the costs of ingredients, labour and other operating expenses for the small scale mill is about ₦6,500,000, for the medium scale mill it is ₦16,000,000 while the large scale mill will require about ₦115,000,000. This differences in fixed and variable costs were as a result of the differences in size and scale of operations (Munkaila *et al;*2012).

Several studies conducted in Nigeria and other countries of the world have found feed production to be profitable and a worthwhile investment. Studies by Mbanasor and Jonas (2006), Oladejo,(2012) and Munkaila *et al;*(2012) all confirmed that poultry feed production is profitable with the medium scale producers more profitable than the large and small scale feed producers.However, factors such as prices of ingredients, seasonal nature of supply, power generation and maintenance costs were responsible for low profit margins.

2.20 Poultry Feed Mill Basic Structures and Design.

The function of a feed mill is to produce livestock and other animal and fisheries feeds, concentrates and premixes. These are technically formulated products produced from energy and protein materials, which contain high and concentrated carbohydrates, proteins, minerals and other choice feed ingredients.

The feeds are formulated and blended with vitamin and mineral supplements or additives such as premixes, medicaments, calcium and phosphorous sources, to give the nutritional balanced and fortified finished feed for poultry, fish and other livestock. These feeds are usually in 3 major presentations or forms of Pellets, Crumbs and Mash according to Oyediji (2006).

There is the preponderance of mash feeds in the Nigerian market as pellet or crumbs are more expensive to produce because energy cost for steam that will be required is high. Pellets and crumbs however are scientifically better presentations, in that nutrients delivery to the animal is higher as the ingredients are bound (Oyediji, 2015). The types of feeds and concentrates to be produced are expected to give optimum production and high growth rate to the animals. The production of feeds and concentrates therefore, has to be cost-effective for more profit to the end-user or livestock farmer.

Feed mills vary greatly in design, size and output. However this may be, they all have one basic function, which is to reduce particle size and mix all ingredients efficiently so that every fraction of the feed contains all the ingredients required by the bird in question (Aduku,1993).

For a commercial, toll or even on farm feed mill, a feasibility study as with all business ventures should always precede construction. This study must identify the market size for the product group, market share analysis by competitors, sources and size of supplies which all will determine the Technology Option Analysis (TOA). The Technology Option Analysis will then choose the design, size and predicted economic and maintenance viability of the machine or plant, compared with such other available feed mill machines or plants.

	Q. A. LAB	Finished Goods	MILL	Bins/Silos	Offices
	Security	Weigh		Raw	

	Gate	bridge Gate		Materials Store	

Figure 4: Layout of a standard feed mill

(Adapted from Adediji, 2006)

Estimated returns on investment, payback period, discounted cash flow and other economic viability analysis must be done by a professional Accountant working with an Animal Scientist. The layout and design of a feed mill according to Clayton (2004), must guarantee profitability, efficiency, quality, low cost, expansibility, low maintenance cost, good size working, flexibility and safety.

2.21 Sections of Feed mill

A feed mill no matter how big or complex comprises of some basic units that ensure the flow of feed ingredients until the final feed is produced. The sections and their positions within the premises of the feed mill depends on the miller and the availability of space. The sections include:

2.21.1 **Materials receiving section**

This is where different raw material such as maize, soybean meal, groundnut cake, fishmeal, limestone, bone meal, etc are kept prior to issuance to the production section. All material must be kept on wooden pallets and typical stacking is one metric tonne per pallet, for ease of inventory auditing. Modern feed mills have silos and bins, which saves a lot of space with ease of transfer into bins for weight and grinding. Where weighbridges are not available, platform scales are used to record weights.

Materials should have identification board and there must be space between the wall and the stack to avoid moisture, which may condense grains on walls during humid climate. The space between stacks of pallets should also provide space to spread tarpaulin cover for fumigation. There should also be a loading or discharge bay with a shootout roof to allow discharge of materials or loading during bad weather.

2.21.2 **The grinding section**

This usually consists of either a Hammer mill or a Granulator. The hammer mill since its invention has replaced obsolete methods of grinding such as Rollers. The objective of grinding is to reduce the various ingredients to smaller particle sizes to arrive at a uniform feed in appearance. Particle size is an important aspect of feeding as it influences feed intake and to a good extent the digestively of some ingredients especially in young animals or birds. Grinding is therefore an important aspect of feed milling.

2.21.2.1 ***The hammer mill***

It is made of strong iron housing through which a shaft bearing smaller pieces of flat iron called beaters passed. This shaft at one end carries a pulley on which belts that drive it from an electric motor are fixed. As the shaft is driven by the electric motor, the beaters are rotated and beat the grains fed into the hammer into smaller particles.

Particle size desired is controlled by a sieve at the bottom of the shaft through which ingredients of the desired diameter drop by gravity out of the hammer mill (Oyediji, 2006). Hammer mill size together with mixer capacity determine the feed mill rating in metric tonnes per hour, which ranges from 250kg to 20 tonnes per hour.

2.22 The mixing section

Ingredients ground come in to the mixing section from the hammer mill, and is fed into the mixer where other non-grinding materials such as limestone and premixes or offals are also fed. The mixing section consists of a mixer and its accessories such as a fan or an auger that conveys ground ingredients from the hammer mill into the mixer.

2.22.1 **The Mixer**

The mixer is the heart of the feed mill where all ingredients meet and must mix uniformly with one another. Mixer efficiency is a major factor in feed quality just the same way as ingredient quality. Poor mixer can result in a poor quality feed, even if the best ingredients and the best formulations are used. Conventionally there are 3 types of mixer viz: the vertical mixer, the horizontal mixer and the conical pharmaceutical or premix mixer.

2.22.1.1 ***Vertical mixer (tube mixer)***

Vertical mixers (tube mixers) are the most common type of mixers in Nigeria because it is simple to build and install. It is the one most suited for on farm feed milling in Nigeria, where small scale to medium scale poultry farming are more numerous. It is also the type of mixer in use by Toll milling operators all over the country (Oyediji, 2006 and Oladejo, 2012).

Integrated commercial feed mills sometimes provide vertical mixers along with a small hammer mill as back up against major breakdown or for special rations, which are in small quantities. The vertical mixer is however, not as effective as the horizontal mixer in terms of thorough mixing and the length of time it takes to mix a batch (Oyediji, 2006). It consists of a large cylindrical bin with an Auger in the middle that is driven by an electric motor at the top. It has a tip-in side for adding ingredients that do not require milling and a discharge area at the base for emptying the feed after mixing.

2.22.1.2 ***Horizontal mixers***

These are the ones being used by integrated commercial feed mills due to size of their operation, efficiency of the mixing system and the accommodation of other facilities in the setup such as automatic bins, hoppers, elevators, pelleting facilities, automatic scales, injector for liquid ingredients and effective dust collector. The horizontal mixer is far smaller in size than the vertical mixer which makes its mixing much more efficient. The system uses a ribbon arrangement for mixing which is larger than the mixing auger of a vertical mixer.

2.22.1.3 *Conical pharmaceutical/premix mixers*

These mixers are smaller and consist of various designs that require a high level of mixing efficiency as high as a mixing ratio of 1:1,000,000 or more. They are used in drug or premix manufacturing and less for feed milling.

2.23 Discharge section

The discharge section receives the mixed feed or product. The feed mill design determine the size and scope of this section. In integrated commercial operations, this section has automatic discharge scales of 25kg and 50kg. Under mobile feed mills, platform scales are used. It is important to stich the bags immediately after weighting to allow for proper stacking in the finishing goods area.

2.24 Considerations in establishing a feed mill

To successfully establish a poultry feed mill, certain factors need be considered. These factors include:

2.24.1 **Site and environmental factors**

The quality and safety of the environment must be a paramount consideration in all feed milling operations. On farm, the mill must be located far away from the livestock while commercial operations can only be carried out in a place preferable an industrial estate. Important parameters are wind direction, soil characteristics, waste disposal, cost/benefit analysis, as labour rates differ from place to place and proximity or access to utilities such as water, electricity etc.

Storage areas for raw materials and finished products should be separated to prevent cross contamination. These facilities should be free of chemicals, fertilizers, pesticides and other potential contaminants. Feed products should be stored in such a way that they can be identified easily and that confusion with other products is prevented.

2.24.2 **Sizing the feed mill**

The size of the feed mill should be derived from the initial plan and feasibility. Feed mills in Nigeria are small because compounded feed is fed more or less only to poultry, unlike in advanced countries where cattle, sheep, goats, pigs, fish and pet are all fed with compounded feeds. Annual compounded feeds produced in Nigeria per annum between 1970 and 2000 were below 500,000 metric tonnes, whereas a smaller country as Turkey produced 6 million tonnes in 2000 alone (Oyediji, 2006). Feed consumption table for livestock are used to calculate actual feed requirements on farms multiplied by 1.5 to arrive at budgeted production per week. 0.5% manufacturing loss is usually budgeted on ingredients such as cereal grains.

2.24.3 **Power requirement and electrical design**

An electrical engineer must do the electrical design. In Nigeria, power from municipal source is erratic and not available in many places. Alternative power sources through generators have become the base for planning a feed mill in Nigeria. The bigger the operation, the bigger the power requirement.

The power plant must be such that it can power all equipment at the same time. Total power loaded ideally should not exceed 75% capacity of the power generator. Small feed mill on farms producing about 5 tonnes per day will require a 25 kva backup generator whereas industrial commercial feed mills of 10 tonnes per hour rating provide two 500 kva generators. Electrical designs must be made to optimize power usage while ensuring adequate illumination of every part of the feed mill. All cabling must conform to the engineer’s drawing and must be form reliable manufacturer to avoid fires.

2.24.4 **Manpower requirements in the feed mill**

Typical manning in a commercial feed mill consists of:

1. Feed mill manager
2. 1-2 supervisors (production)
3. Raw materials receiving/issuing officer
4. Product planning/inventory control officer
5. Quality assurance manager
6. Maintenance/engineering crew
7. Security men
8. Loaders and off loaders
9. Weighbridge operator
10. Canteen manager
11. System control manager (auditor)
12. Information technology officer
13. Casuals

For on farm mills, and depending on the size of operation, the manning differs. Whatever it is, there must be a feed mill manager who is the accounting officer for the overall feed mill activities. He should be supported by at least 1 mill supervisor, while casuals' level should depend on production level.

2.24.5 **Ingredients and finished goods warehouse**

Monogastric feeds such as poultry feed consists of approximately 40% energy materials, 25% protein materials, 20% filler materials, 10% minerals (calcium and phosphorus) and 5% micronutrients. Ruminant feeds on the other hand consists largely of fibrous materials, which the anatomy of ruminants can handle with ease. The type of operation and size of the market determine the volume of ingredients to stock for a given quarter in case of a commercial feed mill. For a farm operating a feed mill, it is the population of livestock that should guide the development of ingredient budget and consequently the size of the warehouse and stores for raw materials and finished goods.

2.24.6 **Marketing consideration**

The finished feed is stored temporarily in the warehouse before it is delivered to the depots, dealers, agents and consumers nationwide. The marketing section ensures the flow of the products without hitches. The miller has to deal with some constraints such as high cost of transportation, shortage of trading capital, and price fluctuations while dealing with their customers.

CHAPTER THREE

METHODOLOGY

3.1 Study Area

This study was conducted to cover the six geopolitical Zones of Nigeria. Nigeria has a land area of 351,649 sq miles (910,771 sq km) with a population of 177,155,754 (NPC, 2014). It lies within the geographic coordinates of 10.00N and 8.00E. It is the most populous country in Africa, situated on the gulf of Guinea in West Africa. Its neighbours are Benin, Niger, Cameroon, and Chad. The lower course of the Niger River flows south through the western part of the country into the gulf of Guinea. Swamps and mangrove forests border the southern coast; inland are hardwood forests. The north is mainly savannah grassland with Sahel savannah at the extreme north. The Nigerian economy relies heavily on oil exports with agriculture almost relegated to the background despite its importance in employment, revenue, food and raw materials generation. Arable land is 33% of the total land mass. Major agricultural produce include; cocoa, peanuts, palm oil, maize, rice, sorghum, wheat, millet, cassava, yams, rubber; cattle, sheep, goats, poultry (local and foreign chickens, turkey, quails, guinea fowl, etc.), pigs; timber; fish. The labour force stands at 50.13 million; with agriculture taking 70%, industry 10%, services 20% (NPC, 2014). The country has a comparative advantage in the area of agriculture, where varieties of crops and species of animals are produced and reared respectively due to the favourable weather conditions that prevail across the country, the poultry industry is currently witnessing a high level of expansion in size and number. This has made the provision of adequate feed to cater for the growing farms a necessity, as it constitutes about 65-75% of production needs in the poultry industry.

The Nigerian poultry industry is estimated at ₦80 billion and is comprised of approximately 165 million birds, which produced 650,000 MT of eggs and 290,000 MT of poultry meat in 2013 using approximately 3.5MMT of feed (USDA, 2013 and Oyediji, 2015). From a market size perspective, Nigeria's egg production is the largest in Africa ahead of South Africa at 540,000 MT of eggs and it has the 2nd largest chicken population after South Africa's 200 million birds (USDA, 2013). This growth started during the oil boom era which later declined during the austerity and the structural adjustment programme period of the early eighties to early nineties.

Chicken importation (with the exception of day-old-chicks) was banned by Nigeria in 2003, which spurred growth in domestic poultry production. Statistics Information from the Poultry Association of Nigeria (PAN, 2015) however, high-light that between 2009 and 2011 over 3 MMT worth of poultry products were imported into the Republic of Benin, with the preponderance of these products ending up in the Nigerian market. If this is reflected in overall assumptions, estimated poultry meat consumption in Nigeria is approximately 1.2 million MT.

One of the reasons is that smuggled chicken costs about ₦500- ₦700 per kg while locally produced frozen chicken costs between ₦1,000- ₦1,300 at retail locations, and approximately ₦850 at the farm gate (Oyediji, 2015; Sahel, 2015 and PAN, 2015). The price differential between imported and locally produced poultry is driven primarily by the high cost of feed production ingredients such as maize and soybeans in Nigeria, and wide fluctuations in these commodity prices. In 2013 in particular, high maize prices impacted on the margins of both poultry and animal feed companies, while the first quarter of 2015 has seen the poultry sector squeezed by a combination of high soybean prices (₦ 150,000/MT in May versus ₦110,000/MT during the same period in 2014) and incidences of Avian Flu (Sahel, 2015). Even with these challenges, analysts have projected a 20% annual growth in the poultry industry between 2010-2020 driven by Nigeria's large population and rapidly growing middle class.

The Nigerian poultry sector is extremely fragmented with most of the chicken raised in 'backyards' or on poultry farms with less than 1,000 birds. However, there are a number of large commercial players in the sector most of whom are located in south-western Nigeria, in close proximity to Lagos and its large market of 17.5 million people.

According to the Food and Agricultural Organization of the United Nations (FAO,2013), "growing populations, economies and incomes are fuelling an ongoing trend towards higher consumption of animal protein in developing countries." FAO forecasts that Nigerians are expected to consume two thirds more animal protein, with meat consumption rising nearly 73%. This growth in protein consumption will drive demand for maize and soybeans, which form the core component of animal feed (Oyediji, 2015). In order for Nigeria's poultry sector to become a market leader and to accommodate these changes, challenges such as inadequate finance, high cost of animal feeds and feed production ingredients, animal diseases, inadequate infrastructure, inadequate government policies especially on production incentives, transportation and other factors militating against animal production in Nigeria must be addressed (Bamaiyi, 2013). Other challenges according to Mbanasor and Jonas, (2006) and Munkaila *et al.*(2012) were irregular supply of electricity, theft of products, inadequate capital and unavailability of feed production ingredients in the right quantity and quality.

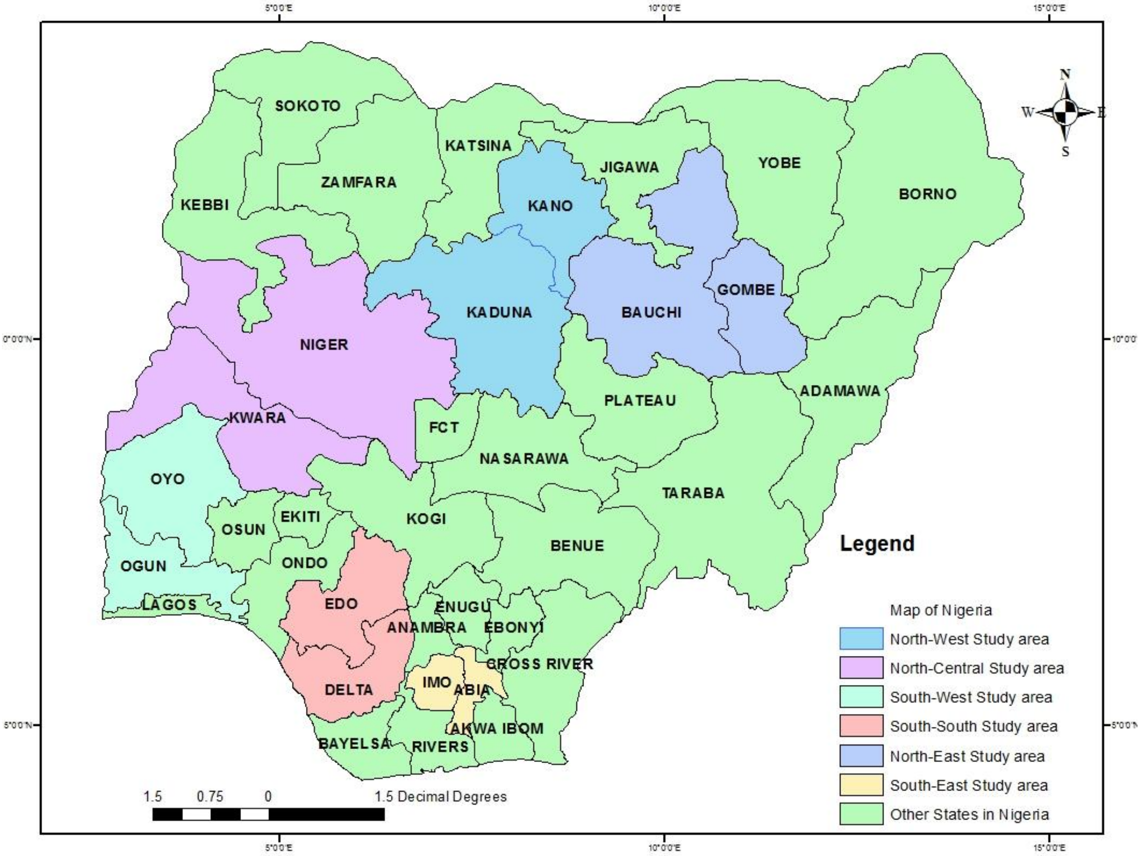

Figure: 5.4: Map of Nigeria indicating the study areas

3.2 Sample Size and SamplingTechnique

Nigeria consists of six geopolitical zones; North West, North East, South West, South East, South South and North Central. From each zone, two states were purposively selected based on their importance (number of mills in the state) in poultry feed production. From each of the two states selected, Local Government areas that have clusters of poultry feed mills were selected for the study. Poultry feed mills identified in those areas were chosen for the purpose of data collection. Due to the small size of the population of feed mills in some of the states, the whole population of the mills identified were chosen for this study. In those States where the number of feed mills exceededfifty (based on the reconnaissance survey conducted), stratified random sampling technique was used to select a sample of such mills based on size and nature of operation. Kaduna and Kano States were selected from the North West zone due to their importance in poulty feed production. Also Niger and Kwara Stateswere selected from the North Central zone, while Bauchi and Gombe were chosen from the North East Zone. From the South West Zone Oyo and Ogun States were selected, also Edo and Akwa Ibom States were selected from the South South Zone; while Abia and Enugu States wereselected from the South East. A total of 450 feed mills were identified from the reconnaissance survey of the states from the six geopolitical zones, out of which 279feed millswere selected based on the criteria outlined earlier. The breakdown of the population by state and the sample sizes that were selected is shown in Table 3.1.

Table: 3. 1: Poultry Feed Milling Industries in 12 states of Nigeria

Location	**States**	**Sampling frame**	**Sample commercial mills**	**Sample Toll mills**	**Sample farm own mills**	**Total sample size**
North	Kaduna	65	9	22	10	40
West	Kano	50	10	21	9	40
North	Kwara	35	5	8	7	20
Central	Niger	25	3	6	11	20
North East	Bauchi	2	0	1	1	2
	Gombe	1	0	1	0	1
South	Oyo	115	11	28	11	50
West	Ogun	87	9	27	14	50
South East	Abia	20	2	8	5	15
	Enugu	20	4	7	4	15
South	Edo	20	6	2	7	15
South	Akwa Ibom	11	2	3	5	10
Total		**450**				**279**

Source: Various State Feed Millers Association, PAN, ADPs and NAERLS zonal offices.

3.3 Data Collection Method

Primary data were collected for this study through the administration of structured questionnaire. The questionnairewas administered by the researcher with the assistance of trained technical staff of NAERLS at the headquarters and the six zonal offices spread across the six geopolitical zones of Nigeria. Information collected from the mills include: experience of owners/operators of the feed mills, educational level of operators, mill capacity, type of technology used, location of the mill, access to and availability of electricity, distance from sources of inputs, access to credit and membership of millers association. Production information collected include: quantity of inputs such as maize, soybean, groundnut cake, maize, rice and wheat bran, palm kernel cake and fish meal used in feed production, the outputs and their prices, various costs (fixed and variable) incurred in the production process, revenue generated and the problems of the feed mills.

3.4 Analytical Techniques:

The analytical techniques that were used for this research to achieve its objectives include:

i) Descriptive Statistics

ii) Net Income Analysis

iii) Stochastic frontier production function

3.4.1 **Descriptive statistics**

Descriptive statistics such as frequency counts, percentages, mode and mean were used for the determination of level of experience, input and outputs level and the constraints to feed production. It was used to achieve objectives 1, 2,3 and 6.

3.4.2 **Net income analysis**

This wasemployed to determine the net income accruing to the feed mills and the average rate of return per Naira invested in the milling industry. It is useful in determining profitability (Olukosi and Erhabor, 2005). It was used to achieve objective 4 of the study. It is given as follows:

$NI = \sum PiYi - \sum Pjxj + \sum Fk$…………………………………………………………..(8)

Where;

NI = Net Income (₦/tonne),

Yi = Output (Quantity of Feed produced, Tonnes),

Pi = price of output (Selling price of feed in ₦/Tonne),

Pj = price of inputs used in feed production (cost of Maize, Soybean, Groundnut cake, Palm kernel cake, maize bran, wheat bran, fish meal, bone meal, limestone, vitamin premix, salt, enzymes, methionine, lysine, labour, electricity consumed and diesel used in ₦/tonne),

Xj = Quantity of Variable Inputs used (Quantity of Maize, Soybean, Groundnut cake, Palm kernel cake, maize bran, wheat bran, fish meal, bone meal, limestone, vitamin premix, salt, enzymes, methionine, lysine, labour, electricity consumed and diesel inputs used inTonne),

Fk = Cost of Fixed Inputs such as Depreciation on machinery, Rent charge, Tax, (₦/Tonne),

∑ = summation sign.

3.4.3 **Empirical stochastic frontier model specification**

The Cobb–Douglas frontier production function was used in this study. Taylor and shonkwiler (1986) noted that as long as interest rests on efficiency measurement and not on the general structure of the production technology, the Cobb–Douglas production function provides an adequate representation of the production technology. This was used to achieve objectives3 and 5 of the study.

3.4.3.1 ***The stochastic frontier model***

$$\ln Y_i = ß_0 + ß_1 \ln x_1 + ß_2 \ln x_2 + ß_3 \ln x_3 + ß_4 \ln x_4 + ß_5 \ln x_5 + ß_6 \ln x_6 + ß_7 \ln x_7$$
$$+ ß_8 \ln x_8 + ß_9 \ln x_9 + ß_{10} \ln x_{10} + ß_{11} \ln x_{11} + ß_{12} \ln x_{12} + ß_{13} \ln x_{13} + ß_{14} \ln x_{14}$$
$$+ ß_{15} \ln x_{15} + ß_{16} \ln x_{16} + ß_{17} \ln x_{17} + (V_i - U_i) \ldots\ldots (9)$$

Where;

Y_i = output of feed from the i^{th} mill (Kg),

x_1= quantity of maize (Kg),

x_2 = groundnut cake (Kg),

x_3 = soybean cake (Kg),

x_4 = palm kernel cake (Kg)

x_5 = wheat bran (Kg),

x_6= Maize bran (Kg),

$\mathbf{x_7}$ = fish meal (Kg),

$\mathbf{x_8}$ = Bone meal (Kg),

$\mathbf{x_9}$= Limestone (Kg),

$\mathbf{x_{10}}$ = Vitamin premix (Kg),

$\mathbf{x_{11}}$ = Salt (Kg),

$\mathbf{x_{12}}$ =Enzymes (Kg),

$\mathbf{x_{13}}$ =Methionine (Kg),

$\mathbf{x_{14}}$ =Lysine (kg),

$\mathbf{x_{15}}$ =labour (man - days),

$\mathbf{x_{16}}$ = electricity consumed (kilowatts),

$\mathbf{x_{17}}$ = diesel fuel (Litres),

$\mathbf{x_{18}}$ = Mill Size (Kg)

$\mathbf{V_i}$ = A random error term ("white noise") assumed to be independent of $\mathbf{U_i}$, identical and normally distributed with zero mean and constant variance N (0, $\delta^2{}_v$),which accounts for the random variation in output by factors such as distance to source of ingredients, source of power, number of millers/competitors nearby that are beyond the control of the millers,

$\mathbf{U_i}$ = A random variable called technical inefficiency effects (disturbance term). This is associated with technical inefficiency of production of millers involved which are assumed to be independent of V_i. They are non-negative truncations at zero or half normal distributions with N (0, $\delta^2{}_u$),

In = the natural logarithm (to base e),

$ß_0$ –$ß_{17}$ = parameters that were estimated. Estimation of equation (2) was accomplished using the Maximum Likelihood Estimation (MLE) technique available in the computer program called frontier version 4.1 developed by Coelli (1996).

3.4.3.2 *Technical inefficiency model*

A part from determining the miller's technical efficiency in poultry feed production, this study also identified their determinants of technical inefficiency in terms of socio-economic characteristics. In this respect, an inefficiency model, which assumes that the inefficiency effects are independently distributed having **N** (O, δ^2_u) distribution and mean **U_i**was used, (Coelli and Battese, 1996). The model was used to achieve objective (5)and specified as follows.

$-Ui= \gamma_0+ \gamma_1w_1+ \gamma_2w_2+ \gamma_3w_3+ \gamma_4w_4+ \gamma_5w_5+ \gamma_6w_6+ \gamma_7w_7+ \gamma_8w_8+ \gamma_9w_9+ \gamma_{10}W_{10}$

$+ \gamma_{11}W_{11}+e_i$ ………………………………………………………………..…(3)

Where;

U_i = Technical inefficiency of the ith miller,

W_1 = Operating capacity of the millers,

W_2= Access to credit (amount of loan obtained in ₦),

W_3 = Year of feed milling experience,

W_4 = Average Distance to source of major ingredients,

W_5 = Source of power (1= National Grid, 0 = Generator),

W_6 = Number of millers/competitors nearby,

W_7 = Access to major market for output (distance from market outlets),

$\mathbf{W_8}$ =Years ofMembership of miller's association (year of cooperative participation), $\mathbf{W_9}$ = Number of employees/operators,

$\mathbf{W_{10}}$ = Number of Months ingredients areavailable duringthe season,

$\mathbf{W_{11}}$ **=** Number ofYears ofEducation of operators,

$\mathbf{e_i}$ = Error term, While

$\gamma_0, \gamma_1 \ldots \gamma_{11}$ are parameters to be estimated.

3.4.3.3 ***Specification of the stochastic frontier cost function***

The Cobb-Douglas cost frontier function was used for the millers in the study area it was used to measure the cost efficiency of the millers. It wasemployed to achieve part of objective 5 and is specified as follow:-

$$InC_i = \alpha + \alpha_i InP_{1i} + \alpha_2 In\ P_{2i} + \alpha_3\ In\ P_3\ In + \alpha_4\ In\ P_{4i} + \alpha_5\ In\ P_{5i} + \alpha_6\ In\ P_{6i} + \alpha_7 In\ P_{7i}$$

$$+ \alpha_8 In\ P_{8i} + \alpha_9\ In\ P_{9i} + \alpha_{10}\ In\ P_{10i} + \alpha_{11}\ In\ P_{11i} + \alpha_{12}\ In\ P_{12i} + \alpha_{13}\ In\ P_{13i}$$

$$+ \alpha_{14}\ In\ P_{14i} + \alpha_{15}\ In\ P_{15i} + \alpha_{16}\ In\ P_{16i} + \alpha_{17}\ In\ P_{17i} + \alpha_{18}\ In\ P_{18i} + \alpha_{19}\ In\ P_{19i}$$

$$+ V_i + U_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Where:

In = Natural logarithm,

$\mathbf{C_i}$ **=** Total cost by the ith feed miller (₦/Kg of feed) ,

$\mathbf{P_1}$ = Cost of milling premises (₦/Kg of feed) (actual cost or rental value),

$\mathbf{P_2}$ = cost of maize (₦/Kg of feed),

$\mathbf{P_3}$ = cost of hired labour (₦/Kg),

$\mathbf{P_4}$ = Cost of Soybean (₦/kg),

$\mathbf{P_5}$ = cost of Groundnut cake (₦/kg),

$\mathbf{P_6}$ = cost of fish meal (₦/Kg),

$\mathbf{P_7}$ = Expenses on milling equipment (₦/Kg depreciation value),

$\mathbf{P_8}$ = Expenses on diesel (₦/Kg feed),

$\mathbf{P_9}$ = cost of electricity (₦/Kilowatt),

$\mathbf{P_{10}}$ = Cost of Palm kernel cake (₦/Kg),

$\mathbf{P_{11}}$ = Cost of Maize bran(₦/Kg),

$\mathbf{P_{12}}$ = Cost of wheat bran (₦/Kg),

$\mathbf{P_{13}}$ = Cost of Limestone(₦/Kg),

$\mathbf{P_{14}}$ = Cost of Bone meal (₦/Kg),

$\mathbf{P_{15}}$ = Cost of Enzymes (₦/Kg),

$\mathbf{P_{16}}$ = Cost of Salt (₦/Kg),

$\mathbf{P_{17}}$ = Cost of Methionine(₦/Kg),

$\mathbf{P_{18}}$ = Cost of Lysine (₦/Kg),

$\mathbf{P_{19}}$ = Cost Vitamins premix (₦/Kg),

$\boldsymbol{\alpha_1, \alpha_2, \ldots\ldots\ldots, \alpha_{19}}$ = coefficients of the parameters to be estimated, and

$\mathbf{V_i}$ and $\mathbf{U_i}$ are as defined earlier.

3.5 Hypothesis testing

The Z-test was used to test the hypothesis on Profitability of feed production, while the generalized likelihood ratio test was usedto test the hypothesis for the presence of inefficiency effects.

3.6 Definition and Measurement of Variables

i. **Educational status:** acquisition of knowledge through schooling. (Years of schooling). It is expected to be negatively related with technical inefficiency. This means the more the number of years spent in a formal school, the less the technical inefficiency (Obeta and Nwagbo, 1991).

ii. **Mill size:** refer to the size of the mill in terms of what it can handle at a time,**(**Kg/production cycle).Mill size is expected to be negatively related with technical inefficiency. The larger the mills the more efficient they are expected tobe (Mbanasor and Jonas, 2005).

iii. **Milling experience:** measured in terms of duration/period a miller has been producing poultry feed (years). Efficiency is expected to increase with years of milling experience as found in the study of indigenous feed mills by Mbanasor and Jonas (2005). It is expected to be negatively related with technical inefficiency.

iv. **Amount of credit:** measured as amount of credit received in Naira. It is expected to be negatively related with technical inefficiency. This means that the more the amount of credit received the more the business is able to purchase and storage of the raw materials needed in the manufacture of feed which reduces the hours wasted especially dusring off season. This reduces the millers' technical inefficiency (Njoku, 1991, Mbanasor and Jonas, 2006).

v. **Membership of millers association:** This is measured as the number of years a miller spent in an association.Membership of associations is expected to be negatively related with technical inefficiency. The more the years of membership of association, the lower the technical inefficiency. The reason being cooperative membership enhances access to information on prices of material inputs, their availability and use of improved technology (Njoku, 1991).

vi. **Distance to ingredient sources:** This is measured as the distance covered by millers to acquire feed production ingredients in Kilometers. Distance to ingredients sources is expected to be positively related with technical inefficiency. This means the longer the distance covered to acquire feed ingredients, the lesser the efficiency of the millers (Oladoja and Olusanya, 2009).

vii. **Source of Power:** This measure the source of power used by the millers to run the feed mills. The sources are Generator or diesel and Electricity from the National grid. It was measured using a proxy of 1= electricity and 0 = Generator/diesel. It is expected that millers using electricity to be more technical and allocative efficient than those using generator or diesel to power their mills.

viii. **Number of competitors nearby:** This is measured as the number of millers close or nearby a miller. It is expected to be positively related with technical inefficiency. The higher the number of competitors for ingredients and market for output, the lesser the efficiency.

ix. **Distance to major output market:** This is measuredas the distance of the mill from its major output market measured in Kilometre. It is expected to be positively related with technical inefficiency that is the farther an output market is the less efficient a mill becomes.

x. **Number of employees:** Thisrefers to the number of people employed in the production of feed. Expected to be negatively related with inefficiency. That is the more employees hired the more the output is produced efficiently produced all things being equal.

xi. **Months ingredients available:**This is measured as the number of months in a calendar year that ingredients are available in the market in reasonable quantity. Expected to be negatively related with technical and allocative inefficiency. That is the more the number monthsthe more the quantity of inputs that can be acquired at cheaper rate consequently, the more output is produced efficiently produced all things being equal.

xii. **Quantity of maize used:** Amount ofmaize used in the production of feed (/Kg/batch)

xiii. **Quantity of Palm kernel cake (PKC) used:** PKC used in the production of feed (Kg/batch)

xiv. **Hired labour:** (man-days). Eight hour of work equals one man-day. Measured in terms of the number of workers and number of hours spent/batch

xv. **Soybean quantity:** quantity of soybean used in feed production (Kg/batch)

xvi. **Quantity of Limestone used:** Amount of used Limestone used in feed production(Kg/batch)

xvii. **Quantity of Bone Meal (BM) used:** Amount of Bone Meal used in feed production(Kg/batch)

xviii. **Quantity of Salt used:** Amount of Salt used in feed production(Kg/batch)

xix. **Quantity of Enzymes used:** Amount Enzymes of used in feed production(Kg/batch)

xx. **Quantity of Methionine used:** Amount of Methionine used in feed production (Kg/batch)

xxi. **Quantity of Lysine used:** Amount of Lysine used in feed production(Kg/batch)

xxii. **Quantity of Vitamin premix used:** Amount of Vitamin premix used in feed production (Kg/batch)

xxiii. **Groundnut cake used in production:** Amount of Groundnut Cake used in feed production(Kg/batch)

xxiv. **Quantity of Feed Produced:** The total quantity of feed of all types a miller produced(Kg/batch)

xxv. **Cost of production:** It is the total cost of production (Variable and Fixed costs).This includes costs of input such as Maize, soybean, groundnut cake, Maize Bran, wheat bran, fish meal, fixed ingredients (Salt, Vitamin-mineral premix, Lysine, Methionine, Lysine, Limestone, Bone or Oyster shell meal, enzyme), depreciation on mixer and mill, building(depreciation or rental value), electricity, fuel, tax and utility bills used in the poultry feed production (measured in Naira at market price)

xxvi. **Revenue/Income:** The sum total of revenues of the millers from the sales of feed (measured in₦/kg).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Characteristics of Poultry Feed Industries in Nigeria

The poultry feed industry is characterized by the presence of different type of mills operating all over the country depending on size and nature of business, coverage,milling technology and product type. This section shows the result of these characteristics of feed mills which were aimed at achieving the first objective of the study.

4.1.1 **Distribution of mills based on source of ingredients,product coverage, mill type,nature of product and milling technology**

4.1.1.1 ***Distribution based on market coverage***

From the results of the characteristics of poultry feed mills in Nigeria in Table 4.1 it shows that the mill can be classified into three based on market coverage or theareas covered by their products. Theyare characterized into National, regional and local feed mills with7 (2.51%), 30 (10.75%) and 242 (86.74%) of mills respectively.This indicates that not all the mills studied have capacity to reach all the poultry producing areas of Nigeria due to some constraints. It is an opportunity for new investors in the feed milling industry to take advantage especially where there is low coverage. This finding on the classification of mills is in line with the findings of Fagbenro and Adebayo (2005) in their review of the poultry and aqua feed industries. It also agrees with the work ofApantaku, Oluwalana, and Adepegba, (2006) in the study of Poultry Farmers' Preference and use ofCommercial and Selfcompounded Feeds in Oyo Area of Oyo State, Nigeriawhere they classified feed mills into commercial, toll and on farms with National, Regional and local coverage.

Table: 4. 1: Distribution of mills based on coverage, Mill business type, nature of product and millng technology

Parameters	Frequency	Percent
Market coverage		
Local	242	86.74
Regional	30	10.75
National	7	2.51
Total	279	100
Mill business type		
Commercial feed millers	84	30
Toll millers	134	48
Farm own mills	61	22
Total	279	100
Nature of product		
Mash	260	93
Pellets	19	7
Total	279	100
Technology		
Semi-automated	265	97
Automated	9	3
Total	279	**100**

4.1.1.2 ***Distribution based on sources of ingredients***

The study also revealed that (Appendix 2) feed mills source their ingredients from various parts of the country for locally available ingredients, while those not available locally are imported. Cereals and legumes used in feed production are obtained mainly from markets in the North, while Palm kernel cake issourced from the south. Soybean cake or mill and groundnut cake are products of oil mills mainly from Kano, Kaduna, Niger and Benue States. Rice, maize and wheat brans are obtained from wet milling process of cereals and flour mills found across the nation. Bone meals from various slaughter houses or abattoirs across the country while limestone is obtained from cement factories and quarries found across Nigeria. Fish meal is from both local (Maiduguri, Hadeija and Yauri)and imported sources.Lysine, methionine, enzymes and vitamin premix are imported or blended by companies dealing with feed additives (Appendix 2).The implication of this finding is that all the major ingredients required for feed production are available locally. This supports the findings of Fagbenro and Adebayo(2005), in their review of poultry and aquafeed sources in Nigeria.This finding is also similar to that of Oladejo (2012), on the economic analysis of feed mill industry in Lagos State. It also supports the findings of Sonaiya (2002), on Feed resources for smallholder poultry in Nigeria; where they found cereals and legumes or oilseed and by products of the oil mills found all over Nigeria formed the backbone for the local supply of major feed ingredients. This implies that for one to succeed in the feed mill business there is the need for a proper understanding of the areas or sources and markets where the raw materials can be obtained both locally and internationally (Appendix 2).

4.1.1.3 ***Distribution based on type of operations***

The feed mills were also classified based on type of operations (Table 4.1),into commercial feed mills 84 (30%), Toll feed mills 134 (48%) and farms own mills 61 (22%). The commercial feed mills mainly produce feed and concentrates with wide market coverage, the toll mills on the other hand produce feed for markets within their locality or nearby poultry farmers and render services such as feed milling for a fee (toll milling services) and sell feed production ingredients to poultry farmers while the on the farm mills were established by large scale poultry farm owners as a cost saving technique. This implies that the feed milling industry caters for different category of participants as found by Bello (2008), in his study on the Nigerian poultry feed crisis.

4.1.1.4 ***Distribution based on product form***

The result in Table 4.1 also revealed that the mills produce feed mainly in mash form 260 (93%), while the remaining mills 19 (7%) produce pelletized feed and a mixture of pellets and mash. Pelletized feeds need an additional processing but market faster than the mashand equally recommended by poultry nutritionist against selective feeding by the birds (Oladejo, 2012). The implication of this finding is that mills who add pelleting technology can capture additional market and hence make a better return.This finding supported the findings of Bello (2008), who worked the type poultry feed mills in his study of the feed crisis in Nigeria.

4.1.1.5 ***Distribution based on technology of production***

The technology used by the mills (Table 4.1) ranged from semi-automated to automated technology. The semi-automated uses more of manual labour together with machines as found in all the toll and on the farm feed mills. The labour was employed in weighing the ingredients, feeding the ingredient batches in to the mill, moving the ground ingredients into the mixer, bagging and moving the finishedfeed to the warehouse or loading in trucks for transportation to depots or markets. The automated production is associated with the large commercial feed mills that have most of those operations done through the use of machines guided by their operators. The result of the study showed that majority of the millers 265 (97%) hadsemi-automated operations while the remaining 9 (3%) had automated operations. This finding is similar to that of Mijinyawa *et al.* (2012), in a study assessing noise levels generated in feed mills in Ibadan where they found most of the mills were small scale and withmanual or semi-automated operations. The implication of this finding is that technology plays an important role in determining output and hence level of profit. Studies such as that of Oladejo (2012) and Munkaila *et al.* (2012), have found a direct relationship between equipment used in feed milling with total revenue.

A standard bag of poultry feed weigh 25Kg in all the conventional mills studied except in toll mills and on farm mills where customers specify up to 50Kg bag. Feed is usually produced on average of 6days of a week in all the mills studied, a result that corroborates the findings of Mijinyawa *et al.* (2012) who found that mills in Ibadan area spend 5-6 days operating their mills with little or no attention given to maintenance of machinery. This they found has affected the health of the mill attendants through noise and other environmental pollution. This has seriously affected their performance and consequently the level of efficiency of the mills. The implication of this inadequate maintenance of equipment and machinery could be reduction in the level of technical efficiency of the mills as could be seen in the next sections of the thesis.

4.1.2 **Characteristics of mills based on years of experience, ownership status and mill capacity,**

This section explains the characteristics of the feed mills in the study area. It explainsthose characteristics that could affect the level of technical, allocative and economic efficiency of the mills. Attributes such as years of milling experience, year of participation in cooperatives, mill size, batches of feed per day, output per batch, number of hours spent by mills per batch of feed, number of hours spent per day, number of shifts per day, number of work days per week, installed capacity and achieved capacity of the mills.

4.1.2.1 ***Years of milling experience***

The result on the characteristics of mills based on milling experience and years of operation is presented in Table 4.2. The result shows that most of the feed mills have considerable number of years of experience as owners and or operators of the business. The number of years of operation for the commercial mills ranges between 3 and 24 years with a mean of 8years. The toll mills on the other hand have years of milling experience ranging from 2 to 12 years with a mean of 6 years, while the farm own mills have experience ranging from 1 to 12 years with a mean of 4 years. The commercial mills have the highest number of years of experience which could be as a result of being the pioneer establishments before the advent of toll and on farm mills which were both child of necessity (Oyediji, 2006 and Eruvbetine, 2009). The implication ofthis is that the mills with reasonable years of experience are expected to be more efficient that those with low number of years. Also the commercial mills with the highest number of years are expected be more efficient than the toll and on farm mills. Many studies such as that of Etuah (2014) and Umar (2012) on the determinants of cost efficiency among broiler farmers in Ghana and the technical efficiency of poultry farms in Bauchi state respectively found a positive relationship between poultry rearing experience and efficiency.

4.1.2.2 ***Mill size/capacity***

The result on mill size is also presented in table 4.2. The result shows that the mill capacity of the commercial mills ranges from 8 to 50 tonnes/ day with a mean of 36 tonnes/day. The toll mills have capacity ranging from 4 to 15 tonnes/day with an average capacity of 8.5 tonnes/day, while the farm own mills have capacity ranging from 1to 5 tonnes with an average of 2.5 tonnes/day. This indicates that the commercial mills are larger than the toll mills who in turn are bigger than the farm own mills. The implication is that the larger mills could be more efficient than the smaller ones a result confirmed by Etuah (2014) and Umar (2012).

4.1.2.3 ***Membership of association***

The result on year of membership of association is presented inTable 4.2.shows that the commercial mills have more years in association ranging from 2 to 20 years with an average of 6 years of membership. The toll mills on the other hand have years of membership ranging from 2 to 16 years with an average of 5 years, while the on farm mills were the least in terms of participation with a range of 1 to 4 years and an average of 2 years.The implication is that mills with higher number of years in association with others mills are expected to be moreefficient than those with low or no association with other mills (Munkaila*et al.,* 2012).

4.1.2.4 *Number of days of operation in a week*

The result on the number of days feed mills operate per week is shown in table 4.2.The commercial feed mills operate on days ranging from 5 to 6 days with a mean of 6 days of operation. For the toll mills also, their operations range between 5 to 6 days with an average of 5 days in a week. The on farm mills number of days of operation in a week ranges from 1 to 4 days with an average of 3 days per week.The implication of this is that feed mills with more days of operation per week could be more efficient than those who operate on a few days a week.

4.1.2.5 *Number of batches per day*

The result on the number of batches of feed milled per day is shown in table 4.2. For the commercial mills, the number of batches of feed produced per day ranges from 1 to 10 batches with an average of 6 batches milled per day. For the toll mills, the number of batches ranges from 1 to 7 with an average of 4 batches per day. The on farm mills produce 1 to 3 batches with an average of 2 batches per day.This is an indication that the commercial mills produced more per period of time than both toll and farm own mills. The assumption is that poultry feed mills with more batches per day are more efficient when compared with those with few batches.

4.1.2.6 ***Output per batch***

The result on output produced per batch is as shown in table 4.2. For the commercial feed mills, the output per batch of feed produced ranges between 5 to 10 tonnes with an average of 5 tonnes per batch. The toll mills produce between 1 to 5 tonnes per batch with an average of 2 tonnes per batch, while the farm own mills produce in batches ranging between 1 to 3 tonnes with an average of 1.5 tonnes per batch. This is implies that the commercial mills produced more per batch than both toll and farm own mills, and hence could be assumed to be more efficient than those with small quantities per batch.

4.1.2.7 ***Number of hours per day***

The result in Table 4.2 also shows the number of hours feed mills in the study area spend per day. The commercial mills spend hours ranging from 5 to 16 with an average of 9 hours daily, while the toll mills spend about 5 to 10 hours averaging 7 hours per day. The farm own mills spend the shortest time per day ranging from 3 to 6 hours with an average of about 3.5 hours. This implies that the commercial mills are more conscious of their time and the size of operation directly relates with efficient utilization of time.

4.1.2.8 ***Number of hours per shift***

The result on number of shifts operated by the mills per day is also presented in Table 4.2. The commercial mills spend about 5 to 12 hours per shift with an average of 7.5 hours per shift. The toll mills on the other hand spend 5 to 8 hours averaging 5.5 hours, while the on farm mills spend 3 to 5 hours with an average of 3.5 hours per shift. The result implies that the commercial feed mills spend the highest number of hours per shift, which consequently relates positively with efficiency.

4.1.2.9 ***Number of hours per batch***

The result in Table 4.2 indicates the number of hours feed mills spend in the production of a batch. The commercial mills spend 1 to 5 hours with an average of 1.7 hours per batch, while it takes the toll mills 1 to 3 hours per batch with an average of 1.5 hours per batch. The farm own mills spend about 0.5 to 1 with an average of 1 hour per batch.The implication is that, feed mills who spend lesser number of hours per batch could be more efficient compared with those with longer hours per batch. time saving devices such as automatic weighing scales and feed ingredient conveyors could help reduce the time spent per batch of feed (Oyediji, 2006).

Thesecharacteristics of feed mills (commercial, toll and on farm) were found to be similar with those in the findings of Oladejo(2012), Mbanasor and Jonas (2005)and Munkaila *et al*. (2012) who studied efficiency of poultry feed production enterprises in Lagos, Abia and Ogun and Oyo States respectively. The implication of this finding is that the mills can improve on their output and consequently their efficiency if they can adjust some of these attributes as suggested in the discussions. The milling industry in Nigeria is yet to realize its full potential of supplying all the feed requirements of the country as a resulting in a wide gap between supply and demand for quality poultry feed. Therefore,there is room for improvement from the existing feed mills and for potential investors in the sector, sky is the limit (Eruvbetine, 2009 and Adediji, 2015).

TABLE: 4. 2: CHARACTERISTICS OF FEED MILLS BASED ON YEARS OF OPERATION, MILL SIZE AND HOURS OF OPERATIONS

Variables	Miller types commercial				toll				On farm			
	Min	**Max**	**Mean**	**S. dev**	**Min**	**Max**	**Mean**	**S. dev**	**Min**	**Max**	**Mean**	**S. dev**
Years infeed mill business	3.00	24.00	8.34	0.48	1.00	18.00	6.34	0.57	2.00	12.00	4.23	0.32
Year of cooperative	2.00	20.00	6.35	3.59	3.00	17.00	5.25	2.43	1.00	4.00	2.35	1.593
Mill size	8.00	50.00	35.96	18.36	4.00	15.00	8.54	10.83	1.00	5.00	2.54	1.8
Batches mill/day	1.00	10.00	6.03	1.65	1.00	7.00	5.03	1.65	1.00	3.00	2.03	1.25
output/batch	5.00	10.00	5.42	3.37	1.00	5.00	2.41	2.17	1.00	3.00	1.50	1.37
Hours/batch	1.00	5.00	1.74	0.71	1.00	2.00	1.54	0.23	0.50	1.50	1.00	0.11
Hours in a day	5.00	16.00	9.12	3.93	5.00	10.00	7.12	2.07	3.00	6.00	3.50	1.93
Shift length	5.00	12.00	7.45	1.83	5.00	8.00	5.50	0.82	3.00	5.00	3.45	1.82
Output/day	8.00	50.00	20.52	15.72	8.00	30.00	16.40	7.71	5.00	12.00	8.52	5.55
Days mill/week	5.00	7.00	5.87	0.89	5.00	6.00	5.00	0.68	1.00	4.00	2.56	0.47
Installed capacity	8.00	50.00	35.96	18.36	4.00	15.00	8.54	10.83	1.00	5.00	2.54	1.8
Achieved capacity (%)	50.0	100.0	77.78	13.09	40.00	80.00	65.34	9.36	20.00	50.00	35.78	6.09

4.1.4 **Distribution of millers based on product type or line**

The result in Table 4.3 shows the different type of products generated by the poultry feed mills. It shows that all the feed mills (pooled data)studied 279 (100%) produce feed for broilers (starter and finisher), pullets, layers and cockerels (chick, grower and layer). About (50) 17.92% also add turkey and fish feeds to the range of feeds they produce, while about 15 (5.38%) of the feed mills produce feed concentrate and 44 (15.77%) produce breeder feedin addition to the range of feeds listed above. This result is similar with the findings of Oladejo(2012), in the economic analysis of feed mill industry in Lagos State Nigeria where he found that the poultry feed mills produce various feeds for all classes of livestock.

The commercial toll and on farm feed mills all produce layer, grower, chick, broiler starter and finisher. In addition to the feeds listed, they also produce breeder, concentrate and turkey with fish feed, the toll and own farms however don't produce concentrates.The implication of this is that feeds are produced based on market demand; potential entrants in to the market should note those feeds that move faster in the market all season. These are the layer followed by the broiler feeds. The concentrate production is an area in which not all mills explore for now, this can be targeted for better profit.

Table: 4. 3: Product Line of Feed Mills in Nigeria.

Product Type	Commercial millers	Toll millers	Farm Made	Frequency total	Percent
Broiler Starter	61	134	84	279	100
Broiler Finisher	61	134	84	279	100
Chick	61	134	84	279	100
Grower	61	134	84	279	100
Layer	61	134	84	279	100
Breeder	17	25	12	44	15.77
Concentrate	15	0	0	15	5.38
Fish and Turkey feed	12	10	28	50	17.92

4.2 Level of Input Use by Feed Mills

The level of input and type used by a feed mill depends on the size of its operations and the birds or target customers. The result on the type of ingredients used for feed manufacture reveals that, the commonest ingredients are the ones that supply the basic and production requirements of the birds.

4.2.1 **Classification of ingredients for poultry feed production**

The ingredients for feed production are classified in to micro and macro ingredients based on the quantity included in the feed or the quantity required by the bird in question. The feed ingredients are better classified according to the respondents based on the function they perform to the animal in question or the type of nutrients supplied. Thus, there are energy, protein, vitamins and minerals sources (Aduku, 1993). The average quantity of the ingredients used in a tonne of feed depending on the animal type as shown in Table4.4 is 620Kg (62%)Energy, 328.5Kg (32.85%)Protein, and 51.5Kg (5.15%) for fixed ingredients (vitamin and mineral sources).

The sources of these ingredients are basically from plant sources (cereals, legumes, pulses and oil seeds), animals sources (fish, shrimps, slaughter house by products, bones), mineral and vitamin sources (Limestone, oyster shell, bones and salt). The ingredients are available from local sources and Imports as shown in the Tables in appendix 2. This finding is similar to those of Oladokun and Johnson (2012), in their study of feed formulation problem in Nigerian Poultry farms. The implication of this finding is that, poultry feed mills have to contend with the provision of enough storage facilities due to the bulky nature of the ingredients that are needed for sustained feed production throughout the year bearing in mind the seasonal fluctuation in supply and prices of the ingredients.

Table: 4. 4: Average quantity ingredients used and inclusion rate for a tonne of poultry feed

Feed Ingredients	Average Inclusion Rate Kg/tonne	Percent
Energy sources		
Maize	550	55
Maize Bran	25	2.5
Wheat bran	45	4.5
Protein sources		
Soybean (meal or cake)	200	20
Groundnut cake	100	10
Palm kernel Cake	20	2
Fish Meal	8.5	0.85
Vitamin/Mineral Sources		
Vitamin premix	2.5	0.25
Salt	3	0.3
Bone meal	22.5	2.25
Limestone	18	1.8
Enzymes	2	0.2
Methionine	1.5	0.15
Lysine	2.0	0.2

4.2.2 Classification of ingredients based on their sources

The result in Tables4.5and 4.6indicates the sources, average prices and distance to sources of the feed ingredients. The sources of cereals legumes and some animal proteins is the northern part of the country, where maize, soybean, groundnut, fish meal, sorghum, millet, maize bran and rice bran are obtained; while ingredients such as palm kernel cake, oyster shells, fishmeal, wheat (imported), wheat bran, vitamin and mineral premixes(imported) are from mainly the south. The distances covered for such ingredients ranges from a few kilometres to thousand kilometres depending on the location of the mill, prices and availability. This has led to high transport charges that range from N1.00 to about N5.00 per kg of an ingredient depending on location.

Table: 4. 5: Available feed resources for poultry in Nigeria

	Geographical zones						
Feed resource	**NWZ**	**NCZ**	**NEZ**	**SWZ**	**SEZ**	**SSZ**	**Imported**
Maize	***	***	***	**	*	*	
Wheat	**	**	**	**	*	*	***
Palm Kernel Cake		*		***	***	*	
Fish offal	***	**	***	**	**	*	**
Brewer's grain	*	**	*	***	***	***	
Maize bran	***	***	***	**	*	*	
Groundnut cake	***	***	***	**	**	*	
Soybean cake	***	***	***	*	*		
Bone Meal	***	***	***	**	*	*	
Limestone	**	***	**	***	**	**	
Oyster shell				**	**	***	
Periwinkle shell				**	***	***	
Vitamins	*	*	*	**			***
Rice by-products	**	**	**	**	**	**	
Wheat offal	*	*	*	**	**	**	

***Abundant in Large Qty, **Relatively Abundant *Abundant in Small Qty.

Table: 4. 6: Average distance to market (km), prices/kg (N) and transport costs/kg (N) for commonly used feed ingredients in Nigeria

Variables (N=279)	Mean	Std. Deviation	Coefficient of Var
Maize	169.64	199.53	117.62
Maize price	47.83	8.65	18.08
Maize transport cost	1.74	1.03	59.20
Groundnut cake	344.33	342.47	99.46
Groundnut price	95.01	18.97	19.97
Groundnut transport cost	1.72	0.79	45.93
Soybean meal distance	306.09	283.87	92.74
Soybean meal price	179.09	80.19	44.78
Soybean meal transport	1.44	0.61	42.36
Palm kernel cake distance	274.79	342.39	124.60
Palm kernel cake price	10.89	3.94	36.18
Palm kernel cake transport	1.37	0.64	46.72
Wheat bran distance	170.82	200.93	117.63
Wheat bran price	39.77	8.39	21.11
Wheat bran transport	3.86	2.93	76.07
Maize bran distance	102.96	122.78	119.25
Maize bran price	30.71	5.79	18.86
Maize bran transport	1.38	0.49	35.86
Fish meal distance	169.02	315.37	186.59
Fish meal price	164.59	172.25	104.66
Fish meal transport cost	1.90	0.77	40.58
Limestone distance market	119.31	170.00	142.49
Limestone price	17.40	173.98	999.90
Limestone transport cost	1.89	0.69	36.24
Vitamin premix distance	64.82	122.74	189.36
Vitamin premix price/kg	259.39	197.75	76.23
Vitamin premix transport	1.32	0.46	34.52
Enzymes distance market	72.47	117.47	162.09
Enzymes price	883.96	332.58	37.62
Enzymes transport cost	2.36	0.78	32.97
Methionine distance market	80.53	135.33	168.05
Methionine price	998.90	527.26	52.78
Methionine transport	1.67	0.50	30.00
Lysine distance market	77.58	127.04	163.76
Lysine price	559.14	129.34	23.13
Lysine transport cost	1.75	0.37	20.93

4.3 Level of Poultry Feed Production

This section deals with the level of production or output of the feed mills in the study area. The major output is the finished feed. This feed consists of Broiler starter and finisher for the meat type chickens, chick, grower and layer feed for the egg type chickens and cockerels, turkey feed and concentrate which can be diluted by other mills and or farmers to produce any of the poultry feeds listed above. The result for the pooled data (all mills), commercial, toll and on farm mills is in Table 4.7 as thus:

4.3.1 **Level of feed production for all the mills (pooled data)**

The result in Table 4.7 shows the pooled data for feed producedby all the mills. The mills produced on the average 21,155Mt of feed weekly which is broken down in to chick mash 2,107Mt (9.96%), Broiler starter 3174Mt (15.00%), broiler finisher, 4246Mt (20.07%), grower 4205 Mt (19.88%)and layer 7422Mt (35.08%). This implies that layers feed is produced the most with broiler finisher and grower closely following, while the last produced feed is the chick mash. This gives the mills an average revenue of ₦2,031,578,538 from the sale of these feeds at an average of ₦ 96,033.02 per tonne. The average cost of producing a tonne for the pooled data for all the mills was found to be ₦ 81,942.27 and are thus, making on the average a profit of ₦ 14,090.75 from the sale of a tonne of feed, with a return of ₦ 16.97 per Naira invested, this shows that feed milling business is profitable (Table4.18). This is confirmed by the z-test result which was significant at 1% (Table4.19). This finding is similar to those of Oladejo, (2012), Munkaila *et al* (2012) and Mbanasor and Jonas (2005), who all found poultry feed production as a profitable venture in their study of efficiency of poultry feed production enterprises in Lagos, Oyo and Ogun and Abia States respectively. Although the large scale mills were found to make the highest profit, the medium scale make the highest return on investment.

The implication is that there are a lot of opportunities in the milling industry which prospective investors can go in to bearing in mind that the venture is profitable.

4.3.2 **Level of feed production for commercial mills**

The result in Table 4.7 shows the level of feed production for commercial mills. The commercial feed mills control about 11,138 Mt (53%) of the total feed produced by all the mills in the study areas. This comprises of about 1,746MT (16%) broiler starter, 1911 (17%) broiler finisher, 990Mt (9%) chick feed, 2187 Mt (20%) grower and 4305Mt (39%) layer feed.

4.3.3 **Level of feed production for toll mills**

The result in Table 4.7 also reveals that the toll mills have control over 6948Mt (33%) of the total feed produced by all the mills in the study locations. This comprises of 1143Mt (16%) broiler starter, 1698Mt (24%)broiler finisher, 906Mt (13%) chick feed, 1346Mt (19%), grower and 1856 (27%) layer feed.

4.3.4 **Level of feed production for on farm mills**

The on farm mills have control over about 14% of the total feed produced by all the mills studied. This consists of 286Mt (9%) broiler starter, 637Mt (21%) broiler finisher, 211Mt (7%) chick, 673Mt (22%) grower and 1262Mt (41%) layer feeds. This implies that all the mills produce different feed types, but layer feed is the highest produced feed across all feed mills while the chick feed is the least produced.

Table: 4. 7: Weekly average quantity, price and revenue from feed production

Variables	Pooled data		Commercial		Millers Type Toll		On Farm	
Feed types	Qty	%	Qty	%	Qty	%	Qty	%
Broiler starter	3174	15.00	1746	16	1143	16	286	9
Broiler finisher	4246	20.07	1911	17	1698	24	637	21
Chick	2107	9.96	990	9	906	13	211	7
Grower	4205	19.88	2187	20	1346	19	673	22
Layer	7422	35.08	4305	39	1856	27	1262	41
Total	**21155**	**100.00**	11138	53	6948	33	3068	14
Av. Price ₦/tonne		96,033.02						
Av. `Revenue ₦		2,031,578,538						

4.4 Efficiency of the Poultry Feed Industries

This section gives an estimate of Technical, Allocative and Economic Efficiencies among poultry feed millers in the study area. This analysis was used to achieve objectives 5 of the study. The previous section indicated that the millers were classified in to commercial, toll and on farm feed mills. The results in this section is therefore discussed based on the three categoriesAjibefun (2008), highlights parametric methods to include production, costs, profit and revenue functions as alternative methods of describing production and estimating efficiency of production.

4.4.1 Input/output relationship in poultry feed production (Production function)

Regression Results of the Maximum likelihood estimates of parameters of the Cobb-Douglas stochastic frontier production function and the estimated standard errors and their statistical significance levels for the commercial, toll and on farm mills were presented in Table 4.8.

4.4.1.1 *Maximum likelihood estimates for commercial mills*

The estimates of the specified Cobb-Douglass stochastic production function (Table 4.8) concurrently with the specified technical inefficiency effects yields the result of the value of gamma (ɣ) = 0.87 for commercial feed mills is statistically significant at the 1% level, which implies that 87% of the residual variation in feed output was due to the inefficiency effect. This was further confirmed by a test of hypothesis for the presence of inefficiency effects using the generalized likelihood ratio test. The chi-square computed was 77.75, while the critical value of the chi-square at 99% confidence level and 28 degree of freedom, (0.99, 28) = 13.57. The null hypothesis of no inefficiency effects in commercial poultry feed production Ho = 0, was strongly rejected. Thus, the Cobb-Douglas functional form is an adequate representation of the data. It also confirms the presence of the one-sided error component in the model; rendering the use of Ordinary Least Square (OLS) estimation techniques inadequate in representing the data. The sigma (σ^2) on the other hand was 0.147 and significant at 1%, indicating the correctness of the specified assumption of the distribution of the composite error term.

The result (Table 4.8) also showed that the estimated coefficients for parameters such as mill size, maize, groundnut cake, soybean cake, palm kernel cake, maize bran, fish meal, vitamin premix, salt, lysine and electricity used by the commercial mill category were positive indicating that an increase in the quantity of any of the inputs will increase output level. On the other hand, the coefficients of parameters such as wheat bran, bone meal, limestone, methionine, labour and diesel were negative indicating that their increase will have a negative effect on output. Groundnut cake, soybean cake, maize bran and salt were all positive and significant at 1%, lysine is significant at 5% while maize and palm kernel cake were significant at 10%. The result implies that a 1% increase in the quantity of Groundnut cake, soybean cake, maize bran, salt, lysine, Maize and Palm kernel cake by the commercial feed millswill lead to approximately

0.226%, 0.309%, 0.980%, 0.637%, 0.021%, 0.435% and 0.220% increases in total output respectively. On the other hand, Wheat bran, limestone, enzymes, methionine, and diesel were all negative and significant at 1%, while bone meal and labour were significant at 10%. The result against expectations implies that a 1% increase in the quantity of Wheat bran, limestone, enzymes, methionine, diesel, bone meal and labour will reduce output by 0.328%, 0.312%, 0.338%, 0.025%, 0.419%, 0.056% and 0.710% respectively. This finding hasconfirmedthe work of Mbanasor and Jonas (2006), who found mills in Abia state having both positive and negative estimates of their coefficients. In the study, they found the coefficient of raw materials and depreciation on fixed assets to be positively related to output while labour and enterprise or mill size were negatively related to output of the mills. The implication of the findings of this study is that the commercial feed mills are underutilizing some resources while over utilizing others. In other words, inputs such as mill size, maize, groundnut cake, soybean cake, palm kernel cake, maize bran, fish meal, vitamin premix, salt, lysine and electricity are underutilized while inputs such as wheat bran, bone meal, limestone, methionine, labour and diesel are over utilized by the commercial feed mills. This indicates that it is possible to increase output of commercial feed mills by increasing the underutilized inputs and decrease the use of the overutilized inputs in feed production.

4.4.1.2 ***Maximum likelihood estimates for toll mills***

Also, the estimates of the specified Cobb-Douglass stochastic production function together with the specified technical inefficiency effects for the toll mills (Table 4.8) yield the result of the value of gamma (ɣ) = 0.71 is statistically significant at the 1% level, which implies that 71% of the variation in feed output from the toll mills was due to the inefficiency effect. This was further confirmed by a test of hypothesis for the presence of inefficiency effects using the generalized likelihood ratio test. The chi-square computed was 140.42, while the critical value of the chi-square at 99% confidence level and 28 degree of freedom, (0.99, 28) = 13.57. The null hypothesis of no inefficiency effects in toll mills poultry feed production Ho = 0, was strongly rejected. Thus, the Cobb-Douglas functional form is an adequate representation of the data. It also confirms the presence of the one-sided error component in the model; rendering the use of Ordinary Least Square (OLS) estimation techniques inadequate in representing the data. The sigma (σ^2) on the other hand was 0.256 and significant at 1%, indicating the correctness of the specified assumption of the distribution of the composite error term.

For the toll mills the result of the estimates of coefficients (Table 4.8) follow the same pattern but with differences in the variables that were significant or not significant and those that have positive or negative coefficients. From the result in Table 4.8, it shows that mill size, groundnut cake, soybean cake, maize bran and bone meal all have positive coefficients and significant at 1%, maize and vitamin premix were significant at 5% while palm kernel cake, fish meal and enzymes were significant at 10%. Limestone and electricity were positive but not significant. It implies that a 1% increase in mill size, groundnut cake, soybean cake, maize bran, bone meal, maize, vitamin premix, palm kernel cake, fish meal and enzymes will increase feed output of the toll millers by 0.44%, 0.104%, 0.109%, 0.961%, 0.156%, 0.096%, 0.120%, 0.176%, 0.904%, 0.841% and 0.098% respectively. On the other hand, salt and lysine were both negative and significant at 1% while methionine was significant at 10%, implying that a 1% increase in their quantity will reduce output by 0.521%, 0.873% and 0.868% respectively. This shows that some resources are being underutilized while others are over utilized by the toll mills. Mill size, groundnut cake, soybean cake, maize bran, bone meal, maize, vitamin premix, palm kernel cake, fish meal and enzymes are underutilized while inputs such as salt, lysine and methionine are over utilized. The result of this study is similar to the study of Mbanasor and Jonas (2006),who found mills in Abia state having both positive and negative estimates of their coefficients. In the study, they found the coefficient of raw materials and depreciation on fixed assets to be positively related to output while labour and enterprise or mill size were negatively related to output of the mills. Therefore, the toll millers can improve on their level of efficiency by increasing the utilization of Mill size, groundnut cake, soybean cake, maize bran, bone meal, maize, vitamin premix, palm kernel cake, fish meal and enzymes, while decreasing the quantity of salt, lysine and methionine.

4.4.1.3 ***Maximum likelihood estimates for on farm mills***

The estimates of the specified Cobb-Douglass stochastic production function with the specified technical inefficiency effects gives the result (Table 4.8). The value of gamma (ɣ) = 0.89 for on farm feed mills is statistically significant at the 1% level, implying that 89% of the variation in feed output of the toll mills was due to the inefficiency effect. This was confirmed further by a test of hypothesis for the presence of inefficiency effects using the generalized likelihood ratio test. The chi-square computed was 19.61, while the critical value of the chi-square at 99% confidence level and 28 degree of freedom, (0.99, 28) = 13.57. The null hypothesis of no inefficiency effects in on farm poultry feed production Ho = 0, was strongly rejected. Thus, the Cobb-Douglas functional form is an adequate representation of the data. It also confirms the presence of the one-sided error component in the model; rendering the use of Ordinary Least Square (OLS) estimation techniques inadequate in representing the data. The sigma (σ^2)

on the other hand was 0.174 and significant at 1%, indicating the correctness of the specified assumption of the distribution of the composite error term.

The result in Table 4.8 further shows the estimates of parameters for on farm feed mills. From the result, it shows that mill size, maize, groundnut cake, vitamin premix, methionine, electricity and diesel were positive and significant at 1%, fish meal and lysine were significant at 5% while labour was significant at 10%. Maize bran, salt and enzymes are all negative and significant at 1%. This indicates that ingredients such as mill size, maize, groundnut cake, vitamin premix, methionine, electricity, diesel, fish meal, lysine and labour were underutilized and an increase of 1% in these inputs will increase output by 0.310%, 0.426%, 1.156%, 0.481%, 1.104%, 1.176%, 1.301%, 0.253%, 0.259%, and 0.417% respectively. Inputs such as maize bran, salt and enzymes are all negative and significant at 1%; meaning a 1% increase will reduce the on farm mills output by 0.841%, 1.678% and0.654% respectively. For the on farm mills to increase efficiency, inputs such as mill size, maize, groundnut cake, vitamin premix, methionine, electricity, diesel, fish meal, lysine and labour should be increased, while decreasing the quantity of maize bran, salt and enzymes.

The result from the three mill types (Table 4.8) showed that all the mills were over utilizing some inputs and underutilizing others at the same time. Hence there is the presence of inefficiency in their operations which can be reduced by increasing the quantity of the inputs that were underutilized and decreasing those being over utilized. (Mbanasor and Jonas, 2006) and (Oladejo, 2012).

Table: 4. 8: Maximum Likelihood Estimation results of stochastic frontier production function

	Millers Type					
	Commercial		Toll		On Farm	
Parameters	Coeff. & Std error	t-ratio	Coeff. & Std error	t-ratio	Coeff. & Std error	t-ratio
Constant	-0.016(0.096)	-0.169	-0.453 (0.081)	-5.64***	0.239 (0.118)	2.019**
Mill size (X_{1})	0.021(0.045)	0.445	0.44 (0.102)	4.309***	0.310(0.066)	4.714***
Maize (X_2)	0.435(0.241)	1.8057*	0.096 (0.041)	2.372**	0.426 (0.085)	4.993***
Groundnut cake (X_{3})	0.226(0.066)	3.391***	0.104 (0.030)	3.590***	1.156 (0.324)	3.568***
Soybean cake (X_4)	0.309(0.038)	8.092***	0.109 (0.074)	12.86***	0.048 (0.268)	0.179
Palm kernel Cake (X_5)	0.220(0.119)	1.845*	0.904 (0.525)	1.722*	0.194 (0.217)	0.895
Wheat Bran (X_6)	-0.328(0.091)	-3.658***	0.120 (0.053)	2.251**	-0.345 (0.858)	-0.403
Maize Bran (X_7)	0.980(0.298)	3.287***	0.961 (0.0074)	12.93***	-0.841 (0.210)	-3.995***
Fish meal (X_8)	0.799(1.016)	0.786	0.841 (0.464)	1.813*	0.253 (0.1003)	2.517**
Bone Meal (X_9)	-0.312(0.177)	-1.7606*	0.156 (0.024)	6.449***	-1.853 (1.454)	-1.274
Limestone (X_{10})	-0.338(0.091)	-3.348***	0.118 (0.095)	1.241	-1.002 (1.901)	-0.527
Vitamin Premix (X_{11})	0.025(0.107)	0.233	0.176 (0.066)	2.680**	0.481 (0.122)	3.922***
salt (X_{12})	0.637 (0.110)	5.81***	-0.521 (0.087)	-5.99***	-1.678 (0.104)	-16.08***
Enzymes (X_{13})	-0.025 (0.010)	-2.456	0.098 (0.057)	1.705*	-0.654 (0.124)	-5.259***
Methionine (X_{14})	-0.419 (0.102)	-4.187***	-0.868 (0.525)	-1.654*	1.104 (0.099)	11.044***
Lysine (X_{15})	0.021 (0.011)	2.066**	-0.873 (0.096)	-9.09***	0.259 (0.101)	2.576**
Labour mandays (X_{16})	-0.056 (0.035)	-1.649*	-0.255 (0.648)	-0.392	0.417 (0.227)	1.837*
Electricity kilowts(X_{17})	-0.241 (0.224)	-1.075	0.031 (0.106)	0.294	1.176 (0.384)	3.059***
Diesel Litres(X_{18})	-0.710 (0.104)	-6.859***	-0.090 (0.165)	-0.547	1.301 (0.169)	7.708***
Variance Parameters						
Sigma Squared	0.147(0.021)	6.973***	0.256(0.048)	5.362***	0.147 (0.003)	52.099***
Gamma	0.866 (0.003)	258.04***	0.709(0.009)	72.66***	0.894 (0.025)	35.436***
LogLikelihood Function	46.457		152.229		58.0549	
LR test of the one-sided error	77.748		140.421		19.6013	

$\sigma = \sigma_v^2 + \sigma_u^2$, $\gamma = \sigma_u^2/\sigma^2$ ***P<0.001, **P<0.05, *P<0.10 values in parentheses are standard errors

4.4.2 **Elasticity of production and returns to scale for the mills.**

Elasticity of production is a useful tool that enhances the producer to be prudent and rational when allocating and utilizing inputs in production. The return to scale (RTS) analysis which stands for a measure of total resource productivity is presented in Table 4.9. The return to scale (RTS) for the commercial, toll and on farm mills we presented as thus:

4.4.2.1 ***Elasticity of production and returns to scale for commercial mills***

The RTS parameter of 1.234(Table 4.9) wasobtained from the summation of the coefficients of the estimated inputs involved in poultry feed production process (Mill size, maize, groundnut, soybean cake, palm kernel cake, wheat bran, maize bran, fish meal, bone meal, limestone, vitamin premix, salt, enzymes, methionine, lysine, labour, electricity and diesel) for commercial mills. The RTS value of 1.234 for the commercial feed mills indicated a positive increasing return to scale at stage I of production. Stage one is the period of most growth in a company's production. In this period, each additional variable input will produce more products. This signifies an increasing marginal return; the investment on the variable input outweighs the cost of producing an additional product at an increasing rate. At this stage increase in those factors that have positive coefficients by a unit, will lead to a more than proportionate increase in output. It is therefore rational to add more of the inputs in order to enjoy the economies of scale and reduce the quantity of those inputs with negative coefficients.

4.4.2.2 ***Elasticity of production and returns to scale for toll mills***

On the other hand, the RTS value of 0.9622 (Table 4.9) for toll mills indicated that poultry feed production for this mill type in the study area was in the stage II of the production surface which by implication is within the rational zone for producers to operate. Stage II is the stage of decreasing positive return-to-scale, where resources and production were believed to be efficient. That is, increasing input use will result in output increasing at a decreasing rate until the optimum level is attained. Hence, it is advisable that the toll feed mills should maintain the level of input utilization at this stage as this will ensure maximum output from a given level of input all things being equal. They can expand on the mill size so that they can enjoy the economics of scale (Ojo, 2003).

4.4.2.3 *Elasticity of production and returns to scale for on farm mills*

On the other hand, the RTS value of0.7501(Table 4.9) for the on farm mills indicated that poultry feed production for this mill type was also in the stage II of the production surface which by implication is within the rational zone for the mills to operate. Stage II is the stage of decreasing positive return-to-scale, where resources and production were believed to be efficient. That is, increasing input use will result in output increasing at a decreasing rate until the optimum level is attained. The mills can however, expand on the mill size so that they can enjoy the economics of scale (Ojo, 2003). The implication of this finding is that the level of profit of the mills will be affected by the over utilization of some of the inputs used and underutilization of inputs that supposed to be increased in quantity.

Table: 4. 9: Elasticity of production and return to scale in poultry feed production

Variables		**Millers Type**	
	Commercial Coefficients	**Toll Millers Coefficients**	**On Farm Coefficients**
Mill size (X_1)	0.0200	0.4398	0.310
Maize (X_2)	0.4350	0.0969	0.426
Groundnut cake (X_3)	0.2255	0.1038	1.156
Soybean cake (X_4)	0.3085	0.1090	0.048
Palm kernel Cake (X_5)	0.2197	0.9043	0.194
Wheat Bran (X_6)	-0.3281	0.1195	-0.345
Maize Bran (X_7)	0.9795	0.0960	-0.840
Fish meal (X_8)	0.7990	0.8405	0.253
Bone Meal (X_9)	-0.3124	0.1560	-1.853
Limestone (X_{10})	-0.3384	0.1180	-1.002
Vitamin Premix (X_{11})	0.0249	0.1759	0.480
salt (X_{11})	0.6369	-0.5204	-1.678
Enzymes (X_{12})	-0.0246	0.0977	-0.654
Methionine (X_{13})	-0.4194	-0.8684	1.104
Lysine (X_{14})	0.0209	-0.8725	0.259
Labour (X_{15})	-0.0563	-0.2546	0.417
Electricity (X_{16})	-0.2413	0.3108	1.175
Diesel (X_{17})	-0.7100	-0.0900	1.301
Total	**1.2394**	**0.9622**	**0.7501**

4.4.3 Technical efficiency indices for the mills

The result in Table 4.10 showed the distribution of technical efficiency indices according to mill type. These mills were thus, classified as commercial, toll and on farm poultry feed mills:

4.4.3.1 *Technical efficiency indices for commercial mills*

The technical efficiency (T.E.) indices for commercial mills range from 0.56 to 0.99 (56% to 99%) with a mean efficiency of 0.88 (88%) (Table 4.10). This means that if the average commercial feed mill was to achieve the T.E. level of its most efficient counterpart, then it could realize an 11% cost savings (i.e. 1-0.88/0.99x100).Similar calculation for the most technical inefficient commercial mill reveals cost savings of 43% (i.e. 1- 0.56/0.99x100).

4.4.3.2 ***Technical efficiency indices for toll mills***

The average T.E. of the toll mills was 0.82 (82%), with a minimum of 0.61 (61%) and maximum of 0.99 (99%) (Table 4.10). Also, for the average performing toll mill to operate at 100%, it needs 17% cost saving (i.e. 1-0.0.82/0.99x100). Similarly, for the least efficient toll mill to attain the most efficient level, it needs 38% savings (i.e. 1-.61/0.99x100).

4.4.3.3 ***Technical efficiency indices for on farm mills***

The average T.E. of the sampled on farm mills was found to be 0.79(79%), with minimum T.E. of 0.52 (52%) and a maximum of 0.95 (95%) (Table 4.10). These figures indicate that if the average on farm mills in the sample were to reach the T.E. level of their most efficient counterparts, then it could experience a cost savings of 17% (i.e. 1-0.79/0.95x100). The same computation for the most technically inefficient of on farm mill suggests a gain in T.E. of 45% (i.e. 1-0.52/0.95x100).

It is evident from the above discussion that the commercial mills had the majority (67%) of its mills in efficiency intervals of 0.81-0.99; followed by the toll mills with most (82%) of its producers in efficiency intervals of 0.71-0.90. The on farm mills also had the greater (80%) percentage of its mills in efficiency interval of 0.61-0.90. This trend may be as a result of the fact that large commercial mills may have more capital available at their disposal which may enable them to acquire more feed ingredients through a vast network of suppliers and latest milling technologies that made them to effectively utilize their productive resource efficiently.

However, the mean technical efficiency of the commercial mills (88%) is the highest followed by the toll (82%) and the on farm mills (79%). These values showed that majority of the mills are technically inefficient, this confirmed the findings of Mbanasor and Jonas (2005). It also confirm the results of a similar study by Munkaila*et al. (*2013) estimating the technical efficiency of poultry feed production in Ogun and Oyo States reported an average technical efficiency level of 0.88 with a range of between 0.70 and 0.99.

Table: 4. 10: Frequency distribution of technical efficiency estimates

	Millers Type							
Variables	**All mills**		**Commercial**		**Toll Millers**		**On Farm**	
Technical Efficiency Range	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
0.51 - 0.60	2	0.72	1	1.64	1	0.75	3	3.57
0.61 - 0.70	47	16.85	4	6.56	23	17.16	19	22.62
0.71 - 0.80	73	26.16	9	14.75	40	29.85	23	27.38
0.81 - 0.90	80	28.67	18	29.51	42	31.34	26	30.95
0.91 - 0.99	77	27.60	29	47.54	28	20.90	13	15.47
Total	**279**	**100**	**61**	**100**	**134**	**100**	**84**	**100**
Average	0.82		0.88		0.82		0.79	
Maximum	0.99		0.99		0.99		0.95	
Minimum	0.52		0.56		0.61		0.52	

4.4.4 Test of hypothesis on technical efficiency model (Ho_1 and Ho_3)

The estimates of the specified Cobb-Douglass stochastic production function concurrently with the specified technical inefficiency effects yields the result presented

Tables4.8and4.11. The estimate values for the commercial, toll and on farm mills were presented as follows:

4.4.4.1 *Test of hypothesis on technical efficiency model for commercial feed mills (Ho_1 and Ho_3)*

The result presented in Tables 4.8 and 4.11 shows the value of gamma (γ) = 0.87 for commercial feed mills was statistically significant at the 1% level, which implies that 87% of the residual variation in feed output of the commercial mills was due to the inefficiency effect. This was confirmed by a test of hypothesis for the presence of inefficiency effects using the generalized likelihood ratio test. The chi-square computed was 77.75, while the critical value of the chi-square at 99% confidence level and 28 degree of freedom, (0.99, 28) = 13.57. The null hypothesis of no inefficiency effects in commercial poultry feed production $Ho_1 = 0$, was strongly rejected. Thus, the Cobb-Douglas functional form is an adequate representation of the data.

4.4.4.2 *Test of hypothesis on technical efficiency model for toll feed mills (Ho_1 and Ho_3)*

Also, the result in Tables 4.8 and 4.11 shows the estimates of the specified Cobb-Douglass stochastic production function together with the specified technical inefficiency effects for the toll mills. The value of gamma (γ) = 0.71 was statistically significant at the 1% level, which implies that 71% of the variation in feed output from the toll mills was due to the inefficiency effect. This was further confirmed by a test of hypothesis for the presence of inefficiency effects using the generalized likelihood ratio test. The chi-square computed was 140.42, while the critical value of the chi-square at 99% confidence level and 28 degree of freedom, (0.99, 28) = 13.57. The null hypothesis of no inefficiency effects in toll mills poultry feed production $Ho_1 = 0$, was strongly rejected.

Table: 4. 11: LR-test of hypothesis for stochastic frontier production function and frontier inefficiency function

		Millers Type					
		Commercial		**Toll Millers**		**On Farm**	
Parameters	**Null hypothesis**	**L/R**	**Chi-square**	**L/R**	**Chi-square**	**L/R**	**Chi-square**
Technical Efficiency function	Ho_1: β =0	77.75	13.57	140.42	13.57	19.60	13.57
Technical Inefficiency function	Ho_3: $\gamma = \sigma u^2 = 0$	77.75	13.57	140.42	13.57	19.60	13.57
Allocative Efficiency function	Ho_1:p= $u^2 = 0$	22.	16.05	49.76	16.05	31.91	16.05
Allocative Inefficiency function	Ho_3:p= $u^2 = 0$	22.68	16.05	49.76	16.05	31.91	16.05
Decision		Reject null hypothesis		Reject null hypothesis		Reject null hypothesis	
Decision		Reject null hypothesis		Reject null hypothesis		Reject null hypothesis	

4.4.4.3 *Test of hypothesis on technical efficiency model for on farm feed mills (Ho_1 and Ho_3)*

Finally, the estimates of the specified Cobb-Douglass stochastic production function with the specified technical inefficiency effects result (Table 4.11 and 4.8). The value of gamma (γ) = 0.89 for on farm feed mills is statistically significant at the 1% level, implying that 89% of the variation in feed output of the toll mills was due to the inefficiency effect. This was confirmed further by a test of hypothesis for the presence of inefficiency effects using the generalized likelihood ratio test. The chi-square computed was 19.61, while the critical value of the chi-square at 99% confidence level and 28 degree of freedom, (0.99, 28) = 13.57. The null hypothesis of no inefficiency effects in on farm poultry feed production $H_O = 0$, was strongly rejected.

Therefore, since the estimates of the parameters of the technical efficiency model were statistically significant for all the three category of mills (Commercial, Toll and on farm) the null hypothesis $Ho_{1:}\beta_1 = \beta_2 = \beta_3 \ldots \beta_{17} = 0$ wasdecisively rejected. This finding has confirmed other studies such as that of Mbanasor and Jonas (2006), Oladejo (2012) and Munkaila *et al*. (2012), where the mills in their studies were found to be technically inefficient. The implication of this finding is that all the category of mills (commercial, toll and on farm) in the study area are technically inefficient in the allocation of their resources. The inefficiency was as a result of the interaction of some attributes of the mills which are within the control of the millers. The mills can attain full efficiency by eliminating those attributes that lead to inefficiency.

4.4.5 **Determinants of technical inefficiency**

Having confirmed that the feed millers were technically inefficient, the study went further to investigate the causes of the technical inefficiency.The result of technical inefficiency model for the three category of mills (commercial, toll and on farm) was presented in Table 4.12.

4.4.5.1 ***Determinants of technical inefficiency for commercial mills***

The result of the determinants of technical inefficiency for the commercial feed mills (Table 4.12) shows that operating capacity of the mills, number of competitors, educational level of operators and number of months ingredients are available were all positive and significant at 1%. This means a unit increase in these variables will increase the efficiency of the commercial feed millers by 0.02%, 0.45%, 0.20% and

0.17%. On the other hand, distance to major output markets and number of employees were negative and significant at 1%, meaning that a unit increase in these variables will lead to a decrease in efficiency by 0.15% and 0.23% respectively. Other variables such as access to credit, years of milling experience, distance to ingredient sources and source of power were not significant at all levels.

4.4.5.2 ***Determinants of technical inefficiency for toll mills***

On the other hand, the result of the determinants of technical inefficiency for the toll mills(Table 4.12) shows that the inefficiency variables that were positive and significant at 1% include source of power, number of competitors and educational level of the operator.A unit increase in these inputs will increase efficiency by 0.10%, 0.23% and 0.13% respectively. Other variables such as distance to ingredient sources, distance to output market and number of months ingredients are available were all having negative coefficients and significant at 1%. This implies that a unit increase in these ingredients will reduce the toll mills' efficiencyby 0.20%, 0.06% and 0.07% respectively. Other inefficiency variables such as operating capacity, access to credit, years of milling experience and number of employees were statistically not significant at all levels.

4.4.5.3 ***Determinants of technical inefficiency for on farm mills***

Similarly, the result on the determinants of technical inefficiency for the on farm mills (Table 4.12), shows that access to credit, years of milling experience and number of employees were all having positive coefficients and statistically significant at 1%. Implying that a unit increase in these variables will increase efficiency of toll millers by 0.16%, 0.47% and 0.27% respectively. On the other hand, operating capacity, distance to ingredient sources, source of power, educational level of operator and number of months ingredients are available were significant with negative coefficients which implies a 1% increase in any of the variables will reduce efficiency of the on farm mills by 0.75%, 0.37%, 0.09%, 0.24% and 0.13% respectively. Other inefficiency parameters such as number of competitors and distance to major output markets were not statistically significant at all levels.

Table: 4. 12: Socioeconomic factors influencing technical efficiency

	Millers Type					
	Commercial		**Toll Millers**		**On Farm**	
Variables	**Coeff &Std Error**	**t-ratio**	**Coeff & Std Error**	**t-ratio**	**Coeff & Std Error**	**t-ratio**
Constant γ_0	-3.2915 (0.753)	-4.370***	-1.530 (0.459)	-3.335***	0.2338 (0.189)	1.231
Operating Capacity γ_1	0.0224 (0.008)	2.814***	0.0011 (0.004)	0.243	-0.7482 (0.177)	-4.235***
Access to credit γ_2	0.0004 (0.0096)	0.039	0.0001 (0.0009)	0.118	0.1573 (0.0167)	9.396***
Years of milling operation γ_3	-0.0269 (0.0206)	-1.311	0.0096 (0.0076)	1.263	0.4695 (0.0475)	9.886***
Distance to ingredient sourcesγ_4	0.0001 (0.0007)	0.187	-0.2042 (0.023)	-9.068***	-0.366 (0.0182)	-20.124***
Source of Electricity γ_5	-0.0797 (0.082)	-0.978	0.1022 (0.018)	5.754***	-0.094 (0.022)	-4.363
Number Competitors γ_6	0.4478 (0.156)	2.871***	0.2322 (0.036)	6.521***	-0.035 (0.033)	-1.056
Distance to Output Market γ_7	-0.1502 (0.037)	-4.119***	-0.0551 (0.0063)	-8.786***	-0.1133 (0.088)	-1.292
Number of Employees γ_9	-0.2238 (0.024)	-9.455***	0.0020 (0.0079)	0.258	0.266 (0.047)	5.729***
Educational level of operator γ_{10}	0.2003 (0.028)	7.289***	0.1228 (0.0394)	3.119***	-0.2401 (0.104)	-2.310***
Months ingredients available γ_{11}	0.1659 (0.041)	4.073***	-0.0718 (0.0245)	-2.929***	-0.133 (0.014)	-9.864***
sigma-squared	0.1474 (0.021)	6.973***	0.2558 (0.048)	5.362***	0.147 (0.0028)	52.099***
Gamma	0.8658 (0.0034)	258.04***	0.7094 (0.0098)	72.656***	0.894 (0.0252)	35.437***
Log likelihood function =	46.4573		152.230		58.055	
LR test of the one-sided error =	77.7481		140.421		19.601	

*Note: ***, **, * values Sig. at 1%, 5% and 10%

The implication of the above findings is that the mills can increase their level of efficiency by increasing those variables with positive coefficients and at the same time reducing those with negative coefficients. These findings were similar to those of Mbanasor and Jonas(2006),who found experience of operator and level of technology to be positively related with efficiency, while credit status and membership of cooperative society were negatively related with technical efficiency.

4.4.6 **Allocative efficiency estimatesof feed mills**

Regression Results of the maximumlikelihood estimates of parameters of the Cobb-Douglas stochastic frontier cost function together with the estimated standard errors and their statistical significance levels for all the mills (commercial, toll and on farm) are presented in Table 4.13.

4.4.6.1 ***Allocative efficiency estimates for commercial feed mills***

The estimates of the specified Cobb-Douglass stochastic cost function with the specified cost inefficiency effects shows the value of gamma (ɣ) = 0.64 for the commercial feed mills is statistically significant at the 5% level, implying that 64% of the variation in cost of feed production of the commercial mills was due to the inefficiency effect. This was confirmed further by a test of hypothesis for the presence of inefficiency effects using the generalized likelihood ratio test. The chi-square computed was 29.68, while the critical value of the chi-square at 95% confidence level and 30 degree of freedom, (0.95, 30) = 16.05. The null hypothesis of no cost inefficiency effects in the commercial poultry feed production $H_{O1} = 0$, was strongly rejected.

The result for commercial feed millsshows that most of the coefficients of variables of the stochastic cost frontier model have the expected signs (positive coefficients) indicating that an increase in price of any of them as well as an increase in output level will eventually increase total production cost. The result in Table 4.13 impliesthat 1% increase in the cost of rent, maize, labour, groundnut cake, soybean cake, maize bran, fishmeal, bone meal, vitamin premix, salt, enzymes, methionine, lysine, diesel, electricity, tax, and utilities as well as increase in output level will lead to approximately 0.37%, 0.06%, 0.07%, 0.07%, 0.04%, 0.27%, 0.05%, 0.24%, 0.14%, 0.10%, 0.16%, 0.13%, 0.04%, 0.02%, 0.06%, and 0.03% increase in total production cost respectively.

4.4.6.2 ***Allocative efficiency estimates for toll feed mills***

The result of allocative efficiency estimates for the toll mills (Table 4.13), shows the estimates of the specified Cobb-Douglass stochastic cost function with the specified cost inefficiency effects shows the value of gamma (ɣ) = 0.67which is statistically significant at1% level, implying that 67% of the variation in cost of feed production of the toll mills was due to the inefficiency effect. This was confirmed further by a test of hypothesis for the presence of inefficiency effects using the generalized likelihood ratio test. The chi-square computed was 49.76, while the critical value of the chi-square at 95% confidence level and 30 degree of freedom, (0.95, 30) = 16.05. The null hypothesis of no cost inefficiency effects in the toll mill poultry feed production H_{O1} = 0, was rejected.

The result further showed that most of the coefficients of variables of the stochastic cost frontier model have the expected signs (positive coefficients) indicating that an increase in price of any of them will eventually increase total production cost of the commercial feed mills. The result in Table 4.13 impliesthat 1% increase in the cost of rent, maize, labour, groundnut cake, soybean cake, palm kernel cake, maize bran, vitamin premix, enzymes, diesel, electricity, tax, and utilities will increase output by 0.52% as well as lead to approximately 0.027%, 0.19%, 0.24%, 0.17%, 0.19%, 0.15%, 0.035%, 0.04%, 0.24%, 0.039%, 0.10%, 0.18% and 0.25% increase in total production cost of the commercial feed mills respectively. The variables that have negative coefficients and significant include cost of wheat bran, fish meal, bone meal, limestone and lysine. The implication of this finding is that those variables with positive coefficients could lead to increase in costs of production hence, the toll millers have to rationally utilize them. Other variables that show negative coefficients contrary to expectations could be looked at as alternative cost saving ingredients in feed production.

4.4.6.3 *Allocative efficiency estimates for on farm feed mills*

Lastly, the result for the on farm mills (Table 4.13), shows the estimates of the stochastic cost function with the specified cost inefficiency effects shows the value of gamma (ɣ) = 0.76which is statistically significant at1% level, implying that 76% of the variation in cost efficiency and cost of feed production of the on farm mills was due to the inefficiency effect. This was confirmed further by a test of hypothesis for the presence of inefficiency effects using the generalized likelihood ratio test. The chi-square computed was 37.91, while the critical value of the chi-square at 99% confidence level and 30 degree of freedom, (0.95, 30) = 14.95. The null hypothesis of no cost inefficiency effects in the on farm poultry feed production $H_{O1} = 0$, was rejected.

The result further showed that most of the coefficients of variables of the stochastic cost frontier model have the expected signs (positive coefficients) indicating that an increase in price of any of them will eventually increase total production cost. The result in Table 4.13 impliesthat 1% increase in the cost of rent, maize, labour, wheat bran, maize bran, fish meal, bone meal, salt, diesel and tax will increase output by 0.42% as well as lead to approximately 0.33%, 0.0.06%, 0.33%, 0.43%, 0.14%, 0.53%, 0.34%, 0.49% and 0.34% increase in total production cost respectively. The variables that have negative coefficients and significant include cost of labour, limestone, vitamin premix, enzymes, electricity, depreciation on machinery and utilities. The implication of this finding is that those variables with positive coefficients could lead to increase in costs of production hence, the toll millers have to rationally utilize them. Other variables that show negative coefficients contrary to expectations could be looked at as alternative cost saving ingredients in feed production.

Table: 4. 13: Millers cost efficiency estimates

	Millers Type					
	Commercial		Toll Millers		On Farm	
Cost Variables	**Coeffi.**	**t-ratio**	**Coeffi.**	**t-ratio**	**Coeffi.**	**t-ratio**
Constant	0.232 (0.052)	4.504***	0.634 (0.044)	14.307***	0.687(0.130)	5.281***
Output produced	0.146 (0.088)	1.661*	0.523 (0.174)	3.003***	0.420(0.092)	3.469***
Rent on premises	0.365 (0.101)	3.617***	0.027 (0.010)	2.707***	0.329(0.057)	5.766***
Cost of maize	0.062(0.016)	3.698***	0.193 (0.098)	1.971**	0.057 (0.017)	3.365***
Cost of Labour	0.071(0.012)	6.97***	0.235 (0.094)	2.502**	-0.174(0.103)	-1.695*
Cost of Groundnut cake	0.067(0.039)	1.692*	0.169 (0.085)	1.994**	0.078(0.313)	0.250
Cost of Soybean cake	0.036(0.012)	3.650***	0.186 (0.092)	1.997***	0.225 (0.203)	1.112
Cost of Palm kernel cake	-0.118 (0.011)	-10.36***	0.147 (0.054)	2.714***	-0.124 (0.163)	-0.762
Cost of wheat bran	-0.237 (0.074)	-3.191***	-0.167 (0.068)	-2.447**	0.331(0.124)	2.672**
Cost of Maize bran	0.274 (1.014)	0.270	0.035 (0.018)	1.971**	0.432 (0.080)	5.408***
Cost of Fishmeal	0.051 (0.007)	7.875***	-0.269 (0.032)	-8.339***	0.136 (0.086)	1.653*
Cost of Bonemeal	0.2411 (0.129)	1.877*	-0.140 (0.026)	-5.385***	0.526(0.086)	6.084***
Cost of Limestone	-0.401 (0.091)	-4.454***	-0.119 (0.073)	-1.640*	-0.301(0.092)	-3.252***
Vitamin Premix	0.140 (0.056)	2.493**	0.044 (0.019)	2.253**	-0.325 (0.086)	-3.789***
Salt	0.097 (0.021)	4.731***	-0.132 (0.084)	-1.571	0.339 (0.134)	2.539***
Enzymes	0.162 (0.093)	1.745*	0.237(0.024)	7.275***	-0.209 (0.095)	-2.267**
Methionine	0.132 (0.079)	1.659*	-0.078 (0.076)	-1.017	0.033 (0.091)	0.367
Lysine	0.144 (0.1053)	1.363	-0.188 (0.044)	-4.284***	0.106 (0.071)	1.496
Diesel	0.036(0.009)	3.813***	0.039 (0.004)	11.211***	0.493 (0.042)	11.699***
Electricity	0.015 (0.008)	1.716*	0.102 (0.011)	9.952***	-0.319 (0.075)	-4.275***
Depreciation on Mach	-0.246 (0.101)	-2.442***	-0.013 (0.098)	-1.308	-0.207 (0.090)	-2.297**
Tax	0.064 (0.010)	6.196***	0.181 (0.055)	3.278***	0.342 (0.029)	11.734***
Utilities	0.026 (0.004)	6.586***	0.252 (0.121)	2.088**	-0.433 (0.093)	-4.657***
sigma-squared	0.259 (0.131)	1.974**	0.266 (0.098)	2.704***	0.228 (0.092)	2.465**
Gamma	0.636 (0.254)	2.501**	0.674 (0.084)	7.985***	0.757 (0.194)	3.902***
Log likelihood function	-165.229		-378.278		-244.666	
LR test of the one-sided error	29.6755		49.7558		37.9089	

Note:values in parentheses are standard errors. ***= sig. at 1%, **= sig. at 5% and *=Sig. at 10%.

4.4.7 **Elasticity of cost efficiencyfor mills**

Elasticity of cost of production is a useful tool that enhances the producer to be prudent and rational when allocating and utilizing inputs in production. The elasticity of cost analysis stands for a measure of resource (cost) productivity is presented in Table 4.14. The result for elasticity of cost efficiency for the commercial, toll and on farm mills (Table 4.14) is presented as thus:

4.4.7.1 ***Elasticity of cost efficiency for commercial feed mills***

The elasticity of cost parameter of 1.13(Table 4.14) obtained from the summation of the coefficients of the estimated costs of inputs involved in poultry feed production process by the commercial mills,indicated a positive increasing costs. At this point, each additional unit of cost on inputsused will result in more than a unit cost in total production costs of the mills. At this stage increase in those factors that have positive coefficients by a unit, will lead to a more than proportionate increase in cost of production. To attain full cost efficiency, the commercial feed mills will require some cost saving measures that will help reduce cost by 0.13%.

4.4.7.2 ***Elasticity of cost efficiency for toll feed mills***

The elasticity of cost value of 1.27 (Table 4.14) for toll mills indicates that, each additional unit of cost on inputsused will result in more than a unit cost in total production costs of the mills. At this stage increase in those factors that have positive coefficients by a unit, will lead to a more than proportionate increase in cost of production. To attain full cost efficiency, the commercial feed mills will require some cost saving measures that will help reduce cost by 0.27%.

It is therefore rational for the mills to find a way of reducing the costs of those ingredients by adopting some cost minimizing strategies.

4.4.7.3 ***Elasticity of cost efficiency for on farm feed mills***

The elasticity of cost efficiency for the on farm mills is also presented in Table 4.14. The estimated value of coefficients 1.35for the on farm feed mills, indicated a positive increasing costs. In this period, each additional unit of cost on inputsused will result in more than a unit cost in total production costs of the mills. At this stage increase in those factors that have positive coefficients by a unit, will lead to a more than proportionate increase in cost of production. To attain full cost efficiency, the commercial feed mills will require some cost saving measures that will help reduce cost by 0.35%.

It is therefore rational for all the mills to find a way of reducing the costs of those ingredients by adopting some cost minimizing strategies. Some of those strategies according to Soniya (2006) and Aduku (2003), include bulk purchase of ingredients for storage and use during off season, using non-conventional feed stuffs, identifying and purchasing ingredients from the area of production and using cost minimizing software in preparing feed formula.Softwares that use Linear Programming for Feed Formulation such as MIXIT (various version exist), Winpas, Feedlive, EGGPRO Version 2.0, and Feed Mania, and those that use stochastic method suchWinfeed and WUFFDA are capable of formulating minimum cost rations for the mills (Aduku, 1993; Ogundipe, 2002 and Afolayan and Afolayan, 2008).

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Table: 4. 14: Elasticities of allocative/cost efficiency for all mills

Parameters	Commercial	Mill types Toll	On farm
Output produced	0.1460	0.5234	0.3202
Rent on premises	0.3652	0.0273	0.3294
Cost of maize	0.0602	0.1934	0.0565
Cost of Labour	0.0709	0.2354	-0.1742
Cost of Groundnut cake	0.0664	0.1693	0.0782
Cost of Soybean cake	0.0364	0.1836	0.2254
Cost of Palm kernel cake	-0.1176	0.1470	-0.1240
Cost of wheat bran	-0.2368	-0.1667	0.3305
Cost of Maize bran	0.2736	0.0353	0.4316
Cost of Fishmeal	0.0508	-0.2690	0.1356
Cost of Bonemeal	0.2411	-0.1398	0.5259
Cost of Limestone	-0.4013	-0.1189	-0.3001
Vitamin Premix	0.1402	0.0444	-0.3245
Salt	0.0965	-0.1320	0.0338
Enzymes	0.1618	0.2370	-0.2094
Methionine	0.1322	-0.0777	0.0333
Lysine	0.1436	-0.1875	0.1059
Diesel	0.0364	0.0393	-0.3188
Electricity	0.0148	0.1015	0.4930
Depreciation on Mach	-0.2455	-0.0128	-0.2070
Tax	0.0637	0.1809	0.3423
Utilities	0.0263	0.2516	-0.4326
Total	1.1249	1.2649	1.3511

4.4.8 **Allocative efficiency indicesof the feed mills**

From the result in Table 4.15, it shows the allocative efficiency estimates of the poultry feed mills. The result for commercial, toll and on farm mills is presented as thus:

4.4.8.1 ***Allocative efficiency indicesfor the commercial feed mills***

The minimum allocative efficiency score index (Table 4.15) obtained for the commercial feed mills is 1.024, while the maximum Score index was 1.297 with a mean of 1.145. This result shows that the mills are highly inefficient in the allocation of costs among their resources. There is a significant over utilization of some of the resources in the production of poultry feed hence the inefficiency in costs.This result implies that an average commercial feed mill incur costs that are about 14%, above the minimum defined by the frontier. Thus, about 14% of the total cost incurred was avoidable if an average commercial feed mill in the study area were to be very efficient in terms of cost. This confirms the findings by Alrwis and Francis (2008) that cost of production may be relatively high, as a result of inefficiencies.

4.4.8.2 ***Allocative efficiency indicesfor the toll feed mills***

The minimum allocative efficiency Score index (Table 4.15) obtained for the toll mills was 1.011, while the maximum score index was 1.332 with a mean of 1.132. This result implies that an average toll feed mill incur costs that are about 13% above the minimum defined by the frontier. Thus, about 13% of the total cost incurred was avoidable if an average toll feed mill in the study area were to be very efficient in terms of cost.

4.4.8.3 ***Allocative efficiency indicesfor the on farm feed mills***

The minimum allocative efficiency Score index (Table 4.15) obtained forthe on farm mills was 1.011, while the maximum score index was 1.34 and with a mean of 1.152. The result shows that the on farm feed mills were highly inefficient in the allocation of costs among their resources. There is a significant over utilization of some of the resources in the production of poultry feed hence the inefficiency in costs.The result implies that an average on farm feed mill incur costs that are about 15% above the minimum defined by the frontier. Thus, about 15% of the total cost incurred was avoidable if an average on farm feed mill in the study area were to be very efficient in terms of cost.

4.4.8.4 ***Allocative efficiency indicesfor the pooled data of all the feed mills***

The minimum allocative efficiency Score index (Table 4.15) obtained forthe pooled data was 1.011, while the maximum was 1.34 and the mean allocative efficiency score index for the pooled data was 1.143. This result shows that the mills are highly inefficient in the allocation of costs among their resources. There is a significant over utilization of some of the resources in the production of poultry feed hence the inefficiency in costs.

This result implies that an average feed millin the study area incur costs that are about 15% above the minimum defined by the frontier. Thus, about 15% of the total cost incurred was avoidable if an average feed mill in the study area were to be very efficient in terms of cost. This confirms the findings by Alrwis and Francis (2008) that cost of production may be relatively high, as a result of inefficiencies.

The presence of economics of scale as found from the result of the elasticity of production mean that expanding production will in the long run reduce costs of production of all the mills. For instance, the commercial mills can increase labour to add to the number of shifts per day to enjoy economies of scale, the toll mills and the on farm mills need to reduce labour or increase in mill size in order to save more costs.

Table: 4. 15: Frequency distribution of allocative efficiency estimates

	Millers Type							
	Pooled data		Commercial		Toll Millers		On Farm	
Allocative Efficiency Range	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
0.09-1.09	77	28.0	22	36.0	43	32.0	12	14.0
1.10-1.19	135	48.0	22	36.0	65	48.0	48	57.0
1.20-1.29	64	23.0	17	28.0	25	19.0	22	27.0
1.30-1.39	3	1.0	0	0	1	1.0	2	2.0
Total	279	100	**61**	100	**134**	100	**84**	100
Average	1.143		1.145		1.132		1.152	
Maximum	1.339		1.297		1.332		1.340	
Minimum	1.011		1.024		1.011		1.011	

4.4.9 **Determinants feed mills allocative inefficiency**

The result of the cost inefficiency variables specified in the model (Table4.16) showed that most of the explanatory variables in the inefficiency model gave the expected sign (negative) of the coefficients while those with positive signs can be explained in terms of their contribution towards increase in cost inefficiency. The determinants of allocative inefficiency were presented for the commercial, toll and on farm mills as follows:

4.4.9.1 ***Determinants commercial feed mills allocative inefficiency***

The result in Table 4.16 revealed for the commercial feed mills, the coefficients of operating capacity, milling experience, source of power, years of membership of association, number of employees and amount of credit received were all negative and statistically significant implying that a1% increase in any of the inputs will approximately increase cost efficiency by 0.17%, 0.07%, 0.26%, 0.18%, 0.48% and 0.16% respectively. On the other hand, the estimated coefficients of distance to ingredients sources, number of competitors nearby, distance to output market and mill size .were positive and significant indicating that a 1% increase in the above variables, will approximately reduce cost efficiency 0.81%, 0.09%, 0.08%, and 0.05% respectively.

4.4.10 **Determinants toll feed mills allocative inefficiency**

The result of the cost inefficiency variables for the toll mills (Table4.16) showed that most of the explanatory variables in the inefficiency model gave the expected sign (negative) of the coefficients while those with positive signs can be explained in terms of their contribution towards increase in cost inefficiency. The coefficients of operating capacity, milling experience, source of power and number of months ingredients are available, are all negative and statistically significant implying that their increase by 1% will approximately increase cost efficiency by 0.18%, 0.06%, 0.15% and 0.14% respectively. On the other hand, the estimated coefficients of distance to ingredients sources and number of employees were positive and significant indicating that a 1% increase in the above variables, will approximately reduce cost efficiency 0.04% and 0.13% respectively.

4.4.11 **Determinants feed mills allocative inefficiency**

For the on farm feed mills, the result of the cost inefficiency variables in Table4.16revealed that the explanatory variables source of power, amount of credit obtained and mill size are all negative and statistically significant implying that their increase by 1% will approximately increase cost efficiency by 0.13%, 0.17% and 0.51% respectively. On the other hand, the estimated coefficients of distance to ingredients sources and number of employees were positive and significant indicating that a 1% increase in the above variables, will approximately reduce cost efficiency 0.04% and 0.17% respectively.

Table: 4. 16: Socioeconomic variables affecting Allocative Efficiency

	Millers Type					
	Commercial		Toll Millers		On Farm	
Allocative Efficiency Range	**Coeff & Std Error**	**t-ratio**	**Coeff & Std Error**	**t-ratio**	**Coeff & Std Error**	**t-ratio**
Constant	0.015(0.014)	1.016	0.167(0.018)	9.566***	0.019(0.069)	0.2789
Operating capacity	-0.175(0.094)	-1.866*	-0.181(0.069)	-2.625**	-0.288(0.234)	-1.2331
Milling experience	-0.072(0.039)	-1.832*	-0.057(0.029)	-1.941*	0.514(0.558)	0.9206
Distance to ingredient sources	0.806(0.083)	9.762***	-0.043(0.013)	-3.32***	0.041(0.024)	1.674*
Source of Power	-0.261(0.101)	-2.579**	-0.152(0.020)	-7.61***	-0.132(0.080)	-1.646*
Number of Competitors	0.094(0.052)	1.816*	-0.077(0.103)	-0.7455	0.022(0.029)	0.774
Distance to Major Output Market	0.084(0.084)	1.0031	-0.032(0.045)	-0.7102	0.134(0.153)	0.878
Years of Membership of Association	-0.178(0.095)	-1.879*	0.029(0.036)	0.7924	-0.485(0.690)	-0.702
Number of Employees	-0.484(0.215)	-2.252**	0.127(0.013)	9.626***	0.173(0.092)	1.886*
Amount of credit accessed	-0.165(0.064)	-2.589**	-0.009(0.011)	-0.8250	-0.170(0.098)	-1.742*
Months ingredients available	-0.527(0.829)	-0.6350	-0.141(0.058)	-2.445**	0.098(0.091)	1.076
Mill size	0.046(0.047)	0.9922	-0.035(0.036)	-0.9834	-0.510(0.291)	-1.755*
sigma-squared	0.259(0.131)	1.974**	0.266(0.098)	2.704***	0.228(0.092)	2.465**
Gamma	0.636(0.254)	2.501**	0.674(0.084)	7.985***	0.757(0.194)	3.902***
Log likelihood function	-165.2287		-378.278		-244.666	
LR test of the one-sided error	22.6755		49.7558		31.90885	

4.4.12 **Economic efficiency indicesfor feed Mills**

The result in Table 4.17 shows the economic efficiency indices of the commercial, toll, on farm and pooled data for the mills. The minimum, maximum and mean economic efficiency score indices were determined and presented as thus:

4.4.12.1 ***Economic efficiency indicesfor commercial feed Mills***

The result in Table 4.17 shows the minimum economic efficiency score index for the commercial millswas 0.44. The maximum economic efficiency score index on the other hand was 0.93 and the average economic efficiency of 0.70. These values signify that most of the commercial millswere economically inefficient. There is a wide margin between the more efficient and the less efficient mills, hence the low value of the mean economic efficiency. For the average commercial feed mill to attain full economic efficiency, it has to be 25% more efficient (i.e. 1-0.70/0.93x100) while for the least efficient mill to be fully efficient it has to be 0.52% more efficient (i.e. 1-0.44/0.93x100)

4.4.12.2 ***Economic efficiency indicesfor toll feed Mills***

The result in Table 4.17 shows the minimum economic efficiency score index for the toll mills was 0.39. The maximum economic efficiency score index on the other hand was 0.83 and the average was 0.61. These values signify that most of the mills are economically inefficient. There is a margin between the more efficient and the less efficient mills, hence the low value of the mean economic efficiency. For the average toll feed mill to attain full economic efficiency, it has to be 26% more efficient (i.e. 1-0.61/0.83x100)to attain full economic efficiency. For the least efficient toll mills to attain full efficiency, they have to be 0.53% more efficient (i.e. 1-0.39/0.83x100).

4.4.12.3 ***Economic efficiency indicesfor the on farm feed Mills***

The result in Table 4.17 shows the minimum economic efficiency score index for the on farm mills was 0.37. The maximum economic efficiency score index on the other hand was 0.72 and the average 0.56. These values signify that most of the on farm millswere economically inefficient. There is a margin between the more efficient and the less efficient mills, hence the low value of the mean economic efficiency.For the average on farm mill has to be 23% more efficient (i.e. 1-0.56/0.73x100) to attain full efficiency. The least efficienton farm mills have to be 49% more efficient (i.e. 1-0.37/0.73x100).

4.4.12.4 ***Economic efficiency indicesfor the feed mills pooled data***

The result in Table 4.17 shows the minimum economic efficiency score index for the pooled that was 0.37. The maximum economic efficiency score index on the other hand for the pooled data was 0.93, while the average was 0.61. These values signify that most of the mills are economically inefficient. There is a wide margin between the more efficient and the less efficient mills, hence the low value of the mean economic efficiency.The average mill has to be 34% more efficient (i.e. 1-0.61/0.93x100)to attain full economic efficiency while the least efficient mill has to be 60% more efficient (i.e. 1-0.37/0.93x100) to attain full efficientlevel.

Table: 4. 17: Frequency distribution of economic efficiency estimates

	Pooled data		Commercial		Millers Type Toll Millers		On Farm	
Economic Efficiency Range	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
0.35 - 0.45	16	5.73	1.00	1.64	5.00	3.73	10.00	11.50
0.46 - 0.55	76	27.24	6.00	9.84	38.00	28.36	31.00	36.48
0.56 - 0.65	94	33.69	14.00	22.95	44.00	32.84	36.00	42.50
0.66 - 0.75	65	23.30	23.00	37.70	36.00	26.87	8.00	9.52
0.76 - 0.85	23	8.24	12.00	19.67	11.00	8.21	0.00	0.00
0.86 – 0.95	5	1.79	5.00	8.20	0.00	0.00	0.00	0.00
Total	**279**	**100.00**	**61.00**	**100.00**	**134.00**	**100.00**	**84.00**	**100.00**
Average	0.61		0.70		0.61		0.56	
Maximum	0.93		0.93		0.83		0.73	
Minimum	0.37		0.44		0.39		0.37	

4.5 Net Income Estimation(Profitability)

The analysis of net income was carried out so as to determine the level of costs, revenues and profits associated with poultry feed production (Table 4.18). The analysis was carried out on per tonne (1000Kg) basis for the commercial, toll, on farm and pooled data of the mills. The result is as presented below.

4.5.1 **Net income estimation (Profitability) for commercial feed mills**

The result of the analysis per 1000Kg (Table 4.18) of feed revealed that the net income realized by the commercial mills was₦16, 855.98 when all cost items of ₦82, 977.29 were deducted from the gross income of ₦98, 833.27. Theresult shows that poultry feed production is profitable with the commercial mills enjoying a higher profit margin compared to the toll and the on farm mills. The value of return per ₦100 invested in the commercial feed mills was ₦20.78. This finding confirm other similar studies by Oladejo (2012) and Munkaila *et al.* (2012) in the study of efficiency of feed mills in Lagos and in Ogun and Oyo States of Nigeria.

4.5.2 **Net income estimation (Profitability) for toll feed mills**

The result of returns to feed mill for the toll mills (Table 4.18) shows a return of ₦14, 277.07 when all cost items of ₦80,855.82 were deducted from the gross income of ₦95,132.89 in the analysis. This shows that poultry feed toll milling is profitable with the toll mills enjoying a higher profit margin to the on farm mills. The values of return per ₦100 invested in the toll mills was₦17.44.

4.5.3 **Net income estimation (Profitability) for on farm feed mills**

The result of returns to feed mill business for the on farm mills (Table 4.18) shows a return of ₦13,082.11 when all cost items of ₦82,050.78 were deducted from the gross income of ₦95,132.89 in the analysis on per 1000Kg of feed. Theresult shows that poultry feed production is profitable. The values of return per ₦100 invested in the on farm mills was₦15.39.

4.5.4 **Net income estimation (Profitability) for all feed mills pooled data**

The result of returns to feed mill business for all the mills pooled data (Table 4.18) showsfor the pooled data, the net income was ₦14,090.75 when all cost items of ₦81,942.27 were deducted from a revenue ₦96,033.02 per 1000Kg of feed. Theresult shows that poultry feed production is profitable in Nigeria. The values of return per ₦100 invested in the mills was₦17.87.

The implication of the result is that the commercial millers enjoy a higher return to investment compared with the toll and on farm mills.By improving on their technical and allocative efficiencies, the mills can make more returns than what they are currently enjoying. To improve on this profit level, the millers will have to reduce the over utilized inputs to an acceptable level and look for ways of reducing costs through the purchase of ingredients when prices are low especially during harvest. This finding supports the findings of Oladejo (2012), Munkaila *et al.*(2012) and Mbanasor and Jonas (2005) who all found poultry feed production as a profitable venture despite the presence of inefficiencies in the study of efficiency of poultry feed production enterprises in Lagos, Oyo and Ogun and in Abia States respectively.

Table: 4. 18: Average costs, returns and profitability of poultry feed production

N=279		Millers Type		
	Pooled data	**Commercial**	**Toll**	**On Farm**
Cost/Returns/tonne	**Cost/ Rev. (₦)**	**Cost/ Rev. (₦)**	**Cost/ Rev. (₦)**	**Cost/ Rev.(₦)**
a. Gross Revenue (₦)	**96033.02**	**98833.27**	**95132.89**	**95132.89**
b. Variable Cost				
Maize	29964.02	29452.72	29885.84	30460.02
GNC	15279.51	15583.97	15132.55	15292.86
SBC	23264.7	23741.05	22946.01	23427.18
PKC	318.9	309.39	326.22	314.14
Wheat bran	927.12	949.02	921.9	919.54
Maize bran	570.49	572.77	571.13	567.82
Fish meal	2086.4	2126.51	2028.17	2150.15
Bone meal	1143.98	1074.8	1165.86	1159.31
Limestone	335.13	338.62	334.78	333.15
Vitamin premix	1116.53	1117.89	1130.28	1093.63
Salt	178.25	167.67	183.8	177.07
Enzymes	1185.33	1230.98	1184.65	1153.27
Methionine	2144.9	2238.79	2105.64	2139.36
Lysine	1300.47	1313.85	1304.04	1285.04
Power/Electricity	610.09	693.64	570.49	601.41
Bagging	1200	1600	800	800
Total variable cost	**81625.82**	**82511.67**	**80571.36**	**81873.95**
c. Fixed Cost				
Salary	178.53	251.34	180.75	140.23
Rent	51.67	64.2	7.8	5.57
Dep. On equipment	6.47	18.79	12.16	6.23
Tax	4.33	25.52	9.4	3.8
Utilities	75.45	105.77	74.35	21
d. Total fixed cost	**316.45**	**465.62**	**284.46**	**176.83**
e. Total Feed cost/tonne (₦)	**81942.27**	**82977.29**	**80855.82**	**82050.78**
f. Net Income/tonne	**14090.75**	**16855.98**	**14277.07**	**13082.11**
Return per Naira Spent	**16.97**	**20.78**	**17.44**	**15.39**

4.5.5 Test of hypothesis on net farm income (Profitability)

Based on result of the net income analysis presented in table 4.18, the test of hypothesis for net income associated with poultry feed production was conducted the Parameters HO_2: Profit = 0 was rejected (Table 4.19). This was based on the result of the z test statistic that shows the calculated z value for all the mills (commercial, toll, on farm and the pooled data)

The calculated z value for the commercial, toll, on farm and the pooled data were 6.48, 18.2, 8.01 and 137.9 respectively and statistically significant at 1% with critical values of 1.96 and 1.64 at 2-tail and 1-tail respectively. The result of the test of hypothesis signifies that poultry feed production is a profitable enterprise because there is difference between the means of costs and revenues for all the mills at 1% level of significance. Hence, the null hypothesis (Ho_2: π=0) which states that poultry feed production is not profitable was outrightly rejected. Therefore, investors in the agricultural sector can seize this opportunity by investing in this very important sector of the poultry industry which constitutes about 70 % of the total cost of poultry production (Hassan, 2002).

Table: 4. 19: Test of Hypothesis for Net Income from Poultry Feed Production for pooled and the 3 type of mills.

Parameters	Pooled data		Millers Type Commercial		Toll		Farm own	
	Cost	Rev.	Cost	Rev.	Cost	Rev.	Cost	Rev.
Mean	83.16	95.25	82.97	99.82	80.86	95.13	82.05	95.13
Variance	37.55	41.67	29.28	41.27	33.39	21.5	44.17	50.2
Observations	279	279	61	61	134	134	84	84
Hypothesized Mean Diffc.	0		0		0		0	
Df	555		117		254		165	
z Stat	137.91		-6.48		-18.2		-8.009	
P(Z<=z) 1-tail	0.000		0.00015		0.0003		0.001	
z Critical 1-tail	1.647		1.657		1.651		1.654	
P(Z<=z) 2-tail	0.0000		0.00002		0.0006		0.0002	
z Critical 2-tail	1.964		1.980		1.969		1.974	

4.6 Poultry feed production constraints

The result in Table 4.20 shows that market constraints include high costs of ingredients and markets for ingredients are far away from feed millers. The two constraints rank highest among the mills. The most important market constraints are stiff competition from well-established mills and the preference some farmers show for the feeds produced by those mills. Source of power is another constraint, where majority of millers have to own generators for power generation. Most of the millers studied are also limited in coverage to sales in towns not exceeding 100Km from their mills. They reported a high level of insecurity which affects production. Taxes are said to be multiple and very high (59%). Lack of genuine parts for repairs and the high cost of maintenance are reported. 39.6% of the sampled millers reported ingredients adulteration, had inadequate ingredients, fluctuation in prices and seasonality of Ingredients availability as the factors affecting poultry feed production. Majority of the millers encountered problems of electricity and access to credit as factors affecting them with 47% of the sampled millers. High cost of diesel and raw material adulteration were also found to be important constraints by 40% of the millers. Other constraints are multiple taxes levied on the millers and long distances to market for inputs. About 28 % of millers had problem of electricity supply and 25% cited long distances to Sources of ingredients as a Constraint. Inadequate market and price fluctuation are also some of the factors that posed some problems among millers representing about 35%.

The problem of feed adulteration and unstable market prices and nutrient variations was supported by the findings of Habib *et al* (2015) and Oladokun and Johnson (2012) who obtained results indicating that all the feed samples they studied in Kaduna State were contaminated with a number of fungal species and prices of feed ingredients in Nigeria are unstable with high prevalence of nutrient variations. There is also stiff competition from well-established mils and the Preference some farmers show for the feeds produced by those mills. Source of power is another constraint, where majority of millers have to own generators for power generation. Most of the millers studied are also limited in coverage to sales in towns not exceeding.

Source of power is another constraint, where majority of millers have to own generators for power generation. Most of the millers studied are also limited in coverage to sales in towns not exceeding 100Km from their mills. They reported a high level of insecurity which affects production. Taxes are said to be multiple and very high and multiple. There are reported cases of lack of genuine parts for repairs and the high cost of maintenance are reported. Majority of the millers encountered problems of electricity and access to credit as factors affecting them with the sampled millers. High cost of diesel and raw material adulteration were also found to be important constraints by the millers. Inadequate market and price fluctuation are also some of the factors that posed some problems among millers. Most of these constraints were also reported in studies on efficiency of feed millers by Oladejo, 2012 and Mbanasor and Jonas 2005.

Table: 4. 20: Millers' constraints

Variables	Pooled data	Mill type Commercial	Toll	Farm own
	Freq (%)	Freq (%)	Freq (%)	Freq (%)
Market				
high prices of ingredients	279(100)	61(100)	134(100)	84(100)
Markets are far for ingredients	229(82)	45(74)	110(82)	74(88)
Preference for feed from established mills	140(50)	20(33)	120(90)	0(00)
some farmers produce feed themselves	136(49)	19(31)	117(87)	0(00)
High product competition	164(59)	32(52)	134(100)	0(00)
Source Power				
Generator	200(72)	40(66)	119(89)	84(100)
National Grid	229(82)	51(84)	134(100)	34(40)
National Grid and Generator	240(86)	61(100)	134(100)	45(54)
Insecurity				
Threat to lives and investment	235(84)	45(74)	114(85)	56(67)
Reduction in production inputs availability	201(72)	50(82)	108(81)	43(51)
T ax and levies				
Multiple charges	238(85)	61(100)	104(78)	43(51)
Amount charged Very High	233(84)	61(100)	94(70)	38(45)
Machinery and spare parts				
genuine spare parts not readily available	256(94)	56(87)	125(93)	70(83)
High maintenance cost	265(83)	53(82)	115(86)	69(82)
parts are very expensive	279(100)	52(79)	124(93)	84(100)
Electricity				
Expensive	232(81)	50(77)	124(93)	38(45)
Inadequate supply of electricity	231(81)	50(77)	134(100)	32(38)
power not stable	219(78)	58(90)	114(85)	45(54)
Feed ingredients				
Adulterated ingredients	243(87)	56(92)	124(93)	64(76)
Fluctuation in prices of ingredients	279(100)	54(89)	134(100)	84(100)
High Transportation cost	215(77)	48(79)	107(80)	50(60)
Market for Ingredients far from mills	217(78)	45(74)	112(84)	60(71)
Very high Prices of ingredients	189(68)	61(100)	108(81)	55(65)

N= 279, 61, 134 and 84 for all millers, commercial, toll and farm own respectively, but Multiple responses recorded

In order to reduce some of the constraints explained in the previous section, solutions were proffered by the responds. Such solutions include provision of stable power supply, enforcement of regulatory standard to reduce adulteration, credit facilities and adequate inputs should be available.

4.6.1 **Suggestions on poultry feed production constraints**

In order to reduce some of the constraints explained in the previous section, solutions were proffered by the responds as shown in Table 4.21. Such solutions include provision of stable power supply, enforcement of regulatory standard to reduce adulteration, credit facilities and adequate inputs should be available.

Table: 4. 21: Suggested Solutions for the Constraints

		Mill type		
Suggestions	**All millers**	**Commercial**	**Toll**	**Farm own**
	Freq(%)	**Freq(%)**	**Freq(%)**	**Freq(%)**
Milling Equipment and Spare parts should be available and affordable	220(84)	50(83)	115(84)	78(87)
Stability of and reduction in Feeds ingredients prices	270(93)	56(88)	115(86)	74(85)
Provision of adequate Security in the country	279(100)	50(77)	124(93)	84(100)
Provision of low interest credit facilities	232(81)	59(77)	124(93)	38(45)
Stability of power supply	215(75)	59(93)	134(100)	32(38)
Reduction in transport cost	219(78)	58(90)	114(85)	45(54)
Reduce tax/levies	243(87)	56(92)	124(93)	64(76)
reduction in the prices of diesel to lower running cost	279(100)	61(100)	134(100)	84(100)
Enforcement of feed regulatory standards feed milling industry	207(70)	45(74)	100(72)	70(71)

N= 279, 61, 134 and 84 for all millers, commercial, toll and farm own respectively, but Multiple responses recorded

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This study determined the production efficiency of poultry feed industries in Nigeria. The factors that influenced the Technical, Allocative and Economic efficiency levels of the sampled poultry feed mills in Nigeria. 279 mills were identified and examined accordingly using structured questionnaires to obtain data. Descriptive statistics was used to describe the characteristics of the mills, net income analysis for the determination of costs and returns (Profitability) and the Stochastic frontier analysis (SFA) was employed in determining the technical, cost and economic efficiency levels of the feed mills. Two Hypotheses were tested to determine whether feed production is profitable and if the feed mills are technical and allocative efficient or not.

The result shows that the poultry feed industry is characterized by the presence of commercial, toll and on farm mills which are the equivalent of the large, medium and small scale feed mills. The mean years of operation for the millswas 15 years for the commercial mills, while the toll and on farm mills have less than 15 years mean experience. The average capacity of all the mills was 10 tonnes per day with the commercial mills averaging 30 tonnes per day, operating on the average of 5days/week using 1-2shifts in a day. Products generated by the poultry feed mills are broilers starter and finisher for broilers, chick, grower and layer feed for pullets, layers and cockerels. About 15% also add turkey and fish feeds while about 10% produce feed concentrate in addition. The feeds are produced from basic feed ingredients such as maize, soybeans, groundnut cake, limestone, methionine, lysine and vitamin premix that are local and imported.

The feed mills were found to be technical and cost inefficient with mean technical efficiency of 0.88. 0.82, 0.79 and 0.82 for the commercial, toll, on farm and the pooled data respectively. The mean allocative efficiency for the mills were 1.145, 1.132, 1.152 and 1.143 for the commercial, toll on farm and the pooled data. The test of hypothesis for the presence of inefficiency further confirmed the presence of inefficiency at 1% level.

The commercial, toll, on farm and pooled mills are making an average profit of ₦16, 855.98, ₦14, 277.07, ₦13,082.11 and ₦14,090.75 from the production of 1000Kg of poultry feed. The test of hypothesis on profitability confirm that all the categories of mills were making profit with a return to Naira invested ranging from ₦0.15 to ₦0.28.

Some of the constraints to efficient and profitable poultry feed production as identified by the mills include: adulteration of feed ingredients, fluctuation in prices and seasonal nature of the ingredients. There was also inadequacy of electricity and high cost of diesel to power generators. Taxes were equally high and multiple in nature.

5.2 Conclusion

The result of the study revealed thatsome characteristics of the feed mills, such as milling experience, access to credit, educational level of operator, operating capacity are positive and significant, implying that an increase in any of them will increase efficiency and consequently the output of the feed mills. Also characteristics of mills such distance to source of inputs, source of power, distance to output market, and number of employees have the tendency to reduce technical efficiency. The technical efficiency levels of the sampled feed mills ranged from 0.52 to 0.99 with a mean of 0.82. This implies that, on average, the mills have to increase output at current level of input usage by 17% to attain full efficiency. The study also revealed that the cost efficiency levels of the feed mills ranged from 1.01 to 1.34 with the mean of 1.14. This implies that, on average, the feed mills incurred about 14% cost above the frontier cost (an indication of about 14% cost inefficiency). Thus, on average, the mills could have produced the same levels of feeds using about 86 % of the total cost incurred if they were to be efficient. The analysis of the net income indicated that the profit levels of the feed mills ranged from ₦13,082.11 to ₦16,855.98 with the mean of ₦14,090.75. This implies that when full cost efficiency is attained by the mills, the mean profit could increase by 16% through cost reduction. This cost reduction by implication could be transmitted to the poultry farmers which will enhance their profit levels. Therefore, poultry feed production is a profitable enterprise in Nigeria despite the presence of some constraints such as adulteration, high cost of ingredients and seasonality of their production as well as inadequate electricity to power the mills. The result of the Stochastic frontier analysis showed that the production function exhibit a decreasing return to scale while the technical efficiency is above average, the allocative and economic efficiencies involved in feed production were very low .

5.3 Recommendations

Based on the resultsobtained from this study some policy recommendations and suggestions that are deemed very important in improving the levels of technicaland cost efficiency of the poultry feed industry are proffered.

i. It is very evident from the findings of this study that the mill operator or manager’s level of education has a crucial role to play in improving the technical efficiency levels of the feed mills. The mill owners should therefore recruit farm managers or operators who have at least acquired formal education up to the Senior Secondary School or training in higher school of agriculture. For those owners who manage the business themselves, they should equally acquire formal trainings such as the ones conducted by the Nigerian Institute of Animal Science (NIAS) in conjunction with the Poultry Association of Nigeria (PAN) and the Federal Livestock Department (FLD).

ii. The result also indicated that access to credit even though only significant in the results of the on farm mills, the positive coefficient indicates that it can increase technical efficiency. Provision of credit facilities Improve access to ingredients through bulk purchase and storage during harvest to reduce the effectof hike in prices during the off season which the study has found to significantly reduce technical efficiency. This requires the provision of capital through access to credit facilities. The Bank of Agriculture, Bank of Commerce, Commercial Banks as well as the Small and Medium Enterprises Development Agency of Nigeria (SMEDAN) have a big role to play in this area of credit availability.

iii. Cost of transport and the distance to ingredient sources were also found to be negatively affecting cost efficiency. A means of reducing these costs could help reduce the costs incurred by the mills, which will consequently help increase their cost efficiency. A well connected road network to the areas of ingredients availability, reduction in diesel costs and the revival of the rail system as well as the federal inland water ways by the relevant government agencies could help reduce these problems.

iv. Forward and backward integration by the mills could reduce cost and increase efficiency. The feed mills especially on the farm mills can go in to farming to produce some of the basic feed manufacturing ingredients. They can also go further in to processing especially of soybean and groundnut, the byproducts of the processing mills could be used to produce feed. Parent stock and grandparent stock could also be kept with a hatchery to produce day old chicks using the feed manufactured.

v. The study also revealed that there was serious adulteration of feed production ingredients. Standardization of ingredients for quality is recommended through the standard organization of Nigeria, who can set standards on the inputs supplied for feed milling process. The creation of Veterinary Medicine and Allied Products (VMAP) Directorate initiated by the National Agency for Food and Drug Administration and Control (NAFDAC) for regulating feed import/distribution and marketing in Nigeria, will help regulate feed in the same manner as the agency had done with regulating processed food products. The Nigerian Institute of Animal Science (NIAS) which equally has a mandate on the control of feed quality in Nigeria need to up their services for control in this sector.

vi. The cost inefficiency reported in the study (14%) can be reduced by the mills through contract purchase of ingredients. This can reduce cost as well as help maintain some level of quality of the ingredients based on the contract terms.

vii. Inadequate supply of electricity and high cost of diesel reported in the study enormously affect the milling industry. Improvement in the current electricity supply to the industries by the Power Holding Company of Nigeria (PHCN) coupled with reduction in the prices of diesel by the government is needed to rescue the sector from collapse.

viii. The study also revealed that commercial millshave better cost efficiency compared with the toll and on farm mills based on their sizes. This implies that the mills who had larger mill sizes were more cost efficient than their counterparts who operated small mill sizes due to the utilization of production inputs particularly the fixed resources. Therefore, an increase in mill sizes (scale of production) by the other mills could result in reductions in their average production cost per Kg and eventually increase their profit. Access to improved credit facilities could help facilitate this activity.

5.4 Contribution to Knowledge

The study revealed that poultry feed production is a profitable production enterprise despite the inefficiency of the mills. The current mills and other potential entrants into the business need to explore cost reduction techniques available in order to increase their level of profit and better services to the customers. Based on this, the study has contributed in the following areas:

i. There was a significant relationship between socioeconomic attributes of the mills and their technical, allocative and economic efficiencies. The ‘mean technical efficiency of the mills was 0.88 and below the frontier levels of 1, while the mean cost efficiency of mills was 1.143 and slightly above the frontier value of 1. The application of some cost saving techniques could improve on the cost efficiency.

ii. For an average mill to attain full technical efficiency, it has to be 17% more efficient in the utilization of their production resources and to be allocative efficient, they need to be approximately 14% more cost efficient or produce the current level of feed with about 86% of the resources of production.

iii. The average economic efficiency of the mills was found to be 0.61, which was below the frontier level of 1.

iv. Feed production was profitable with a profit of ₦14,090.75/tonne of feed produced or approximately₦14.01/Kg of feed produced with an average return to Naira invested of ₦0.17.

v. The elasticity of production and cost were found to be 0.98 and 1.24 for all the mills. Implying that the response of output to a unit of input was 0.98 and inelastic while the response of total cost to a unit increase in the cost of resources is more than unity (elastic)

vi. The efficiency and productivity of mills were beset with problems such as high cost of ingredients, instability in power supply and which serve as constraint to the mills' ability to be more efficient.

vii. The study also provides ample knowledge of how to start a small to large scale feed mill. Knowledge of the feed ingredients and their inclusion levels are provided as well as where to obtain the ingredients.

viii. The study has also added to what was missing in the body of knowledge and literature in this special area of poultry feed production. Literature in this area was difficult to come by especially on the efficiency of feed mills in Nigeria.

REFERENCES

Adene, D.F; and Oguntade A.E. (2006). The Structure and importance of the commercial and village based poultry industry in Nigeria. FAO (Rome), 109pp (TechnicalReport)http://www.fao.org/docs/eims/upload//214281/poultrysector_nga_en.pdf.

Aduku, A. O. (1993). Tropical Feedstuff Analysis Table. Ahamdu Bello University, Samaru-Zaria. S. Asekome & Company, Samaru Publishers. Feed Formulation Document: 1-4

Adebayo, E.F. (2005). Resource-use Efficiency and Multiple Production Objectives of Dairy Pastoralist in Adamawa State. 2nd Seminar Paper Department of Agricultural Economics University of Ibadan Seminar Series.

Adebayo, E.F. and Onu, J.I. (1999) Economics of rice production in Yola North and South Local Governments Areas. *Nigerian Journal of Tropical Agriculture.*1:15-20.

Afolayan, M. O. and Afolayan, M. (2008). Nigeria Oriented Poultry Feed Formulation Software Requirements. *Journal of Applied Sciences Research, 4(11): 1596-1602, 2008.* © 2008, INSInet Publication. https://www.researchgate.net/publication/228652695

Agricultural Transformation Agenda (ATA) 2011: Federal Ministry of Agriculture & Rural Development Abuja, Nigeria. ATA Main Report 9th September, 2011.

Aigner, D. and S. Chu, (1968). "On Estimating the Industry Production Function," *American Economic Review,* 58, pp. 826-839.

Aigner, D. J., Lovell, C. A. K and Schmidt, P. (1977). "Formulation and Estimation of Stochastic Frontier Production Models", *Journal of Econometrics,* 6:21-37.

Ajibefun, I. A., (2008): An evaluation of parametric and non-parametric methods of technical efficiency measurement: application to small scale food crop production in Nigeria. *Journal of Agriculture and Social Sciences*. 4: 95–100

Ajibefun, I.A and Abdulkadiri A. O. (1999). An Investigation of Technical Inefficiency of Production of Farmers under the National Directorate of Employment in Ondo State, Nigeria, *Applied economics Journal*. 6: 111-114.

Ajibefun, I.A. and Daramola, A.G. (1999). Measurement and sources of technical inefficiency in poultry egg production in Ondo state, Nigeria. *Journal of Rural Economics and Development* **13**: 85-94.

Ajibefun I.A. and Daramola, A.G. (2003) "Efficiency of Microenterprises in the Nigerian Economy" African Economic Research Consorium RP 134.

Akintoye, I. R (2010): “Enhancing the Performance of the Informal Sector for the Economic Development of Nigeria: A Case Study of Lagos State” International Journal of Social Sciences, Vol. 5 No. 1, pp 100-112

Ali, M. and Chaudhary, M.A. (1990). Inter-regional farm efficiency in Pakistan Punjab: A frontier production function study. *Journal of Agricultural Economics* **41** (1): 62-74.

Alimon, A. R. and Hair-Bejo M. (1995). Feeding Systems based on oil palm by-products in Malaysia. In proceedings of the first symposium on the integration of Livestock to oil Palm production. Kuala Lumpur, Malysia, 102-113.

Allison J.R. and D.M. Baird, (1974) “least cost livestock productions Rations.” Southern journal of Agricultural Economics, 6: 41-45.

Alrwis, K. N. and Francis, E. (2008): Technical, Allocative, and Economic Efficiencies of Broiler Farms in the Central Region of Saudi Arabia: Data Envelopment Analysis Approach. King Saud University. Saudi Arabia. Riyadh 11451

Amos, T.T. (2007). ”An Analysis of Productivity and Technical Efficiency of SmallholderCocoa Farmers in Nigeria. ”*Journal. Social Science, 15(2):127-133*

Arrow, K., H. Chenery, B. Minhas, and R. Solow, (1961). “Capital Labor Substitution and Economic Efficiency,” *Review of Economics and Statistics*, 45, pp. 225-247.

Atteh, J. O. and Ologbenia, F. D. (1993) “Replacement of Fish meal with maggots in broiler diets Effects on performance and nutrient retention” *Nigerian Journal of Animal Production* 20: 44–49.

Atteh, J. O. (2002). Principles and Practice of Livestock Feed Manufacturing. Adlek Printers, Sabon-line Ilorin. P:159.

Bamiro, O. M; Shittu A. M. and Kola-Olukotun S. A. (2001). Private Feed Production as a Cost Reduction Strategy: Effects on Profitability of Poultry Business in Ogun State, Nigeria. *The Ogun Journal of Agric. Science, pp: 37-41*

Battesse, G.E. and Corra, G.S. (1977); Estimation of a Production Frontier Model: With Application to the Pastoral Zone of Eastern Australia. *Australian Journal of Agricultural Economics,* 21:167-179.

Bauer, P., A. Berger, G. F. and D. Humphrey, (1998). “Consistency Conditions for Regulatory Analysis of Financial Institutions: A Comparison of Frontier Efficiency Methods,” *Journal of Economics and Business*, 50, pp. 85-114.

Belbase K. and Grabowski R. (1985). Technical efficiency in Nepalese Agriculture. *Journal of Development Area*, 19: 515 – 525.

Bello, B. (2008). Feed Crisis: Way out. A Paper Presented at the World Poultry Science Association, Nigeria Branch Seminar, Lagos. March 14-16.

Bhasin, V.K. (2002). ”Credit Allocation and Technical Efficiency of Vegetables Growers in the Brong-Ahafo Region of Ghana." *African Economic Research Consortium, Nairobi Kenya.*

Bjurek, H., L. Hjalmarsson and F. Forsund, (1990). "Deterministic Parametric and Nonparametric Estimation of Efficiency in Service Production: A Comparison," *Journal of Econometrics*, 46, pp. 213-227.

Bravo-Ureta, B.E. and Pinheiro, A.E. (1993): Efficiency Analysis of Developing country Agriculture: A review of the frontier literature; *Journal of Agricultural Economics* 10 (3):27-37

Bravo-Ureta, B.E. and Evenson, R.E. (1994). Efficiency in Agricultural Production: The case study peasant farmers in Eastern Paraguay. *The Journal of the International Association of Agric. Econs.* 14: 23-30.

Caves, D., L. Christensen, and M. Trethaway, (1980). Flexible Cost Functions for Multiproduct Firms. *Review of Economics and Statistics*, 62, pp. 477-481.

Chakraborty, K., B. Biswas and W. Lewis, (2001). "Measurement of Technical Efficiency in Public Education: A Stochastic and Nonstochastic Production Function Approach," *Southern Economic Journal*, 67, pp. 889-905.

Cobb, S. and P. Douglas, (1928). "A Theory of Production," *American Economic Review*, 18, pp. 139-165.

Central Intelligence Agency (CIA) (2014): World Fact Book 2014. https://www.cia.gov/library/publications/the-world-factbook/geos/ni.html

Coelli, T.J. (1996) A guide to FRONTIER version 4.1 a Computer Programme for Stochastic Frontier Production and \Cost Function Estimation. CEPA Working 96/07 University of New England, Armidale, Australia.

Coelli, T.J. and Battese, G.E (1996): Identification of factors which influence the Technical Efficiency of Indian Farmers. *Australian Journal of Agricultural Economics* 40: 103-128.

Cummins, J. and H. Zi, (1998). "Comparison of Frontier Efficiency Models: An Application to the U.S. Life Insurance Industry," *Journal of Productivity Analysis*, 10, pp. 131-152.

Dean, J., (1951), *Managerial Economics*, Prentice Hall, Englewood Cliffs, New Jersey.

Debreu, G., (1951), "The Coefficient of Resource Utilization," *Econometrica*, 19, pp. 273-292.

Etuah, S. (2014). Cost Efficiency and Economies of Scale in Broiler Production in Ghana. A Case Study of the Ashanti Region. An M.Sc. Thesis Submitted to the Department of Agricultural Economics, Agribusiness and Extension, Kwame Nkrumah University of Science and Technology

Eruvbetine D. (2009): Revolutionising the Feed Industry for Increased Poultry Production, University of Agriculture, Abeokuta, Nigeria.UNAAB Inaugural Lecture Series No. 26

Fagbenro, O.A. and Adebayo, O.T. (2005):A Synthesis of the Formulated Animal And Aquafeed Industry In Sub-Saharan Africa: A review of the animal and aquafeed industries in Nigeria. CIFA Occasional Paper No. 26 FAO Rome.http://www.fao.org/docrep/008/a0042e/a0042e05.htm22nd March, 2013.

Farrel, M.J. (1957): The Measurement of Productivity Efficieny. *Journal of Royal Statistic Society,*120:253-281 FMOA (1989).

Federal Ministry of Agriculture and Water Resources FMA&WR (2008). Federal Ministry of Agriculture and Water Resources, National Policy on Agriculture for National Food Security Abuja.

Federal Livestock Department FLD (2005): Federal Department of Livestock Annual Publication as cited in Oyediji G. O. (2006). Feedmill Management in Nigeria. A Handbook for Animal Scientists, Feedmillers, Agriculture Students and Allied Professionals. University Press Ibadan ISBN 978-074-995-0. PP. x-xiii.

Ferrier, G. and K. Lovell, (1990) "Measuring Cost Efficiency in Banking: Econometric and Linear Programming Evidence," *Journal of Econometrics*, 46, pp. 229-245.

Food and Agricultural Organisation FAO, (2012). Poultry feed availability and nutrition in developing countriesAnimal feed safety Edited by Velmurugu Ravindran, Monogastric Research Centre Institute of Food, Nutrition and Human Health, Massey University,Palmerston North, New Zealand.

Forsund, F., (1992) "A Comparison of Parametric and Nonparametric Efficiency Measures: The Case of Norwegian Ferries," *Journal of Productivity Analysis*, 3, pp. 25-44.

Forsund, F. and E. Jansen, (1977) "On Estimating Average and Best Practice Homothetic Production Functions via Cost Functions," *International Economic Review*, 18, pp. 463-476.

Greene, W., (1990). "A Gamma Distributed Stochastic Frontier Model," *Journal of Econometrics*, 46, pp. 141-163.

Greene, W., (1997). "Frontier Production Functions," in H. Pesaran and P. Schmidt, eds., *Handbook of Applied Econometrics, Volume II, Microeconomics*, Oxford University Press, Oxford.

Greene W. H. (2008). “The Econometric Approach to Efficiency Analysis,” in H. Fried, K. Lovell, and S. Schmidt, eds., *The Measurement of Productive Efficiency*, Oxford University Press, Oxford.

Habib M. A. Abdu P. Kwanashie C. N. Kabir J. and Negedu A. (2015) Isolation and identification of Aspergillus species from poultry feeds in Kaduna State, Nigeria*Microbiology Research International* Vol. 3, Issue 2 PP27-32

Hassan A.A. (2002): Comparative Economic Analysis of Poultry Egg production using Commercial and Home made feed in Kaduna State. An Unpublished M.Sc. Thesis, Department of Agric Economics and Rural Sociology, A.B.U. Zaria.

Helfand, S.M. (2003). Farm Size and the Determinant of Productive Efficiency in the Brazilian Centre-West. Proceedings of the 25th International Conference of Agricultural Economics, Durban, South Africa, 16th-22nd Aug., 2003, pp605-612.

Hildebrand, G. and T. Liu, (1965).*Manufacturing Production Functions in the United States*, Cornell University Press, Ithaca, NY.

Huang, T. and M. Wang, (2004). “Comparisons of Economic Inefficiency Between Output and Input Measures of Technical Inefficiency Using the Fourier Flexible Cost Function,” *Journal of Productivity Analysis*, 22, pp. 123-142.

Idiong, I. C. (2006). ”Evaluation of Technical, Allocative and Economic Efficiencies in Rice Production Systems in Cross-Rivers State, Nigeria”. Unpublished Ph.D Dissertation, Michael Okpara University of Agriculture, Umudike.

Johnston, J. (1959)Statistical Cost Analysis, McGraw-Hill, New York.

Kannike A . A. (2015). Poultry Value Chain – Unlocking One Trillion Naira Industry & Five Million Jobs.” Being the Text of Paper Presented at the Nigerian Poultry Show 2015,organized by the Poultry Association of Nigeria (PAN)Abeokuta, Ogun State.

Martinez-Budria, E., S. Jara-Diaz and F. Ramos-Real, (2003). “Adopting Productivity Theory to the Quadratic Cost Function: An Application to the Spanish Electric Sector,” *Journal of Productivity Analysis*, 20, pp. 213-229.

Mbanasor J. A. (2002): Resource Use Pattern Among Poultry Enterprises in Abia State Nigeria. *Nigerian Journal of Animal Production*. Vol. 29 No. 1: 64-70

Mbanasor J. A. and Jonas C.N. (2006): Efficiency of Indigenous Poultry Feed Production Enterprises in Abia State, Nigeria. www.unidep.org/Release3/Conferences/AES_2006/IDEP-AES-06-31PM accessed on: 26th September, 2012.

Meeusen, W., and J. van den Broeck, (1977). "Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error," *International Economic Review,* 18, pp. 435-444.

Mijinyawa Y; Ogbue C. R.; and Emmanuel O. A. (2012):Assessment of Noise Levels Generated in Some Feed Mills in Ibadan, Nigeria *Research Journal in Engineering and Applied Sciences.* 1(3) 156-159 Rjeas Emerging Academy Resources (2012) (ISSN: 2276-8467) www.emergingresource.org

Moreson N. L. (1988). Feed Formulation Guide. A Publication of Moreson Nigeria Limited, Ikeja, Lagos.

Munkaila, A. A; Taiwo, A. G. and Adeeko A. L (2013): Economic Analysis of Feedmill Industries in Ogun and Oyo States, Southwest of Nigeria. *Research Journal.* Vol. 2 No. 1: 24-30.

Murillo-Zamorano, L. and R. Vega-Cervera, (2001) "The Use of Parametric and Nonparametric Frontier Methods to Measure the Productive Efficiency in the Industrial Sector: A Comparative Study," *International Journal of Production Economics*, 69, pp. 265-275.

National Population Commission (NPC) (2014): Population estimates for Nigeria for July 2014. www.population.gov.ng/

Nerlove, M., (1963) "Returns to Scale in Electricity Supply," in Christ, C., et. al. eds., *Measurement in Economics*, Stanford University Press, Stanford.

Nigerian Institute of Animal Science (2015)

Njoku, P. C. (2007). In Iyayi E. A. Prospects and Challenges of Unconventional Poultry Feedstuffs at the 3rd National Institute of Poultry Scientists organized by World Poultry Science Association, Nigeria Branch, Abeokuta, Feb 2007.

Njoroge, S. C, Bett, E. K and Njehia, BB. K. (2015). Impact of Poultry Feed Price and Price Variability on Commercial Poultry Production in Murang'a County, Kenya. *IOSR Journal of Economics and Finance (IOSR-JEF) vol. 6, issue 1. PP 46-53.*

Ogundipe, S.O., (2002). Techniques of Rationformulation for poultry. Poultry production inNigeria. A Training Manual on National TrainingWorkshop on poultry production in Nigeria, held1-6 September 2002, Shika, Zaria, Nigeria.Published by the National Animal ProductionResearch Institute, Ahamadu Bello University,Shika, Zaria, and Nigeria, pg. 115-127.

Odii, A. C. A. (1998). "Modern Farm Management Techniques, *Owerri, Nigeria. Alphabet Publishers.*

Ojewola, G. S. (2004). Productive performance and body composition of broiler as influenced by dietary energyand protein in the humid tropics. PhD Thesis, Department of Animal Science, University of Ibadan, Nigeria.

Ojo, S.O. (2003): Productivity and Technical Efficiency of Poultry Egg Production in Nigeria.*International Journal of Poultry Science.* 2; (6): 459-464.

Oladejo, J.A. (2012), Economic Analysis of Feed Mill Industry in Lagos State, Nigeria. *International Journal of Research in Management Economics and Commerce.* 2; (4): 39-52

Oladoja M. A. and Olusanya T. P (2009). Impact of Private Feed Formulation and Production as a Tool for Poverty Alleviation among Poultry Farmers in Ogun State. *International Journal of Poultry Science* 8 (10): 1006 – 1010. ISSN 1682-8356 Asian Network for Scientific Information

Oladokun V.O. and Johnson A. (2012): Feed formulation Problem in Nigerian Poultry Farms: AMathematical Programming Approach. *American Journal of Scientific and Industrial Research*. Science Huβ, http://www.scihub.org/AJSIR ISSN: 2153-649X doi:10.5251/ajsir.2012.3.1.14.20.

Olowofeso, O. E. and Ajibefun, I. A. (1999). ”The Maximum Likelihood Estimation of Stochastic Frontier Production Function with Technical Efficiency Using Time Series Data. *Journal Sci. Eng. Tech. 6:1527-1536*

Olukosi, J. O. and Isitor, S. U. (1990). Introduction to Agricultural Marketing and Prices. Agitab Publishers Zaria, Nigeria

Oluwafemi R. (2008). Palm Kernel Cake (PKC) Utilization in Monogastric Animal Feeding - Implications for Sustainable Livestock Development.. *The Internet Journal of Veterinary Medicine.* 2008 Volume 6 Number 2.

Onwurah F.B. (2008). Excel Feed Formulation and Feeding Models Proceedings of the 1st International Technology, Education and Environment Conference (c) African Society for Scientific Research (ASSR) Co-Published By: Human Resource Management Academic Research Society 192

Oyediji, G. O. (2006). Feedmill Management in Nigeria. A Handbook for Animal Scientists, Feedmillers, Agriculture Students and Allied Professionals. University Press Ibadan ISBN 978-074-995-0. PP. x-xiii.

Oyediji, G. (2015). Trend in the Production of Animal Feed in Nigeria and the way forward.A paper presented at a three daystraining session organised for students of the Nigerian Institute of Animal Science Lagos Nigeria. June, 2015.

Poultry Association of Nigeria (2015). Trends in the Nigerian livestock Sector. A publication in the Poultry Association of Nigeria Website: www.pan..ng

Sahel Capital Limited (2015). An Assessment of the Nigerian Poultry Sector. Sahel Capital Partners & Advisory Limited (Mauritius). *A Newsletter of the poultry Industry Review Volume 11 June 2015.*

Samuelson, P., (1938)Foundations of Economic Analysis, Harvard University Press, Cambridge.

Sani Isiaku (2007). Cooperative based Dairy Production, Processing and Marketing in Kaduna State: A case study of Milk Cooperative Producers Limited (MILCOPAL). Unpublished M.Sc. Dissertation Submitted to the Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University Zaria.

Schdeler, S. E. (2008). Trace Mineral Balance in Poultry Diet. Available at <http://www.zootecnicalinternational.com/article-archive/nutrition/284-trace-mineral-balance-in-poultry.html>

Shapiro, R.H. (1983). Efficiency differentials in present agriculture and their implications for Development policies. *Journal for Development Studies* 19: 179-190.

Shephard, R., (1953)Cost and Production Functions,Princeton University Press, Princeton.

Shepherd, W.G. (1985). How Competition and Monopoly affect Performance Practice. Economic of IndustrialOrganisation. Hall International Inc., London, pp17.Simar, L. and P. Wilson, 1998, “Sensitivity Analysis of Efficiency Scores: How to Bootstrap in Nonparametric Frontier Models,” *Management Science*, 44, pp. 49-61.

Simar, L. and Wilson, 1999) “Of Course We Can Bootstrap DEA Scores! But, Does It Mean Anything?” *Journal of Productivity Analysis*, 11, pp. 67-80.

Xue, M. and P. Harker, (1999) Overcoming the Inherent Dependency of DEA Eficiency Scoring: A Bootstrap Approach,” Working Paper, Wharton Financial Institutions Center, University of Pennsylvania, Philadelphia.

Singh, B.N., Fagade, S., Ukwungwu, M.N., William, C., Jagtap, S.S., Oladimeji, O., Effisue, A. and Okhidievbie, O. (1997). Rice growing Environments and Biophysical Constraints in Different Agroecological Zones of Nigeria. *Meteorological Journal* **2** (1): 35-44

Singh, R. A. (1981). “Poultry Production Efficiency in India”. Kayyaru Publishers, New Delhi, Ludhiana, India. 3rd Edition.

Sonaiya E.B. (2006): Feed Resources for Smallholder Poultry in Nigeria**.** Department of Animal Science, Obafemi Awolowo University, Ile-Ife, Nigeria.

Tadesse, B. and Krishnamoorthy, S. (1997). ”Technical Efficiency in Paddy Farms of Tamil Nadu: An Analysis Based on Farm Size and Ecological Zone”. *Agricultural Economics Journal*. 16: 185-192.

Taylor, G.T. and Shonkwiler, J.S. (1986). Alternative Stochastic Specification of the Frontier Production Function in the Analysis of Agricultural Credit Programs and Technical Efficiency, *Journal of Development Economics*. 21: 149-160

Tinuke, M. F. (2013): Reducing Unemployment through the Informal Sector in Nigeria. *International Journal of Management Sciences.* Vol. 1, No. 7, 2013, 232-244

Udoh, E. J. and Etim, N. A. (2009). ”Efficiency of Rice Farmers in Akwa Ibom State, Nigeria: Potentials for Food Security and Poverty Alleviation”. *Journal of Farm Management.*16(3):731-735.

Udoh, E. J. and Etim, N. A. (2007). ”Application of Stochastic Production Frontier in the Estimation of Technical Efficiency of Cassava Based Farms in Akwa Ibom State, Nigeria”. *Agricultural Journal.* 2(6): 613-625.

Umar M. (2012).Economic Analysis of Poultry-egg Production in Bauchi Local Government Area, Bauchi State, Nigeria. An Unpublished M.Sc Thesis Submitted to the School of Postgraduate Studies, Ahmadu Bello University, Zaria

United State Department of Agriculture (2008). Nigeria Grain and Feed Annual Report

An ASSESSMENT OF COMMODITY AND TRADE ISSUES USDA. A Global Agricultural Information Network (GAIN) Report Number: NI10007.

United State Department of Agriculture (2013). USDA International Egg and Poultry: Nigeria. The PoultrySite - 5m Publishing, Benchmark House, 8 Smithy Wood Drive, Sheffield, S35 1QN, England.5m Enterprises Inc., Suite 4120, CBoT, 141 West Jackson Boulevard, Chicago, IL, 60604-2900, USA.- A *Benchmark Holdings plc. Company.* www.thepoutrysite.com

Ojo, S.O. and I.A. Ajibefun, (2000). Effects of Training on Labour Productivity and Efficiency in Oil Palm Production in Ondo State, Nigeria. *Journal of Sustainable Agriculture and Environment.* 2: 275-279.

Ray, S. and K. Mukherjee, (1995). “Comparing Parametric and Nonparametric Measures of Efficiency: A Reexamination of the Christensen and Greene Data,” *Journal of Quantitative Economics*, 11, pp. 155-168.

Shephard, R., (1985).Cost and Production Functions,Princeton University Press, Princeton.

Zellner, A., and N. Revankar, (1969) Generalized Production Functions,*Review of Economic Studies*, 36, pp. 241-250.

LIST OF APPENDICES

APPENDIX I:

POULTRY FEED MILLERS QUESTIONNAIRE

DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY

AND

NATIONAL AGRICULTURAL EXTENSION RESEARCH AND LIAISON SERVICES AHMADU BELLO UNIVERSITY, ZARIA.

RESEARCH TOPIC: PRODUCTION EFFICIENCY OF POULTRY FEED ENTERPRISES IN NIGERIA

Dear Respondent,

Please answer the following questions sincerely and tick the appropriate option. There are blank spaces to be filled and yes or no options, choose the correct option as much as possible please. The responses provided will be used strictly for academic purpose and all information will be kept confidentially.

Questionnaire Number………………………Date………………………………..

Name of Enumerator……………………………….GSM…………………………

A. CHARACTERISTICS OF THE FEED INDUSTRIES.

Background Information

1. Name of the Respondent……………………………………………………
2. Designation of the respondent [ ] Owner [ ] Owner Manager [ ] Manager [ ] Others Specify…………………………………………………………
3. GSM No, of the Respondent ………………………………………………..
4. Name of the feed mill……………..…………………………………………
5. Address or location of the mill………………………………………………
6. Year mill was established?..
7. Type of ownership: [ ] sole proprietor [ ] partnership [ ]Cooperative society [ ] Limited Liability [ ]Government owned enterprise [ ] others (specify)…………………… …….

8. Educational level of Proprietor or Respondent: [ ] Primary Education [ ] Secondary Education [ ] Tertiary Education [ ] Others Specify…………………………………
9. Gender of the Proprietor: [ ] Male [ ] Female
10. Age of proprietor (Years): …………………………………………………
11. Number of years in milling business:………………………………………
12. Membership of Miller Association: [ ] Yes [ ] No
13. Years of membership of Millers Association:………………………………
14. Mill Size/ Capacity of your mill per day (tons/day)………………………..…
15. Number of times you mill/day………………………………………………
16. Mill capacity/batch in tonnes…………………………………………………
17. Number of hours a batch of feed is produced..………………………………..
18. Number of hours of operation per day……………………………………..
19. Number of shifts per day……………………………………………………..
20. Length of shift in hours per day………………………………………………
21. Output (Total output per day)………………………………………………..
22. Number of days you mill per week…………………………………………
23. Number of mixers you operate in the mill…………………………………
24. Mill installed capacity…………………………………………………
25. What is the Percent of installed Capacity achieved…………………..………………….

B. LEVEL OF INPUTS USED FOR PRODUCTION

26. Provide information on the sources and distance from sources of the following ingredients

Distance to Market for ingredients

S/No	Ingredients/Inputs	Source(s) Name of Market	Distance from source Market (Km)	Market price/unit ingredient (Kg/bag).	Transport cost/ unit(Kg/bag) including loading and off loading cost
1.	Maize				
2.	Groundnut Cake (GNC)				
3.	Soybean meal				
4.	Soybean cake				
5.	Palm Kernel Cake				
6.	Brewers Dried Grain				
7.	Wheat Bran				
8.	Maize bran				
9.	Rice Bran				
10.	Fish meal				
11.	Bone meal				
12.	Limestone/oyster shell				

13.	Blood meal				
14.	Vitamins/mineral premix				
15.	Salt				
16.	Enzymes				
17.	Methionine				
18.	Lysine				

27. Provide information on the cost of the following ingredients

Cost of Ingredients

S/No	**Inputs/Ingredients**	**Quantity used per annum (tonnes)**	**Cost/unit tonne**	**Total cost ~~N~~**
1.	Maize			
2.	Groundnut Cake (GNC)			
3.	Soybean meal			
4.	Soybean cake			
5.	Palm Kernel Cake			
6.	Brewers Dried Grain			
7.	Wheat Bran			
8.	Maize bran			
9.	Rice Bran			
10	Fish meal			
11	Bone meal			
12	Limestone			
13	Blood meal			
14	Vitamins/ mineral premix			
15	Salt			
16	Enzymes			
17	Methionine			
18	Lysine			

C. OTHER COSTS OF PRODUCTION

28. Number of Employees in your mill…………………………………………

29. Salary paid to your employees per annum ~~N~~ ………………………………..

30. Please provide the following information on the employees of the feed mill

Operators	**Education level**	**Age(yrs)**	**Gender M/F**	**Experience (years)**	**Salary/wage/month**
Employees who mill/mix					

31. Fixed cost items

S/N	Items/ Machinery	Amount paid per annum if Rented	Quantity owned	purchase price/Unit (N)	Year purchased	Expected years of use (Lifespan)
1.	Land					
2.	Warehouse					
3.	Buildings					
4.	vehicles					
5.	Machinery					
i.	Milling machine					
ii.	Mixer					
iii.	Conveyer					
iv.	Sealing machine					
v.	Weighing scale					
vi.	Power Motors					
vii.	Electric. Generators					
viii.	Conveyor belts					
ix.	Wheel barrows					
x.	shovel					
xi.	Protective clothings					

S/No.	Utility Items	No./Quantity	Services Cost/month
1.	Vehicles		
2.	Telephones		
3.	Water		
4.	Electricity		
5.	Tax/levies		

`

32. Sources of energy and price for each source

S/No	Energy source	Quantity used per Annum	Price per unit (Litre)	Total
1.	Diesel (Litres)			
2.	Petrol (Litres)			
3.	Electricity (Kilowatts or Naira)			
4.	Water (Litres)			
5.	Empty bags			
6.	Thread for sealing			
7.	Paper Label			

D. LEVEL OF OUTPUT PRODUCED

33. Please indicate your product form [ ] Mash [ ] Pellet [ ] crumb [ ] others specify…….
34. Please indicate your product line or type [ ] Broiler Starter [ ] Broiler Finisher [ ] Chick [ ] Grower [ ] Layer [ ] Breeder [ ] Others specify…………………….

35. Indicate the quantity produced of each of the products in Q35 above

S/No	Product type	Quantity produced per annum (tonnes)	Price per unit of product	Total revenue
1.	Broiler Starter			
2.	Broiler Finisher			
3.	Chick			
4.	Grower			
5.	Layer			
6.	Breeder			
7.	Others specify…………….			

36. Existence of nearby similar milling business: [ ] yes [ ] No
37. If yes to 37, Number of similar milling business nearby:………………………
38. Are you able to meet the demand of your customers [ ] Yes [ ] No

39. If no what percentage of their demand are you able to meet?...............................
40. Why are you not able to meet their demand?...
    ………………………………………………………………………………
    ………………………………………………………………………………
    ………………………………………………………………………………
41. Suggest ways at which you can improve to meet their demand………………………………………………………………………
    ………………………………………………………………………………
    ………………………………………………………………………………
    …………………………………………………………………………………

D. FACTORS AFFECTING EFFICIENCY

i. Access to Capital and Credit Sources

42. What is your source of startup capital for milling business? [ ] Personal Savings [ ] Friends and Relatives [ ] Grant from an NGO [ ] Cooperative group [ ] Others specify…………..
43. Have you ever access any credit facility [ ] yes [ ] No
44. If yes, what is your source of credit [ ] Commercial Banks [ ] Bank of Agriculture [ ] Bank of Industry [ ] Non Governmental Organisations [ ] Others Specify…………...
45. Amount of credit accessed in 2013/2014 N………………………………………
46. Interest charged on loan…………………………………………………....%
47. Repayment period……………………………………………………………..

ii. Distance to market outlets for output

48. Accessibility to market for outputs: [ ] within the town of operation [ ] nearby towns not exceeding 100Km. [ ] A town above 100Km but within the State [ ] A town outside the state or region [ ]others specify……………………………………………

iii. Availability of ingredients throughout the season

49. Are feed production ingredients available throughout the year? [ ] Yes [ ] No
50. How many months of the year are ingredients available in required quantities…
51. Do you store feed ingredients for use? [ ] Yes [ ] No
52. If yes for how many months of the year do you store?.......................................
53. Give an estimate of annual storage cost for all your ingredient…………………

iv. Access to Electricity

54. What is your source of electricity for milling activities [ ] National Grid [ ] Generator
    [ ] Other Sources (Specify)……………………………………………………………..
55. How many hours of electricity do you enjoy per day……………………………
56. Estimate Number of months you operate on electricity per annum………………
57. How much are you charge per month for electricity…………………………
58. Estimate your average consumption per month (kilowatts)……………………..
59. How much do you spend on fueling generator per annum……………………..

v. Technology of milling

60. Please indicate the type of milling machine in your mill [ ] Hammer mill [ ] Burr Mill [ ]
61. Indicate the type of mixer you operate [ ] Automated [ ] Partly or semi-automated [ ] Manually operated [ ] Others Specify……….….
62. Are you able to meet your mill installed capacity [ ] Yes [ ] No
63. If No, what is the Difference between the installed and achieved capacity………………
64. What are the possible reasons for the differences between the installed and the achieved status
[a]……………………………………………………………………………
[b]……………………………………………………………………………
[c]…………………………………………………………………………
[d]……………………………………………………………………………

E. CONSTRAINTS TO FEED PRODUCTION

65. Please list the Problems of your feed milling Business in terms of Availability, Affordability, quality and Accessibility under the following headings:
i. Feed production ingredients
………………………………………………………………………………
………………………………………………………………………………
………………………………………………………………………………
……………………………………………………………………
ii. Machinery, Spare parts
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ii. Electricity……………………………………………………………
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……………………………………………………………………………
iii.
Marketing…………………………………………………………………
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iv.Tax and levies
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v. Security
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66. Other general problems…………………………………………………………………..
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67. Suggest possible solutions to the problems listed above………………………………….
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Thank You. May God continue to bless your business. Amen.

Time taken to complete Interview (Hours)……………………………………………….

APPENDIX 2:

MARKETS FOR VARIOUS FEED INGREDIENTS IN NIGERIA

MAIZE_MARKETS	Frequency	Percent
Abeokuta	2	.6
Birnin gwari	7	1.9
Bodija	6	1.7
Buruku	4	1.1
Dandume	2	.6
Dawanau	43	11.9
Funtua	2	0.6
Giwa	26	7.2
Ibadan	12	3.3
Idiroko	2	0.6
Igbo-ora	4	1.1
Ikara	1	0.3
Kafanchan	3	0.8
Kafur	1	0.3
Kasuwar magani	8	2.2
Kauru	6	1.7
Kawo	4	3.0
Kontagora	3	0.8
Kubau	1	0.3
Makarfi	20	5.5
Maya-igbora	8	2.2
Niger	3	0.8
Odega	3	0.8
Ojaodan	2	0.6
Oyo	6	1.7
Railway	1	0.3
Sabon Tasha	7	1.9
Sabon wuse	2	0.6
Sabon birni	21	5.8
Saminaka	19	5.3
Soba	7	1.9
Udawa	29	8.0
Yewa	2	0.6
Zaria	5	1.4
Total	**361**	**100.0**

GNC-MARKET	Frequency	Percent
Abeokuta	2	0.6
Bida	26	7.2
Chad	8	2.2
Dawanau	19	5.3
Gombe	19	5.2
Ibadan	2	0.6
Ikara	2	0.6
Kaduna	58	11.0
Kano	93	25.8
Kontagora	10	2.8
Maiduguri	25	7.0
Minna	4	1.1
Sagamu	2	0.6
Zaria	89	24.5

SBM-MARKET	Frequency	Percent
Benue	82	22.7
Bida	6	1.7
Dawanau	7	1.9
Funtua	4	1.1
Giwa	20	5.5
Ibadan	4	1.1
Ikara	6	1.7
Kaduna	103	28.6
Kano	43	13
Katsina	4	1.1
Keffi	4	1.1
Maiduguri	10	2.8
Maigana	3	.8
Makarfi	19	5.4
Makurdi	14	3.9
Niger	8	2.2
Sabuwa	3	.8
Sagamu	2	.6
Soba	7	1.9
Zaria	12	3.4
Total	**361**	**100.0**

SBC-MARKET	Frequency	Percent
Benue	82	22.7
bida	2	.6
dawanau	2	.6
Funtua	6	1.7
Giwa	14	3.9
Ibadan	4	1.1
Ikara	6	1.7
Kaduna	94	26
kano	83	24
Katsina	2	.6
Kawo	9	2.5
kontagora	8	2.2
maiduguri	4	1.1
Makarfi	5	1.4
Mando	5	1.4
minna	2	.6
Niger	2	.6
Sabon gaya	2	.6
sagamu	2	.6
Soba	7	1.9
Zaria	20	5.6
Total	**361**	**100.0**

PKC-MARKET	Frequency	Percent
Anambra	82	22.7
Abeokuta	2	.6
Akure	6	1.7
Calabar	2	.6
Enugu	2	.6
Ibadan	14	3.9
Ilaro	19	5.3
Kaduna	89	24.7
Kano	2	.6
Kogi	2	.6
Lagos	83	23
Mando	2	.6
Nsukka	4	1.1
Ogun	13	3.6
Ondo	4	1.1
Owere	4	1.1
Owode Yewa	28	14
Portharcourt	26	7.3
Sagamu	2	.6
Total	**361**	**100.0**

BDG-MARKET	Frequency	Percent
Lagos	99	27.4
Enugu	10	2.8
Ibadan	14	3.9
Ijebu Ode	2	.6
Kaduna	71	19.7
Kafanchan	2	.6
Railway Market	26	7.2
Nassarawa	49	13.6
Nigerian Breweries	88	24.4
Total	361	100.0

WHEAT BRAN	**Frequency**	**Percent**
Lagos	160	45.7
Abeokuta	2	.6
Golden penny kano	31	8.6
Ibadan	12	3.4
Ideal flour mills	46	12.7
Ivory Flour Mill	2	.6
Kaduna	66	18.3
Kano	18	5.0
Owode	2	.6
Zango	24	6.6
Total	361	100.0

MAIZE-BRAN	**Frequency**	**Percent**
	82	22.7
Abeokuta	2	.6
Birnin gwari	2	.6
Golden penny mills	24	6.6
grains mill	85	23.5
Ibadan	8	2.2
ideal flour mills	15	4.2
Ikara	7	1.9
Jaba	1	.3
Kaduna	58	16
Kano	4	1.1
Kawo	16	4.4
Lagos	16	4.4
Lere	2	.6
Makarfi	12	3.3
Niger	2	.6
railway market	2	.6
Saminaka	2	.6
Suleja	6	1.7

T/Balewa road	7	1.9
Zaria	8	2.2
Total	361	100.0

RICE BRAN	**Frequency**	**Percent**
	82	22.7
Abakalaki	10	2.8
Abeokuta	18	5.0
Benue	2	.6
Bida	21	5.8
grains mill	10	2.8
Ibadan	8	2.2
Ikara	4	1.1
Ilorin	10	2.8
Kaduna	68	18.8
Kawo	8	2.2
Kura	69	19
Lagos	2	.6
Makarfi	4	1.1
Owode	2	.6
Railway Market	18	5.0
Sabo	2	.6
Saminaka	7	1.9
Suleija	6	1.7
T/Balewa Road	10	2.8
Total	361	100.0

FISH MEAL	**Frequency**	**Percent**
	82	22.7
Abeokuta	17	4.8
Ibadan	14	3.9
kaduna market	68	18.8
Lagos	57	15.8
Maiduguri	40	11.1
railway market	35	9.7
sovet Kano	39	10.8
Yauri	9	2.5
Total	361	100.0

BONE MEAL	Frequency	Percent
	82	22.7
ABBATOIR Kano	46	13
Abeokuta	14	3.9
Ibadan	18	5.0
Idiroko	4	1.1
Ijebu Ode	4	1.1
kaduna abbatoir	43	12
Lagos	26	7.2
Niger	7	1.9
Ogun	2	.6
railway market	20	5.5
T/Balewa Road	15	4.2
Zango Kaduna	66	18
zaria abbatoir	16	4.4
Total	361	100.0

LIMESTONE	Frequency	Percent
	82	22.7
Abeokuta	2	.6
Animal care	10	2.8
Auchi	24	6.6
Badagry	4	1.1
Gboko	6	1.7
Ibadan	6	1.7
Ijebu ode	15	3
Kaduna	92	25.5
Kano	1	.3
Lagos	19	5.3
Mando	14	3.9
Obajana	10	2.8
Okpella	10	2.8
railway market	4	1.1
Sagamu	19	5.3
Sokoto	17	4.7
Sovet	14	3.9
T/Balewa Road	5	1.4
Zango Kaduna	7	1.9
Total	361	100.0

VITAMIN PREMIX	Frequency	Percent
	82	22.7
Abeokuta	14	3.9
Animal Care	38	10.6
Bio-Organics	46	12.7
Heritage Agro	2	.6
Ibadan	14	3.9
Kaduna	73	20.3
Kano	5	1.4
Lagos	37	10.2
Micronutrients company	2	.6
railway market	4	1.1
Sovet	27	7.5
Vetco	13	3.6
Zaria	4	1.1
Total	361	100.0

SALT MARKET	Frequency	Percent
	82	22.7
Abeokuta	39	10.8
Central market	62	17.2
Ibadan	14	3.9
Ijebu Ode	2	.6
Kaduna	52	14.4
Kano	11	3.0
Kawo	13	3.6
Lagos	31	8.6
Mando Market	2	.6
Sabon gari	12	2.5
Sagamu	2	.6
T/Balewa road	5	1.4
Tarauni Market	19	5.3
Zaria	15	4.2
Total	361	100.0

ENZYMES	Frequency	Percent
	82	22.7
Animal Care	54	15.4
bio-organics	20	5.5
Heritage Agro	2	.6
Ibadan	6	1.7
Kaduna	48	13.3
Kano	8	2.2
Lagos	50	14
Mando	21	5.8
Sagamu	2	.6
Sovet	21	5.8
Vetco	47	13.0
Total	361	100.0

METHIONINE	Frequency	Percent
animal care	48	13
Bio-organics	16	4.4
Ibadan	14	3.9
Kaduna	77	21.3
Kano	19	5.3
Lagos	68	18.8
Mando	2	.6
Sagamu	2	.6
Sovet	9	2.5
T/Balewa road	5	1.4
Vetco	19	5.3
Total	**361**	**100.0**

LYSINE	Frequency	Percent
	82	22.7
Abeokuta	3	.8
animal care	36	9
bio-organics	15	4.2
Ibadan	15	4.2
Kaduna	85	23.5
Kano	10	2.6
Lagos	72	19.9
Mando	7	1.9
Sovet	7	1.9
T/Balewa road	5	1.4
Vetco	22	6.1
Yakubu G/Way	2	.6
Total	**361**	**100.0**