ANALYSIS OF SCOPE AND ECONOMIC EFFICIENCY IN POULTRY-FISH ENTERPRISES IN IMO STATE, NIGERIA

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CERTIFICATION

This is to certify that this research study on " Analysis Of Scope And Economic Efficiency Of Fish Poultry Enterprises" In Imo State ,Nigeria Was Carried Out By **Opara Thaddeus Chiaka** with, Registration number: **2011455338,** a post graduate student in agricultural economics, Federal University of Technology Owerri in partial fulfillment of the Award Of Doctor of Philosophy (Ph.D) in Agricultural Economics.

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DEDICATION

This work is dedicated to God Almighty for His grace and mercy upon me and to my late father Sir B. O. Opara, whose wish was for me to excel in academics.

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ABSTRACT

This study analysed the scope and economic efficiency of poultry-fish enterprises in Imo State, Nigeria. The specific objectives were to: examine the Socio economic and enterprise characteristics of fish and poultry farmers, estimate cost function from profit function to determine scope efficiency of poultry-fish enterprises, determine how scope and economic efficiency related to the use of specific inputs or the production of specific output, evaluate the determinants of scope efficiency and economic efficiency in poultry-fish enterprises in the study area. A multi –stage sampling technique was used to select 210 respondents comprising of 60 fish farmers 60 poultry farmers and 90 joint poultry-fish farmers. Structured questionnaire were used to elicit information from respondents while descriptive statistics, inferential statistics. Quadratic regression model, Tobit regression model and analysis of variance were used for data analysis. Findings from the study showed that most of the farmers in the three categories were males, 57.1% for fish, 62.3% for poultry and 66.7% for joint enterprises respectively. Most of the Respondents were between 41 and 60 years age bracket, 65.1% for fish 80.3% for poultry and 58.3 for joint enterprises. The distribution of respondents by marital status showed that most of the farmers were married 80.9% for fish, 75.4% for poultry and 81.9% for joint enterprises. Majority of the respondents had household sizes of 4 to 5 persons, 65.1% for fish, 55.7% for poultry and 63.9% for joint enterprises. 69.8% of fish farmers and 67.2% of poultry farmers had 6 to 10 years farming experience while majority of joint farmers (56.9% had 1-3 years of farming experience. Most sole farmers were small scale farmers 39.7% for fish and 42.6% for poultry while most joint farmers were large scale farmer (75%). The three categories of farmers had poor access to credit with only 19.4 % of joint farmer able to access above ₦300, 000 credits. In this research, cost functions were recovered from unrestricted profit functions and were used to calculate scope efficiency. The main scope efficiency was 0.025 indicating that the joint production of fish and poultry enterprises reduces total cost by 2.5%. The mean economic efficiencies were 0.72 for fish, 0.68 for poultry and 0.77 for joint enterprises. This indicated that farms could reduce cost by producing at the lowest possible cost. The correlation of scope and economic efficiency with output quantities was positive and significant at 1% level suggesting that the joint production of fish and poultry on the same farm resulted in cost advantage. Also the correlation of scope and economic efficiency with expense ratio were all significant at 1% level which revealed that larger farms tends to have more scope and economic efficiency scores. Again scope and economic efficiency are significantly determined by level of education, farming experience, pond size, and flock size as well as credit amount. It is recommended that educational packages and appropriate training could be necessary to teach farmers those farming practices that encourages cost complementarities and financial institutions should be encouraged to improve on the volumes and terms of loans extended to farmers.

Key words: Animal protein supply, Quadratic regression model, scope efficiency, Tobit regression model.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Nigeria is faced with nutritional problem. Most Nigerians lack protein of animal origin, which causes negative health effect (Gavrilova, 2020). The growth rate of the Nigeria population is faster than that of animal production, which resulted to inadequate supply. The total production of meat in Nigeria increased from 408722 tons in 1971 to 1.45 million tons in 2020, while population increased from 57.3 million people to 205.87 million people in the same years, (Knoema Corporation, 2021). In per-capita terms, consumption is low compared with advanced economies (Jabo and Zaharadden, 2018). It is therefore necessary that animal protein supply in Nigeria should improve to meet consumption demands of Nigerians. Protein for human consumption usually comes from plant and animal sources. Plant proteins are deficient in certain essential amino acids notably methionine, tryptophan and lysine which are necessary for proper healthy growth (Bamiro, Otunaya, &Idowu, 2012). Animal protein however, is rich in these amino acids and as such a good quality protein. Poultry and Fish are major sources of animal protein which have a pivotal role to play in providing protein rich in these amino acids but their production are not meeting up the requirements of the increasing population, due to low productivity and inefficiency of livestock farmers (Ekaette, 2018).

Emokaro, Akinrinmola, & Emokpae, (2016), revealed that about 70% of Nigerians are engaged in agriculture, 90% of Nigeria's total food production comes from small holder farms and 60% of the country's population earns their living from these small holder farms. Yet animal protein is expensive, compared to other food groups. According to Olumide & Carles, (2017), average weekly household expenditure was highest for meat, fish and animal products.

Omorogiuwa, Zivnovic, & Ademoh, (2014), further explained that Nigeria has spent a huge amount on importation and had been heavily criticized by internal and external organizations who suggested that the federal government should stop depleting the foreign exchange reserve of Nigeria through importation. Furthermore, Nigeria Bureau of Statistics reported that in 2021, that Nigeria spends over 125 billion naira annually on fish importation. Yet the average Nigerian is noted to be protein deficient with no indication of attaining the daily protein requirement of 65g/caput/day (Oguoma, Ohajianya &Nwosu, 2010; Adewuyi, Philip, Ayinde &Adeleke 2010).

The target of increasing animal protein supply in the nation could be achieved through improving productivity and efficiency of farmers in the country especially the small scale farmers who dominate the nation's agriculture (Adeniyi, Omitayin & Ojo 2012).

According to Emokaro & Eweka (2015), luck alone does not explain the difference in profitability and productivity levels of farms with the same resources endowment.

Management is therefore a key factor determining the success or failure of a business enterprise. If farmers are educated about the need for best practices and cost saving strategies, they may well experience tremendous improvement in their monthly income, (Otekhile, 2017).

Producing more than one enterprise base on common and recurrent use of proprietary know-how and indivisible physical asset, is a good practice of cost saving strategy which improves efficiency. This cost saving strategy is the basic principle behind much of the studies on scope efficiency. Without an understanding of scope efficiency, it will be difficult to identify cost economies that may be achieved by multiproduct farms (Mafoua & Hossain, 2001).

According to Gao & Featherstone (2006), scope efficiency exist if the cost of producing several products together are lower than that of producing these products separately. It measures the percentage of cost savings in producing the output jointly in one farm rather than producing the products individually in different farms. The sources of scope efficiency lie in the complementary property among inputs which involves joint utilization of inputs and converting waste from one enterprise into a useful input in another enterprise. These complementary properties of inputs has been an important concept in measuring economic efficiency in a multiproduct framework. Scope efficiency according to Langemeier (2011) will lead to improvements in economic efficiency if properly harnessed. This provided the primary impetus for estimating economic efficiency in this study.

Scope efficiency was calculated by using parameters of quadratic cost function recovered from the parameters of unrestricted profit function because of three reasons;

1. Imposing curvature on a profit function is easier than imposing curvature on cost function (Mash & Featherstone, 2004).
2. Scope efficiency calculated from profit function is always on the production frontier, which avoids the problem that scope efficiency from the cost function is not necessarily on the production frontier. Avoiding X-efficiencies which violates the condition that scope efficiency requires, which entails that calculating scope efficiency from cost function may incorporate output inefficiencies (Berger, Hunter, &Timme, 1993).
3. The scope efficiency calculated from profit function can be a result from both the cost saving process on the input side and the optimal allocation of output supply in response to exogenous output prices.

Normalized quadratic functional form was used in this study, because it is self-dual in cost and profit functions and the links between these two functions do not depend on particular data points (Lusk, Featherstone, Mash, & Abdulhadri, 2002).

This work focused on farms with battery cage system of poultry–egg production and inland pond system of fish farming. This study emphasis was on smallholder farmers as they dominates the Nigerian agricultural sector engaging about 70% of the population and contributing between 30-40% of the nation's GDP (Ajetumobi *et al,* 2010; Emokaro *et al,*2016).

Current research on fish and poultry enterprises revealed that poultry and fish constitute the best quality of protein available to man (Adeniyi *et al.,* 2012). Therefore, analyzing the scope and economic efficiency between poultry and fish in Imo State became more imperative now.

1.2 Problem Statement

In Nigeria, malnutrition is widespread due to the decline in protein intake due to scarcity and unaffordable price of animal protein food sources such as egg, meat and fish, (Adekunmi, Ayinde & Ajala, 2017).

Poultry production is pivotal in the provision of affordable animal protein. Empirical evidence has shown that the products are in short supply and out of reach to majority of the population, thus are expensive in the Nigerian markets and this is attributed to low productivity of farmers, (Ekaette 2018). According to Jabo and Zaharadden, (2018) the available resources for poultry production are not efficiently utilized, Again despite the huge resources made available to poultry farmers in Nigeria, animal protein production is still below the expected quantity in Nigerian markets. The hope of self-sufficiency in animal protein production and supply is still a mirage as farmers cannot meet the demand of the Nigerian populace (Emokaro et al, 2016). In the same manner, Fish which use to be the cheapest animal protein product has gone beyond the reach of a common man. The reason is low productivity as farmers are not making optimal use of available inputs to increase their production in recent times (Umar, Makinta, & Kwatanda, 2014). The issue of major concern is that the reason for farm declining optimal use of available farm resources in maximization of output and expansion of animal protein products in Imo State has not been properly explained. Furthermore, evidence of improved technologies, breeds and relevant livestock production inputs has not been accompanied by increased output. Even where output is high, the expected profit per farmer dropped.

According to Ekaette (2018), the persistent low productivity in Nigeria is attributed to inefficient use of resources and poor managerial skills. This implies that there is a wide difference in performances of farmers with improved technology and farmers who efficiently used this farm input in livestock production. Farmer's inability to reduce cost by sharing cost between enterprises is a serious issue in livestock industry. Scope and economic efficiency has cost reduction and maximum output as a bedrock (Ehirim et al, 2016). Again, the reduction of cost of resources and skill by spreading the use of these resources and skills over two or more enterprise to achieve scope and economic efficiency is a major issue to livestock farmers in Imo state. Hence, the reason for low productivity. empirical evidences such as the works of Bamiro, Dayo, &Momoh, (2006); Nnaji, (2007) Bamiro et al (2012); and Zira et al (2015) have shown how livestock farmers can reduce cost of production and maximise output through joint utilisation of inputs such as labour and capital as well as converting waste from one enterprise into useful inputs for the other enterprise for instance, the use of poultry dropping to fertilize ponds, the use of poultry droppings to grow maggot for feeding fish, the use of poultry carcass to feed fish as well as feeding the fish with left over poultry feeds and droppings. These studies were not able to isolate and test the specific inputs and those activities, as well as the level of cost savings that led to the efficiency gains in poultry-fish enterprises which this study were able to address. The percentage of cost saving, the relationship between scope efficiency and the use of specific inputs as well as the production of specific output are the things to consider in diversification and the analysis of what enterprises can be integrated for the purpose of higher economic returns with reduced risks (Motsatsi, 2015). These are not available to small holder livestock farmers in Imo state. The analysis of scope efficiency for a combination of poultry and fish enterprises could indicate whether Nigerian farmers should focus on the production of a single enterprise or diversify into the production of the two enterprises.

1.3 Objectives of the study

The broad objective of this study was to analyze scope and economic efficiency in poultry -fish enterprises in Imo State, Nigeria.

The specific objectives were to:

i. Examine the socioeconomic and enterprise characteristics of fish farmers, poultry farmers and joint fish-poultry farmers in Imo state.

ii. Estimate cost function from profit function for fish and poultry enterprises and determine scope efficiency in the area.

iii. Estimate and compare economic efficiencies of fish-poultry joint enterprises, Poultry enterprises and fish enterprises in Imo State.

iv. Determine the relationship between scope and economic efficiency to specific input and output produced.

v. Evaluate the determinants of scope efficiency of fish-poultry enterprises in the study area.

vi. Evaluate the determinants of economic efficiency in fish-poultry enterprises in the study area.

1.4 Hypotheses of the study

The following hypotheses were tested.

1. There is no significant difference among the economic efficiencies of Fish enterprises, Poultry enterprises and joint fish-Poultry enterprises in the study area.
2. The sharable costs such as labour, feed and capital do not significantly and positively affect the scope efficiency in fish-poultry enterprise.
3. Scope efficiency is not significantly and positively affected by the use of specific input and the production of specific output in fish-poultry, enterprises in the study area.

4. Socio-economic and farm variables such as age, sex, farming experience, educational level, farm size, no of extension visit, credit amount household size do not significantly and positively affect the level of scope efficiency of sample farmers.
5. Socio-economic and farm variables such as age, sex, farming experience, educational level, farm size, no of extension visit, credit amount household size do not significantly and positively affect the level of economic efficiency of sample farmers.

1.5 Justification of study

World food is now relying more on animal sources and ironically, animal production in Nigeria is facing the dual challenges of sufficiency and safer production (Emokaro & Emokpae, 2013). The level of consumption of animal protein is very low in Nigeria. The report of FAO (2009) revealed that the diet of an average Nigerian contains 20% less than the recommended protein requirement, which is between 65 and 85g per person. This is no doubt responsible for most problems of malnutrition in Nigeria particularly Children and infants. It has been reported by World Health Organization (WHO,2007) that 35.3% of Nigerian Children between the ages of 0.5 and 5.99 years in the Urban Areas are malnourished, while 40.5% of Children of same age bracket in rural areas were under weight. Thus the usefulness of animal protein in human diet cannot be over emphasized (Adekumi Ayinde & Ajala,2017**).**

It is on the basis of this low animal protein intake that this study on scope and economic efficiency of poultry and fish farmers are carried out to proffer possible solution to the low protein production and high cost of animal protein in Nigeria. With the knowledge of scope efficiency, farmers and other stakeholders in agriculture will more effectively invest in this farm type, knowing that a combination of these enterprises can yield maximum profit at any given resource level. The result on the factors that affect efficiency of this farm type will guide financial institutions in disbursement of agricultural loans to farmers that have the ability to produce more efficiently thereby making repayment easier. This study not only will curtail the huge drain on the economy of Nigeria and health hazards associated with importation of frozen fish and chicken, but will also create employment opportunities. Employment of land, labour and capital make this study particularly important in agriculture where resource expansion is costly (Hallam, 1993). Knowing where potential cost savings exist and for which farm type provides stakeholders, economists and farmers with valuable information as they make investment decisions. The government will benefit greatly from this study in terms of provision of adequate policy that will empower farmers as well as enhance efficient utilization of available resources thereby achieving food security. This study will also attempt to extend literature on scope and economic efficiency in Imo State, which will provide basis for further researchers.

1.6 Scope of the Study

This study is limited to three Agricultural zones that make up Imo State. The zones include Owerri, Okigwe and Orlu. The respondents are limited to three groups of farmers which includes, farmers that has only poultry enterprises, farmers with only fish enterprises and farmers with joint fish-poultry enterprises.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Literature

2.1.1 Concept of Scope Efficiency

The concept of scope economies or scope efficiency is defined as the process of reducing the cost of resources and skills for an individual business enterprise by spreading the use of these resources and skills over two or more enterprises (Hofstraud, 2007).

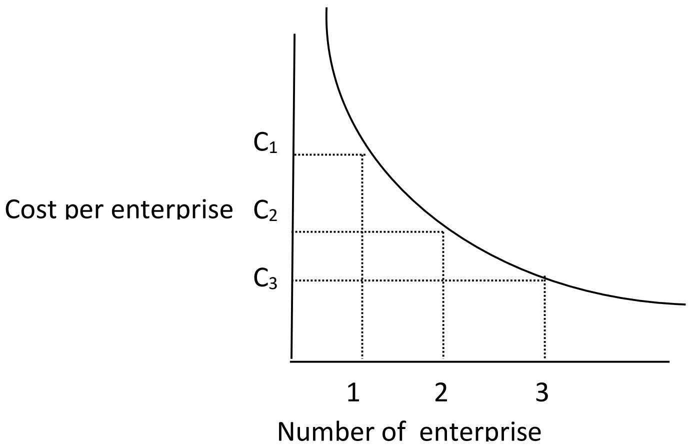

Fig 2.1 Cost per enterprise combination

As shown in figure 2. I, the cost for an enterprise is cut in half if the resources are used in two enterprises rather than just one. If the use of the resources is spread over three enterprises, the cost per enterprise is reduced to a third. These occur because the products may interact with each other as the proportions of non-usable joint products change with varying levels of output from a fixed technical unit (Hofstraud, 2007).

For example, the cost of a combine can be spread over several crop enterprises because, in many cases, the only thing needed to harvest another crop is a different combine thread. Another combine does not need to be purchased for each additional crop enterprise. Also one enterprise may contribute elements required in production of a second enterprise. Legumes and grass crops may contribute elements required in production of grain, fibre or other crops by (a) increasing fertility through the addition of nitrogen (b) Improving soil structure through the addition of organic matter (c) preventing soil erosion and (d) controlling insect (Olayide& Heady, 1982). These will drastically reduce the cost of inorganic manure, insecticides, liming and so on.

Unlike economies of scale, which can reasonably be expected to plateau into an efficient state which will then deliver high-margin revenues for a period, economics of scope may never reach that plateau at all. According to Venkatesh (2012), you may get to a point where you can claim you have right-sized and right-shaped the business, but you have to keep trying. In fact, managing the ongoing scope-learning process is the essential activity in business strategy. Economies of scale are the sufficient condition for the verification of a natural monopoly. In a multi-output case, economies of scope are, however the necessary condition. As a matter of simplification, it is generally accepted that markets may have monopoly features if both economies of scale and scope apply in any multi-output market situation (Venkatesh, 2012).

2.1.2 Economic Efficiency

Economic efficiency is concerned with the relative performance of the process used in transforming economic inputs into output (Ekaette *et al*, 2018).The concept of efficiency is dated back to the pioneering work of Farell (1957), who distinguished between three types of efficiencies

1. Technical efficiency (TE)
2. Allocative efficiency (AE)
3. Economic efficiency (EE)

Technical efficiency in production is the physical ratio of product output to the factor input, the greater the ratio the greater the magnitude of technical efficiency. It is the producer's ability to obtain the highest possible output from a quantity of inputs (Nwaru, Okoye & Ndukwu, 2011). The overall measure of technical efficiency can be segregated into three components; 1) pure technical efficiency (PTE) due to production within an isoquant frontier.2) congestion due to over utilisation of inputs and 3) scale efficiency due to deviation from constant returns to scale (Worthington & Dollery, 2000) .

Allocative efficiency is concerned with choosing optimal sets of inputs. A firm is allocative efficient when production occurs at a point where the marginal value product is equal to the marginal factor cost. It is the producer's ability to maximize profit given technical efficiency.

Economic efficiency is therefore defined as the gain from operating on the production frontier, while taking into account farm-specific prices faced and factor endowments (Mawa, Kavoi, Baltenweck, & Poole, 2014). It is a situation where there are both technical and allocative efficiencies (Nwaru *et al*, 2011; Ekatte, Ohen, &Idiong, 2018).

Economic efficiency of the i^{th} farm can be presented as

$$EEF = E\ [\exp(-u^*/u_i)] = E\ [(\exp(-- \sum^{D}_{d=1d} W_{di}/_i] \qquad \ldots 2.1$$

Where

E =expectation operator, which is achieved by obtaining the expressions for the conditional expectation u^*_i upon the observed value of u_i.

W_{di} = d^{th} explanatory variable associated with inefficiencies on the i^{th} farm

$_o$ and $_d$ = unknown parameter jointly estimated using the maximum likelihood method with the stochastic frontier and the inefficiency effects functions simultaneously.

The likelihood function is expressed in terms of the variance parameters, sigma squared (σ^2) =σ^2_v– σ^2_u and gamma (Y)= $\frac{\sigma u2}{\sigma v^2}$ (Battese & Coelli, 1995).

The parameter represents the share of inefficiency in the overall residual variance with values in the interval of O and 1. A value of 1 suggest the existence of a deterministic frontier, whereas a value of O can be seen as evidence in the favour of ordinary least square (OLS) estimation (Mawa *et al*, 2014).

2.1.3 **X-Efficiency**

X-efficiency is the difference between efficient behaviour of businesses assumed or implied by economic theory and their observed behaviour in practice caused by a lack of competitive pressure. The concept of x-efficiency was first proposed by economist Harvey Leibenstein in a 1966 paper. The theory of x-efficiency is controversial because it conflicts with the assumption of utility-maximizing axiom in economic theory. X-efficiency occurs when a firm has little incentive to control costs. This causes the average cost of production to be higher than necessary. When there is this lack of incentives, the firm will not be technically efficient.

There are two main causes of x-efficiency; first, monopoly power. A monopoly faces little or no competition; therefore it might be easy for the monopolist to make supernormal profits. Thus in the absence of competitive pressure, they may not try very hard to control costs. The second cause of x-efficiency is state control. A nationalized firm owned by the government may face little or no incentive to try and make profit. Therefore, it has less incentive to try and cut costs.

According to Leibenstein (1966), there are three known examples of x-efficiency; first, employing workers who are not necessary for the productive process. For example, a state owned firm may be more concerned about political implications of making people redundant than getting rid of surplus workers. Second, lack of management control. If a firm does not have supervision of workers, then productivity may fall as workers take it easy. Third, not finding cheapest supplier. Out of inertia, a firm may continue to source raw materials from a high cost supplier rather than look for cheaper raw materials.

2.1.4 Stochastic production Frontier

Stochastic production frontier models were introduced by Aigner, Loveli, & Schmidt, (1977) and Meensen & Van den Broeck (1977). Battesse & Coelli (1995) and Coelli (1996). According to Kumbhakar & Lovell (2000), the stochastic production frontier model can be extended to suggest that the inefficiency effects can be expressed as a linear function of explanatory variables, reflecting farm-specific characteristics. The advantage of the stochastic frontier model is that it allows estimation of farm specific efficiency scores and the factors explaining efficiency differentials among farms in a single stage estimation procedure (Mawa *et al.*, 2014).

The stochastic frontier function is defined as:

$$\pi = f(P_{ij}, Z_{ik}) \exp(\varepsilon) \quad \ldots. 2.4$$

Where

$\mathcal{E}_{i=}$ error term

$\mathcal{E}_i = v_i - u_i$ is assumed to behave in a manner consistent with the stochastic frontier concept.

π = normalized profit of the i^{th} farm

P_{ij} = Price of j^{th} variable input faced by the i^{th} farm divided by output price.

Z_{ik} = level of the K^{th} fixed factor on the i^{th} farm

V_i = systematic error term which is assumed to be identically and normally distributed with zero mean and constant variable as V $(0, \sigma_v^2)$

U is the one – sided disturbance term representing economic inefficiency and it is independent of v_i

2.1.5 Tobit Regression Model

The Tobit model is a statistical model proposed by James Tobin (1958) to describe the relationship between a non-negative dependent variable Yi and an independent variable Xi. The Tobit regression model is an econometric model that is employed when the dependent variable is limited or censored at both sides. If the data to be analyzed contain values of the dependent variable that is truncated or censored, the ordinary least square (OLS) is no longer applicable to the concept of estimated regression coefficient. If the OLS is directly used it will lead to biased and inconsistent parameter estimation, thus the Tobit model which follows the concept of maximum likelihood becomes a better choice to estimate regression coefficients. According to Idrissa, Ogunbameru, Ibrahim & Bawa, (2012). The major strength of the Tobit model is that it does not only explain the value of the dependent variables or the probability of limit (point of efficiency) and non-limit (point of inefficiency) response, but also the size (value) of the non-limit response.

Tobit model has been used in a large number of applications. Tobit is widely used in conjunction with Data Envelopment Analysis (DEA) and by economist. In DEA, efficiency scores lies in-between 0 and 1, which means that the dependent variable is censored at 0 from the left and 1 from the right. DEA is a nonparametric method in operation research and economics for the estimation of production frontiers. It is used empirically to measure production efficiency of decision making units (Charnes, 1978). It has also been used where the dependent variable is observed to be zero for some individual in the sample. The Tobit model was used by Akpan, Udoh & Akapn, (2014) to analyze loan default among Agricultural Credit Guarantee Scheme (ACGS) Loan Beneficiaries in Akwa Ibom State. (Salau, Adewumi, Omotesho, & Ayinde, 2011) used Tobit model to analyze the determinants of crop production intensification among Kwara and Niger State maize based farming household. It was also used by Shah (2010) to determine the factors associated with overall scope economies for various enterprise combinations and custom hiring in Irrigated Agriculture in the Punjab, Pakistan.

2.1.6 Fish Production in Nigeria

Fish farming is the rearing or production of fish in a controlled environment like pond, cage, tank, irrigated canals, reservoir and other types of enclosures (Umar *et al*, 2014). Fish accounts for 40% of the country's protein intake with consumption at 13.3kg/person/year(FAO, 2018). Nigerians current fish production stands at 0.8million metric tons with deficit of 1.9 million metric tons of fish as local demand for the protein is 2.7 million metric tons annually (Elsevier, 2020).

After the remarkable increase in both marine and inland fisheries, production has levelled off since 1970s due to the general trends of most of the world fishing areas, which have apparently reached their maximum potential for fish production, with the majority of the stock being fully exploited (Ele, Ibok, Autia-beny, Okon, & Udoh, 2013). This led to shortage in fish supply.

A substantial means of solving the problem of this shortage in Nigeria is by embarking on a widespread homestead/ small scale fish production. In order to bridge this gap between quantity produced and quantity demanded, the Nigerian government in 2001 made a tariff reduction on all fishery product from 25% to 5% in other to encourage importation to make up for the deficit. The value of fish import continue to increase year after year, by 2020 Nigeria had spent over N125 billion on fish imports alone which is a huge drain on the economy (National Bureau of Statistics, 2021).

Fish is medically recommended for pregnant woman, children and adults because of its high- level of protein digestibility, lack of cholesterol and a preventive recipe for heart attack or failure (FAO, 1991; Adeniyi *et al*, 2012). However, the imported seafood has serious health implications. Ingestion of these foods increases risks of cancer and cardiovascular diseases (Okolie, Akuoyamen, Okpoba & Okonkwo, 2009). The high content of lipid peroxidation of imported fish and meat samples may be a consequence of prolonged refrigeration. Imported frozen fish and chicken may take several months to reach the Nigerian consumer due to time used in importation, clearing, distribution and retailing. This period exceeds by far the United States Department of Agriculture (USDA) recommended safe time limits for refrigeration which is one to two days for fresh fish and three to five days for chicken (Okolie *et al*, 2009). Again the over reliance on fish importation has led to the underdevelopment of the domestic catches and aquaculture production in Nigeria. This needs an urgent attention if production in Nigeria is to be developed.

In a bid to address this problem in the past years, Nigeria began an implementation of import quota regime for fish in 2014. The aim was to stimulate the country to become self-sufficient in fish production over the next four years through a 25% annual fish import cut (USDA, 2018). An annual baseline fish import figure was set at 700000 metric tons for 2014 which reduces the allowable quantity of import to 500000 metric tons for the year, except for fish species farmed in the country (catfish and tilapia) which are now under prohibition from being imported without control. However, many industry watchers indicated that Nigeria's fish quota regime increased food prices, open up channels for profiteering by the politically connected and encouraged smuggling which worsened the situation. To this end, a substantial means of solving the demand-supply gap in fish production in Nigeria must be by embarking on widespread homestead/small scale fish farming (Kudi, Bako, &Atala, 2008; Umar *et al* 2014). These must be anchored on improving the productivity and efficiency of farms .

2.1.7 Poultry Production in Nigeria

Poultry refers to all types of domesticated birds. These include chickens, guinea fowl, turkeys, ducks, geese, ostriches, pigeons, pheasants and other game birds. Chickens are the most commonly reared poultry in Nigeria. Poultry production may be on small scale or large scale (FAO, 2018). The Nigerian poultry industry contributes 6-8% to real GDP annually about 30% to the agricultural GDP making it the largest producer of poultry eggs and fourth largest poultry meat producer in Africa, (FAOSTAT, 2018).

Poultry keeping is making an important contribution to the livelihood of the most vulnerable rural households in developing countries. In a study on income generation in transmigrate farming systems in East – Kalimantan, Indonesia, family poultry generated about 53% of the total income, which was used for food, school fees and expected expanses such as medicines (FAO, 2006). Poultry production is no doubt one of the most important ways of alleviating the scourge of protein deficiency in Nigeria and other developing countries.

Nutritionally, eating an egg per day is a good way of putting protein, fats, vitamins and minerals in human diet. According to Binuomote *et al.* (2008), a medium sized egg supplied about 80 calories of energy to our body. Egg contains not only a trace of carbohydrate, but it was also deemed to be a replacement for meat as it contains all essential amino-acids in adequate proportion required by the body for general growth and repair (Binuomote, Ajetomobi, & Ajao, 2008). The production cost per unit of poultry keeping is low relative to other types of livestock and returns to investment is high, thus farmers need just a small amount of capital to start a poultry farm (Okitoli, Ondwasy, Obali, & Murekefu, 2007). Cost, according to Anyanwuocho (2000), refers to monetary value of inputs used in production, while returns refer to income realized from the sale of output.

2.2 Theoretical Literature

2.2.1 Generalized Quadratic Cost Model

As a basis for developing short-run and long-run total cost functions of multi-product farms, the generalized quadratic cost (GQC) model is used (Featherstone and Moss, 1994):

$$C_{ft} = a_o + \sum a_{ij}Q_{flt} + \sum \beta_i W_{fit} + 0.5\ (\sum\sum a_{ij}Q_{fit}Q_{fjt} + \sum\sum\ \beta_{ij}W_{fit}W_{fjt}) + \sum\sum Y_{ij}W_{fit}Q_{fjt} \quad \ldots 2.6$$

Assuming cost minimization and using Shephard'slemna, a set of compensated input demand equations is derived:

$$C_{tI}/W_{fit} = \beta_i + \sum \beta_{ij}W_{fjt} + \sum Y_{ij}Q_{fjt} \quad \ldots 2.7$$

Symmetry is imposed by restricting $a_{ij} = a_{ji}$, $\beta_{ij} = \beta_{ji}$, and $Y_{ij} = Y_{ji}$ in the estimation procedure.

Flexible Fixed Quadratic Cost Model

Input prices are important in estimating cost functions. Due to the homogeneity of the farms location and little variation in input markets, input prices are not included in the model estimation (Mafoua & Hossain, 2001).

Although the use of inputs differs across farms, the sets of variable inputs (fertilizer, pesticides and seed) used by farmers are quite homogeneous. Therefore, the GQC sacrifices the linear homogeneity property of the cost function with respect to input prices. In addition, the use of a single intercept term (a_o) in quadratic cost specification is too restrictive. It does not take into account product-specific stand-alone or incremental fixed costs and reduces the combined effects of the quasi-fixed costs (constant terms) with the quadratic interaction term of output on scope economies. The basic specification of the empirical model is a flexible fixed cost quadratic function suggested by Lau (1974), embellished by Baumol, Panzar and willing (1982), and applied by Mayo (1984). By assuming that farms are in the long-run equilibrium and denoting D_i and D_{ij} dummy variables that will be equal, respectively, to one for farms producing only one enterprise (poultry or fish) and for farms producing two enterprises (poultry and fish), and zero otherwise. The long-run FFCO model may be written as follows:

$$C_{ft} = a_o + \sum a_{ij:i}D_i + \sum a_{oij}D_{fit} + \sum a_iQ_{fit} + 0.5\sum\sum a_{ij}Q_{fit}Q_{fjt} + e_{ft} \qquad \ldots 2.8$$

Where

C_{ft} = Total cost of farm f in year t;(N)

Q_{fit} = Quantity of crop I produced by farm f in year t;(Kg)

D_i = Dummy variable for farm f that produces only crop I; (farm that Produces crop i =1, farm that does not produce crop 1 =0)

D_{ij} = Dummy variable for farm f that produces crops I and j;(farm that Produce both crop 1 and j =1, farm that produces only crop i or j =0

e_{ft} = Residual error term for farm f in year t.

2.2.2 **Generalized quadratic profit function**

If the unrestricted quadratic profit functions which is assumed to be well-behaved can be expressed as:

$$\pi = pbo + P^* PA + PB * W + 0.5\ PC * P^1 + 0.5 * W^1 * PBB * W + P^* PAA * W \qquad \ldots 2.9$$

Assume both input and output markets are perfectly competitive, the unrestricted profit function can be obtained as a result of the following minimization problem.

$$\pi = \text{Max } P * Y - C\ (W, Y)$$

Where

P = vector of output prices P = [P_1, P_2….Pm]

Y = output quantities (kg)

W = input prices (₦)

π = profit

Pbo, PA, PAA, PB, PBB, PC are parameters to be estimated

The first order conditions of profit maximization allow us to determine the optimal output

$$P - \frac{d\pi}{dy} = \frac{c(w,y)}{dy} = 0$$

Is the general condition under perfect competition that the output prices equal the corresponding marginal cost of that output (Gao & Featherstone, 2006).

The stochastic profit function can them be expressed as:

$\pi = f(p_{ij}) = expe_j$ 2.10

Where

π= Normalized profit of the jth farm, calculated as $p_i = Y – C (W,Y)$

P_{ij} = the normalized price of input i for the jth farm, calculated as input price divided by farm specific output price

e_j = An error terms, the error term e is assumed to behave in a way that is consistent with the stochastic concept $e_j = v_j + u_j$.

V_j = The symmetric error term assumed to be independently and identically distributed.

U_i = A one sided error term which represents profits short fall from its maximum

2.2.3**Theoretical Relationship between Cost and Unrestricted Profit Functions**

Suppose that we have a normalized quadratic cost function

C (W, Y) = min wx where W is a vector of normalized input prices and Y is a vector of output quantities.

C (W, Y) has following properties:

1. C (W, Y) is continuous in (W, Y) and differentiable in W and Y
2. C (W, Y) is linear homogenous and concave in W
3. C (W, Y) is convex in Y

The normalized cost function with n+ 1 input and m outputs is:

C (W, Y) = b, + B* W + A* Y + 0.5* W* BB* W + 0.5* Y* cc- Y + W*AA* Y …2.11

1*n n*11*m m*1 1*nn*n l*n 1*m m*m m*11*n n*m m*1

Where: C (W, Y) is the cost, and W is a vector of input prices, both are normalized on the n + 1 input price, which implies that the cost function satisfies the homogeneity condition.

Formally:

$B = [b_1\ b_2\ \ldots b_n]$

$W = [w_1\ w_2 \ldots w_n]$

$A = [a_1\ a_2 \ldots a_m]$

$Y = [y_1\ y_2 \ldots y_m]$

Note; B and A are the coefficients of W (input prices) and Y (output quantities) respectively.

$$BB = \begin{bmatrix} b_{11} & b_{12} & b_{1n} \\ b_{21} & b_{22} & b_{2n} \\ . & . & . \\ . & . & . \\ . & . & . \\ b_{n1} & b_{n2} & b_{nn} \end{bmatrix}$$ and $b_{ij} = b_{ji}$ to satisfy symmetry

Condition in input prices

$$CC = \begin{bmatrix} c_{11} & c_{12} & c_{1n} \\ c_{21} & c_{22} & c_{2n} \\ . & . & . \\ . & . & . \\ . & . & . \\ c_{m1} & c_{m2} & c_{mm} \end{bmatrix}$$ and $c_{ij} = c_{ji}$ to satisfy symmetry

Condition in output quantities

$$AA = \begin{bmatrix} a_{11} & a_{12} & a_{1n} \\ a_{21} & a_{22} & a_{2n} \\ . & . & . \\ . & . & . \\ . & . & . \\ a_{m1} & a_{m2} & a_{mm} \end{bmatrix}$$

Curvature conditions required that cost function is concave in input prices W and convex in output quantities Y. The Hessian matrix of the normalized quadratic cost function on input prices and output quantities are just BB and CC respectively. The curvature and symmetry conditions together imply that the matrix BB and CC are negative semi-definite symmetric matrices and positive semi-define symmetric matrices, respectively. Empirically, Cholesky decomposition can be used to impose curvature globally on the cost function in estimating this function.

Assume both input and output markets are perfectly competitive, the unrestricted profit function can be obtained as a result of following maximization problem.

π=max P*Y-C (W, Y)

Where

π = profit

P is a vector of exogenous output prices, $P = [p_1\ p_2\ ...\ p_m]$.

Y= output quantities, W = input prices, π = profit

The first order conditions of profit maximization allow us to determine the optimal output $P - \frac{d\pi}{dy} = \frac{dc(w,y)}{dy} = 0$

By Solving a set of equations $P' = \frac{dc(w,y)}{dy} = 0$

is the general condition under perfect competition that the output prices equal the corresponding marginal cost of that output. For the normalized quadratic cost function (2.11), the first order conditions are: P' = A' + CC*y + AA'* W and the optimal output quantities are determined by solving for Y:

$Y^* = CC^{-1} * (P' - A' - AA' * W)^2$ ….2.12

Plug Y* into the original cost function (2.11) to solve for the cost function at the optimal output quantities

$C(W, Y^*) = b_0 + B*W + A*CC^{-1}* (P' – A^1 - AA^1 * W) + 0.5 * W*BB* W + 0.5 * [CC^{-1} * (P^1$

1*n n*1 1*m m*1 l*n n*n n*ll*m

$- A^1 - AA^1 * W)]' * CC*[CC^{-1} * (P^1 - A^1 - AA^1 * W)] + W' * AA* CC^{-1} * (P^1 - A^1 -$

$AA^1 * W)$

m*m l*n l*n n*m m*l 2.13

Where

BB, AA, CC, A, B are parameters to be estimated

b_o =constant

W = input prices

Y = output quantities

Expanding the function via multiplication, gives:

$$C(W, Y*) = bo + B*W + (A*CC-1 * P' - A* CC' * A1 - A*CC - 1AA' * W)$$

$$+0.5 * W' * BB * W + 0.5 * [(P' - A' - AA' * W)' * (CC1) * (P' - A' - AA' * W)$$

$$+ (W' * AA * CC' * P' - W' * AA * CC - 1 * AA' * W) \ldots 2.14$$

Because CC and BB are symmetric matrices, (CC^{-1}) is equal to CC and $(BB)^1$ is equal to BB. By further expanding equation (4), the cost function is:

$$C\ (W,Y*)\ =\ bo+\ A*CC-1\ *A1+\ 0.5\ *\ A*CC-1*A1+B*W\ -\ A$$
$$*CC-1*AA1*W\ +\ 0.5*W1*AA*CC-1*A1\ +\ 0.5*\ A$$
$$*CC1*AA1*W\ -\ w1*\ AA*CC-1\ *\ A1\ +A*CC-1$$
$$*P1\ \_0.5*\ A*CC-1*\ P1\ 0.5*\ P*cc-1*\ A1+0.5*W1$$
$$*\ BB*W\ +0.5*W1\ *\ AA*CC-1\ *\ AA1\ *WW\_w1*\ AA$$
$$*CC1*\ AA1*W\ +0.5*P*CC-1\ *\ P1-0.5*W1\ *\ AA$$
$$*CC1*\ P1\ 0.5*\ PCC'\ *\ AA1\ *\ W\ +\ W1*\ AA*CC1$$
$$*P1 \qquad \ldots 2.15$$

Since each term in equation (2.14) is a scalar, we can transpose any item in the above equation.

This allows us to combine A*CC-^{1} * A and 0.5* A* CC-^{1} * A^{1}in line 1, cancel out 0.5*W^{1} * AA*CC-^{1} * A^{1}, 0.5* A* CC-^{1} * AA^{1}* Wand W^{1} * AA*CC-^{1} * A^{1} in line 2, cancel out third line, combine 0.5*W^{1}* AA*CC^{-1} * AA^{1}*W and W^{1} * AA*CC-^{1}* AA^{1} W in line four, and cancel out the last line of equation (2.14). As a result, we can find a simplified cost function, which is:

$$C\ (W,Y*)\ =bo-0.5*\ A*CC-1\ *\ A1\ +\ (B\ -\ A*CC-1\ *\ AAI)*W$$
$$+0.5\ *\ W1\ *\ (BB\ -\ AA*CC-l\ *\ AA1)\ *\ W\ +\ 0.5*\ P*CC-l$$
$$*\ P\ldots 2.16$$

Now, plug the optimal output Y* (equation (2.11) and the above cost function into the profit function,

$$\Pi = p * Y - C(W, Y *), the\ unrestricted\ profit\ function\ is$$

$$= P * CC - l * (P1 - Al - AA1 * W) - (bo - 0.5 * A * CC - 1 * A + (B - A * CC1 * AA1) * W + 0.5 * W1 * (BB - AA * CC - l * AA1) * W + 0.5 * P * CC - 1 * P1] \quad \ldots 2.17$$

$$By\ simplifying\ equation\ (2.17), we\ obtain$$

$$= bo, + 0.5 ** CC - 1 * A1 - ! * CC1 * P1 + (A * CC - 1 * AA1 - B) * W + 0.5 * P * CC - l * P1 + 0.5 * W1 * (AA * CC - 1 * AA1 - BB) * W - W1 * CC1 * AA1 * P1 \ldots 2.18$$

Equation (2.18) is the unrestricted profit function expressed by the parameters of a given cost function, input and output prices. It is also a normalized quadratic function. The next step is to find the inverse relationships, to recover the cost function from the unrestricted profit

Function. At this point, if the unrestricted normalized quadratic profit function is used as the form

$$\pi = pbo + P * PA + PB * W + 0.5 * P * PCC * P1 + 0.5 * W1 * PBB * W + P * PAA * W \ldots 2.19$$

$$1 * m\, m * 1\ 1 * n\ n * 1 \quad 1 * m\, m * m\ m * 1 \quad 1 * n\, n * n\ n * 11 * m\, m * n\ n * 1$$

The profit function can be expressed by the corresponding cost function, and the parameters in these two functions have the following relationships:

$Pbo = -bo + 0.5 * A * CC - 1 * A1, PA + -A * CC - 1, PB = A * CC1 * AA1 - B \ldots 2.20$

$$PCC = CC - 1, PAA + -AA * CC - 1 and\ PBB$$
$$= AA * CC - 1 * AA1 - BB \ldots 2.21$$

With the explicit relationships between the parameters from the cost and unrestricted profit function, we can recover the parameters in the profit function from the cost function.

However, recovering the parameters in the cost function using the profit function may not be as straightforward as recovering the parameters in the profit function using cost function. Two cases exist. In the first case, the relationships between the parameters from the cost and profit functions are highly nonlinear, and it may be intractable to find the inverse function given parameters in profit function as a function of parameters in cost function. That is, it's difficult to express the parameters in the cost function explicitly with the parameters in profit function. Empirically, EXCEL or GAMS can be used to recover the unknown parameters in the cost function using parameters from the profit function by the explicit relationships that we have derived in (2.18) and (2.19) i.e. parameters in profit function as functions of parameters in cost function. In the second case, the relationships are not highly nonlinear, and it is easy to solve the inverse relationships between the parameters of cost and profit functions, i.e., express the parameters of a cost function as a function of the parameters from the profit function. In this case, the cost function can be recovered directly from the profit function using those relationships.

In our case, it is tractable to solve the inverse relationships between the parameters from the profit function and cost functions. With the relationships in (2.20) and 2.21), the parameters in the cost function can be expressed using those in the profit function.

$$bo \ = -pbo + 0.5 * PA * PCC - 1 * PA1, A \ = -PA * \ PCC - 1, B$$
$$= \ PA * \ PCC - 1 \ * \ PAA$$
$$- PB \qquad ..2.22$$

$$CC \ = \ PCC - 1, AA = \ - PAA \ * \ PCC - 1 \ and \ BB$$
$$= \ PAA * \ PCC - 1 \ * \ PAA1 - PBB \ 2.23$$

The results in (2.22) and (2.23) imply that for a normalized quadratic profit function, the underlying cost function can be recovered using linear algebra computations.

Note: All the variables remain as defined in equation 2.13

2.2.4 The Theory of Tobit Regression Model

As econometric models with truncated or censored error terms come into increasing, almost routine, use, it is important that the information they provide be used fully and correctly. One of the models that is seeing increasing use is Tobit analysis, a model devised by Tobin (1958) in which it is assumed that the dependent variable has a number of its values clustered at limiting value, usually

Zero. For example, data on demand for consumption goods often have values clustered at zero; data on hours of work often have the same clustering. The Tobit technique uses all observations, both those at the limit and those above it, to estimate a regression line, and it is to be preferred, in general, over alternative techniques that estimate a line only with the observations above the limit (McDonald &Moffit, 1980).

McDonald &Moffit, (1980) in their paper titled Uses of Tobit Analyses pointed out that the coefficients obtained from using Tobit called "beta" coefficients-provide more information than is commonly realized. In particular, they showed that Tobit can be used to determine both changes in the probability of being above the limit and changes in the value of the dependent variable if it is already above the limit; and they showed that this decomposition can be quantified in rather useful and insightful ways. In addition, applied the decomposition to several journal articles that have used Tobit analysis, and they showed the additional information that could have been obtained in these articles-and the errors that could have been avoided-if the decomposition had been used. Thus their paper illustrated an important use of Tobit analysis which could be usefully employed as the model is more widely used.

The decomposition also has important substantive economic and policy implications. For example, they were first led to the problem by the following question: How will the labor-supply reductions induced by a negative income tax be spread between marginal decreases in hours worked and decreases in the probability of working any hours? As it turns out, policymakers in the executive and legislative branches are *not* indifferent as to the composition of the total reduction. It was not obvious how to use their Tobit beta coefficients to answer this question, and a review of the literature revealed the mathematical relationships involved in the decomposition.

The stochastic model underlying Tobit may be expressed by the following relationship

$$Yt = X_t\beta + u_t, \qquad \text{if } X_t\beta + u_t > 0$$

$$= 0 \qquad \text{if } X_t\beta + u_t, \leq 0,$$

$$t = 1,2,\ldots\ldots\ldots\ldots N, \qquad \ldots\ldots 2.24$$

where N is the number of observations, Y_ts the dependent variable, X_ts a vector of independent variables, β is a vector of unknown coefficients, and u_t, is an independently distributed error term assumed to be normal with zero mean and constant variance Thus the model assumes that there is an underlying, stochastic index equal to $(X_{tt}\beta + U_t)$ which is observed only when it is positive, and hence qualifies as an unobserved, latent variable.

As Tobin shows, the expected value of *Y* in the model is

$$Ey = X\beta F(z) + \sigma f(z) \qquad \ldots 2.25$$

Where z = $X\beta/, f(z)$ is the unit normal density, and $F(z)$ is the cumulative normal distribution function (individual subscripts are omitted for notational convenience). Furthermore, the expected value of *y* for observations above the limit, here called *y**, is simply $X\beta$ plus the expected value of the truncated normal error term (Amemiya, 1973);

$$Ey^* = E(y/y > 0)$$

$$= E(y/u > -X\beta$$

$$= X\beta + \sigma f(z)/F(z). \qquad \ldots .2.26$$

Consequently, the basic relationship between the expected value of all observations, *Ey* , the expected value conditional upon being above the limit, *Ey**, and the probability of being above the limit, *F(z)*, is

$$Ey = F(z)Ey^*. \qquad \ldots .2.27$$

The decomposition that we have found useful is obtained by considering the effect of a change in the i^{th} variable of *X* on y:

$$\partial Ey/\partial X_i = F(z)(\partial Ey^*/\partial X_t) + Ey^*(\partial F(z)/\partial X_i) \cdot \qquad \ldots 2.28$$

Thus the total change in *y* can be disaggregated into two, very intuitive parts; (1) the change in *y* of those above the limit, weighted by the probability of being above the limit; and (2) the change in the probability of being above the limit,

Weighted by the expected value of *y* if above. The relative magnitude of these two quantities is an important indicator with substantive economic implications.

Assuming that one has estimates of β and each of the terms in equation (2.28) can be evaluated at some value of *Xβ,* usually at the mean of the *X's* X. The value of *Ey** can be calculated from equation (2.26), and the value of F(z) can be obtained directly from statistical tables. The two partial derivatives are also calculable:

$$\partial F(z)/\partial X_i = f(z)\ \beta_i/\sigma \qquad \ldots 2.29$$

And, from equation (2.26),

$$\partial Ey^*/\partial X_i = \beta_i + (\sigma/F(z)\ \partial Xi - (\sigma f(z)/F(z)^2)\partial F(z)/\partial x_1$$

$$= \beta_{i;}[1 - zF(z)/F(z) - F(z)^2/F(z)^2] \qquad \ldots 2.30$$

Using $F'(z) = f(z)$ and $f'(z) = -zf(z)$ for a unit normal density.

It should be noted from equation (2.30) that the effect of a change in X_j on y^* is not equal to β_i. It is a common error in the literature to assume that the Tobit beta coefficients for observations above the limit. As can be seen from equation (2.30), this is true only when X equals infinity, in which case F(z) = 1 and f(z) = 0. This will of course not hold at the mean of the sample or for any individual observations. It should also be noted that equations (2.29) and (2.30) are substituted into equation (2.26), the total effect Ey/X_i can be seen to equal simply $F(z)\beta_i$.

Furthermore, by dividing both sides of equation (2.26) by $F(z)\ \beta_{i,}$ it easily can be seen that the fraction of the total effect due to the effect above the limit, $\partial Ey^*/\partial X_j$, is just [I - $zf(z)/F(z) – F(z)^2/F9z)^2]$. Thus, the information seek in the decomposition can be obtained by calculating fraction. In addition, as mentioned this is also the fraction by which the β_i coefficients must be adjusted to obtain correct regression effects for observations above the limit.

The discussion thus far has consisted only of a further elaboration of the implications of Tobin's original model. In order to make an empirical application, the model assumes that estimates of β have been obtained. Tobin (1958) and Amemiya (1973) have shown that consistent estimates of these parameters can be obtained with maximum likelihood techniques, or plim(b) = β and plim(s) = The small-sample, properties of expressions such as those in equation to (2.25) to (2.30) are unknown. Investigation of small-sample properties of models such as the Tobit model would be a fruitful area for future research.

The decomposition outlined here disaggregates Tobit effects into (l) effect on the probability of being above zero and (2) effects conditional upon being above zero. That is, if it is already above zero. It is readily generalizable to several Tobit extensions, such as an upper limit rather than a lower, a nonzero limit rather than a zero, and a different limit for each observation as Tobit originally assumed, in fact). It is also applicable to recent, more sophisticated variants, such as models with an unobserved, stochastic limit (Nelson, 1977); those with two limits, an upper *and* a lower (Rosett& Nelson, 1975); and simultaneous equations models (Amemiya, 1974). In addition, the decomposition can be applied in somewhat different form to models of market disequilibrium (Goldfeld & Quandt, 1975) to obtain separate effects on the probability of supply being greater than demand and so on with obvious extensions.

On the other hand, there are some applications in which the decomposition is not of much interest. For example, the estimation of earnings equations on artificially-created, income-truncated samples (such as that containing only poor families) requires Tobit type maximum-likelihood estimation (Hausman & Wise, 1977), but a decomposition is not of much interest because here one is interested in the underlying Tobit index, whose expected value is that of the underlying population of interest.

Thus the decomposition is not relevant whenever one is indeed interested in the untruncated population; in this case the beta coefficients are directly usable.

A model in which both the problems of a limit value for the dependent variable and sample truncation arise has been developed by Heckman (1976). In this model the labor supply of a woman is limited at zero hours, and a wage rate is observed only for those who work. In the case of the wage rate, we are interested in Tobit beta coefficients if we wish to obtain unbiased estimates of the function describing the wages women can earn in the market. For the labor-supply function, however, the technique pointed out is relevant. Indeed, Heckan (1976) as used the relationship in equation (2.26) labor supply to develop an estimation technique for the model.

2.3 Empirical Literature

2.3.1 Empirical Study on Scope Efficiency

Gao & Featherstone (2006) used the normalized quadratic profit function in estimating economies of scope in Kansas.

In their paper, 500 data points for each of the three input prices and two output prices were generated using Monte–Carlo procedure. The parameters of the normalized cost function (true cost function) were specified so that the cost function satisfied condition of homogeneity. Homogeneity was satisfied by normalizing all prices and cost by the third input price, symmetry was imposed by letting the Hessian matrix of input prices and output quantities being symmetric and curvature was imposed using cholsely decomposition, which means the Hessian matrix on input side can be expressed as

$$BB = \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} = \begin{pmatrix} d11 & 0 \\ d_{21} & d_{22} \end{pmatrix} * \begin{pmatrix} d_{11} & 0 \\ d_{21} & d_{22} \end{pmatrix} \text{ and}$$

Hessian matrix on the output side can be expressed as

$$Cc = \begin{pmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{pmatrix} = \begin{pmatrix} e_{11} & 0 \\ e_{21} & e_{22} \end{pmatrix} * \begin{pmatrix} e_{11} & 0 \\ e_{21} & e_{22} \end{pmatrix}$$

With input and output prices, as well as the parameters in cost function, the optimal output quantities Y* were calculated by

$Y^* = CC^*(P^1 - A^1 - AA^1 * W)$ as in equation 2.12

The minimized cost c(w,y*) were determined using the input prices and optimal output quantities maximized profits were the difference between maximized revenue and minimize cost

$$\pi = p^*Y - c\ (w,y) \qquad ...2.31$$

All the costs and profit were calculated at each of the 500 data points the unrestricted normalized quadratic profit function was estimated with profit on the left side and input and output prices on the right side. At this point, unrestricted profit function was estimated and the objective is to recover the cost function using the relationship between the parameters of cost and profit function.

The result showed that all the recovered parameters in the AA matrix cost function were the same as the true parameters of the cost in data generating process, which verified the method. Using Hotelling's lemma, the optimal output quantities were obtained at each of the 500 data points.

With recovered parameters of cost function, mean input prices and mean output quantities obtained by hotelling's lemma. The economies of scope at mean optimal output quantities and input prices were calculated using

$$EOS = \frac{C\ (w, y1) +\ (w, y2) - c\ (w, y)}{C\ (w, y)} \quad \ldots 2.32$$

Which were 0.44, implying relatively weak economics of scope.

Where C (w,y_1)= the cost of producing only Y_1

C (w, y_2)=the cost of producing only Y_2

C (w,y) = the cost of producing all output by a single multiproduct firm

2.3.2 Economics of Fish Production in Nigeria

Nigerians are large consumers of fish with demand estimated of 1.4 million metric tons. However, a demand supply gap of at least 0.7 million metric tons exists nationally with import making up the short fall at a cost of almost 0.5 billion US dollars per year (Adewuyi *et al.*, 2010). According to Ele *et al.*, (2013), a substantial means of solving the demand – supply gap in fish production in Nigeria is by embarking on widespread homestead / small sale fish production.

Which according to Kudi *et al.,* (2008) must be anchored on analysis of fish production.

Number of studies has been reported on the economics of fish farming around the world. (Kassali, Baruwa, & Manama, 2011) analyzed the economies of inland fishing, aquaculture and fish marketing in Niamey and Tillabery areas of Niger Republic. The study showed that both the aquaculture and inland fish production were profitable with rate of return of 61% and 32% respectively. (Yusuf & Malmo, 2002) assessed the economies of fish farming in Ibadan metropolis, Nigeria. The gross margin analysis revealed that medium scale farmers derived the highest return of ₦1.55 for every one naira expended, this is followed by large-scale farmers at ₦1.52 for every one naira compared with only ₦1.32 for every one naira spent by small-scale farmers. Ajao (2006) found that 80% of fish farmers in Oyo State, Nigeria operated less than two (2) ha which could not capture economy of size. More than 90% of the respondents distributed their fish at the site while 60% had little access to extension agents. Meanwhile fish farming was found to be profitable. Kudi *et al.,* (2008) examined the resources, cost and returns as well as other factors affecting fish production in Kaduna State Nigeria. The study revealed that land, water, labour and capital were the main resources employed in fish production. The cost and returns analysis indicated that, variable cost constituted 97.63% of the total cost of fish production in the study area, while the fixed cost constituted 2.37%. Amongst the variable inputs, Fingerings/juveniles (42.82%) and feed (34.70%) constituted the highest (77.52%) to cost of production, while hired labour constitutes 16.91%. the cost of production was ₦571, 231.79. The total revenue of ₦5, 853,625.64 and the net income was ₦5, 282,393.85 indicating that fish production was highly profitable. Ele *et al.,* (2014) examined the economic analysis of fish farming in Calabar, Cross River State, Nigeria. The study revealed that all the farmers used intensive method of farming. The major fish domesticated was clarias (catfish) 61%, followed by tilapia (ladyfish) 32%. Most feeds used by the farmers were formulated and were brought in from other states (Oyo and Plateau). It was also discovered that amount spent on stocking accounted for (37.27%) of the running cost, followed by amount spent on water (30.21%), feeding (16.51%) and labour (14.84%). Fish farming was also found to be profitable despite the high cost of running the farm and production constraint.

2.3.3 Economics of Poultry Production

Poultry production is no doubt one of the most important ways of alleviating the scourge of protein deficiency and poverty in Nigeria. Egg contains not only a trace of carbohydrate, but it was also deem to be a replacement for meat as it contains all essential amino-acids in adequate proportion required by the body for general growth and repair (Binuomote, Ajetomobi & Ajao, 2008). Ojo (2003), found that the mean value of egg produced in Nigeria was ₦6, 263,105.9 per farmer, when compared with a mean total cost of ₦2, 158,162.53 showing that egg production was very profitable in Nigeria.

Yusuf & Malomo (2007) highlighted that over 90% of the cost of production in poultry egg production is on the variable inputs. Large farm size has the lowest cost of production per bird because as the farm size increases the cost of production decreases. The feeds constitute the highest percentage of 78.09%, 81.04% and 83.86% respectively of the cost for large, medium and small farms. This is followed by labour, cost of stock, transportation cost, medication, veterinary cost, while miscellaneous cost constitute the least cost in production. Charles (2006) gathered that the average variable cost per bird for chick's multiplication and production system (CMPS) for farmers in Plateau State was ₦ 43.45 and average fixed cost was ₦6.64. The variable cost items we investigated were supplementary feed, purchase of stock, labour and vaccines and these accounted for 24%, 27%, 32% and 2.8% respectively of total cost of production. His analysis showed that net farm income (NFI) per bird was ₦544.62 and the profitability index was ₦10.87 which means that when you invest one naira in CMPS you get ₦10.87 return on the investment.

2.3.4 Integration of Fish and Poultry in Nigeria

Apart from the fact that Nigeria's agricultural production are not meeting up with food requirement of its increasing population, its greatest problem is that of inadequate animal protein in the diets of a large proportion of the population especially in the rural areas which constitute over 70% of the population (Bamiro *et al.*, 2012). Due to the nutritional importance of animal protein, successive governments programmes such as farm settlement scheme. Agricultural Development Project (ADP) and United Nation Development Programme (UNDP) as well as sponsored livestock programme have been established by the government with the aim of meeting the FAO recommended 35g per caput of animal protein per day (Bamiro *et al.*, 2012). These programmes are yet to yield substantial result of improving animal protein intake in the nation.

In Nigeria, poultry contributes just about 15% of total animal protein intake while fish provides 40% of the dietary intake of animal protein of the average Nigerian (Kudi *et al.*, 2008). Still in the pursuit of adequate supply of animal protein, recently in Nigeria, The United Nation Development Programme (UNDP) instituted a livestock production enhancing programme in the country recently with the objective of:

- Training farmers on improved livestock breeds
- Training farmers on improved and modern rearing and production methods of livestock
- Increasing the production of livestock products and consequently farmers' income (Bamiro *et al.*, 2012).

The major problems that confront livestock production in Nigeria are high cost of feed and risk associated with unstable prices due to economic instability which affects the profitability of livestock enterprises. Bamiro *et al.*, (2006) reported that horizontal and vertical integration need to be adopted by farmers to reduce risk to some extent. Horizontal integration means acquiring activities dealing with similar products, so that synergies accrue and there is a degree of diversification. Poultry production and fishery or any other combinations of livestock enterprises are examples of horizontal integration in livestock industry. Vertical integration means acquiring activities in the same production path, so that the product of one activity forms the raw material or input of the other activity. Acquiring feed mill and poultry farm or maize farm and feed mill are examples of vertical integration. Market domination and risk reduction, economies of scope and scale are the major motives leading to horizontal integration (Bamiro *et al.,* 2012).

An analysis of poultry enterprise, fishery enterprise and integrated poultry and fishery enterprise was carried out by Bamiro *et al.,* (2012) in the South-West

Nigeria. It was observed that feed consumes the largest share of the total variable cost, in all the three enterprise. Feed cost accounts for 78.9, 55.8 and 68.2% of the variable cost of sole poultry, sole fishery and integrated farms production respectively. The cost components further shows that cost of birds ranked second in the cost share in both sole poultry and integrated farms, while labour cost is the second largest share in fishery enterprise. The least cost share is the cost of fingerlings in integrated farms.

The result showed that the adoption of horizontal integration significantly reduced the feed cost of poultry by 14%. The gross margin analysis indicates that the integrated farms recorded gross margin of ₦1, 994,792.88 which is greater than sole poultry while sole fishery recorded a ₦555, 516.32. This shows that integrated farms are more economically viable than the sole poultry farms which are in turn more viable than the sole fishery

2.4 **Analytical Literature**

2.4.1 **The Measurement of Scope Efficiency**

Scope efficiency refers to the cost savings attributable to joint production. Scope exist if the sum of cost of producing the optional levels of individual outputs in specialized firm is greater than the cost of producing the same optional output levels in a multiproduct firm. Assume C (y_1) is the cost of producing output 1 in a specialized firm while C (y_2) is the cost of producing output 2 in a specialized firm and C(y) is the cost of producing the same amounts of both products in a joint firm, Scope efficiency exist for the two outputs if C (y_1) + C(y_2) > C(y) (Shah, 2010) Scope efficiency Sc(y) is defined as:

$$Sc(y) = \frac{C\ (yl)\ +\ C\ (y2)\ -\ C(y)}{C(y)} \ldots 2.33$$

Note:

C (y_1) = the cost of producing only Y_1

C (y_2)=the cost of producing only Y_2

C (y) = the cost of producing all output by a single multiproduct firm

Scope efficiency can be estimated by using parametric or non -parametric methods. In the non-parametric method, (Faire, 1986). Linear programming is used to calculate the multi-product cost with all/individual output and then the cost of producing multi-products jointly and cost of producing these products individually are compared. The advantages associated with using the non-parametric approach are of three folds. First, by using the non-parametric approach, cost efficiency rather than estimated cost was used to compute scope efficiency. Clearly cost efficiency is the more relevant measure for decision making at the individual farm level. Second, the nonparametric approach imposes curvature on the cost function as part of the estimation. Thus, it is not necessary to test for curvature or impose curvature on the estimated coefficients. Third, the nonparametric approach does not assume a specific functional form for the cost function, which avoids the problem of distorting the technology by imposing a functional relationship on the cost function. (Longemeier, 2011; Zhinfeng & Featherstone, 2006). However, this method does not allow setting the output equal to zero leading to some possible approximation error (Coffey & Featherstone 2004).

The second approach is the parametric approach which estimates a specified cost function and compares the cost of producing multiproduct jointly and the sum of the cost of producing all the products individually. This approach is widely used in studying economies of scope of firms in various sectors such as agricultural and financial sectors. The translog function used to estimate economies of scope is multiplicative in output and the cost will be zero when one or more outputs are zero in the cost function and taking the log of a zero output causes problems. So the normalized quadratic functional form is widely used to approximate the cost function in the study of economies of scope (Featherstone & Moss, 1994; Fermandez–Cornejo *et al.,* 1994; Jiu *et al.,* 2005 and Cohn, Rhine & Santos, 1989). The main problem with the parametric approach is that the data used to estimate cost functions are not always on the efficiency Frontier, and because scope economies are defined only on the efficiency frontier, testing economies of scope by using data off the frontier could confound scope economies with x-efficiencies (Berger *et al.,* 1993) Furthermore, imposing curvature in a profit function is easier than that in a cost function. Normally, the concavity in outputs and the convexity in inputs have been imposed for the two sub-matrices of the Hessian matrix, and off diagonal sub matrices are not considered. Using the profit function makes it easier to impose curvature on the off diagonal sub-matrices (Marsh & Featherstone, 2004). Noting that measuring scope efficiency from cost function didn't consider whether the output bundle is optimal, thus lacking the consideration of the revenue effects on the efficiency measure.

Berger *et al.,* (1993) suggested that more research should concentrate on estimating scope from the profit function, which includes both revenue and cost sides of production. To this end a new concept of optimal scope economies was provided by Berger *et al.,* (1993) which determines whether a firm facing a given set of prices and other exogenous factors should optimally produce the entire array of products or specialize in some of them. With an unrestricted profit function, the optimal quantities of outputs can be derived using Hotelling's Lemma $\partial\pi/\partial p_i = y_i$

Where π = profit, p = price, y = optimal output

If the optimal quantities of all outputs are determined to be positive at given exogenous prices, optimal scope efficiencies exist at that point.

The new concept of scope efficiency, however, loses its connection with the classic definition of scope efficiency, in that while it can be determined whether scope exists, the magnitude of scope measures cannot be determined (Gao & Featherstone, 2006).

Following Berger *et al*'s concept of optimal scope economies, Gao & Featherstone (2006) provided a novel way to estimate scope efficiency using a profit function.

Different from Berger *et al.*, (1993) approach, they used the classic concept of scope efficiency that was first provided by Boumol *et al.*, (1982) by using cost function recovered from profit function and then use the concept of Sc(y) on equation (2.33).

This study on analysis of scope and economic efficiency of poultry-fish enterprises in Imo state adopted the work of Gao & Featherstone (2006) which entails recovering of cost function from profit function and using the parameters of the cost function to estimate scope efficiency.

2.4.2 **Duality and Recovering Cost Function from Unrestricted profit function**

According to the duality theory, a profit maximizing firm must also minimize cost, and the unrestricted profit function from profit maximization problem contains the same information as the cost function from cost minimization problem (Mas-Collell *et al.*, 1995). Therefore, it is possible to link the parameters of the profit function to the parameters in the cost function (Lau, 1976). Profit or cost function or production function can be recovered from an unrestricted profit function and vice versa.

It seems plausible to be able to recover the cost function from the profit function. However, the unrestricted profit function is calculated from the difference between the maximized revenue and the minimized cost, and calculating revenue and cost functions both involve the first order derivative of the corresponding objective functions. Obtaining the cost function from a profit function involves the opposite process, which is integration (Gao and Featherstone, 2006)

Compared to taking the derivative of a function, integrating a function is relatively more difficult and in some cases, may be intractable. To begin the derivation, we begin with a cost function and use the maximization process to calculate the unrestricted profit function theoretically. If the parameters of profit function (Y) can be expressed using the parameter of the cost function (X), such as $Y=f(x)$, an inverse relationship can be obtained, which expresses the parameters of cost function using the parameters from the profit function: $X = f^{-1}(Y)$. In the case that the theoretical inverse relationships cannot be obtained when there are highly nonlinear relationships between the parameters of those two functions, the parameters of cost function can be recovered from the profit function empirically using an algorithm to Min Y - *f* (X). As long as a cost function can be expressed using parameters from a profit function, economies of scope can be calculated using the parameters from unrestricted profit function (Gao and Feartherstone, 2006).

2.4.3 Measurement of economic efficiency

Following the works of Nwaru *et al.,* (2011) and Bamiro *et al.,* (2012) economic efficiency can be measured from a stochastic frontier cost function defined as

$C\ (W, Y) = F\ (W_i, Y, \alpha) \exp e_i\ i=1, 2$ …2.34

Where C is the functional form

W is a vector of input prices

Y is a vector of output quantities

Using sheppard's lemma we obtain

$\frac{dC}{dpi} = \ (X_i\ Y; \alpha)$ …2.35

This is a system of minimizing cost input demand, input prices and quantity of output in equation (2.35) yields the economically efficient input vector *Xe* (Nwaru *et al.*, 2011). With observed levels of output given, the corresponding economically efficient cost of production will be equal to $X_{ie}.P$. While the actual operating input combination of the farm is $X_i.P$

Then economic efficiency is therefore given as;

$$EEF = \frac{X_{ie.}P}{X_{i.}P}$$

Where EEF means economic efficiency

2.4.4 The model for determinants of efficiency

2.4.4.1 Logit model

These models are used for discrete outcome modeling. This can be for binary outcomes (0 and 1) or for three or more outcomes (multinomial logit). The logit model operates under the logit distribution and is preferred. Logit model for a credit access function model is expressed below as according to Essien, (2013).

$$\pi i = \alpha + \psi x1 + Ii\,\sigma + \omega i \qquad \text{....}2.36$$

Where π_i represent the outcome say profit from credit accessibility intervention programme.

X_1=vector of exogenous firm characteristics and

I_i= a binary variable with the value of 1 if the event occur and 0 otherwise (if we assume potential selectivity problem), the variable I cannot be treated exogenously. This implies that the decision of a firm whether or not to access credit depends not only on the firm's effort or attitude towards risk but also on the selectivity discrimination made by credit programmes. If I_i is considered as endogenous, then instrumental technique is the most prudent equation for estimation (Essien, 2013). A more general specification by Maddala (1983) is used to define two categories of firms, those that choose to participate in credit market (programme firm) and those that choose not to participate in credit market (non-programme firms) based on these categories.

$$I11 = x1\,\sigma + e1 \qquad \ldots 2.37$$

$$I12 = x2\,\sigma + e2 \qquad \ldots 2.38$$

Where

I_1 refer to the decision of firm to apply for credit, which takes the value of 1 if firm Ii choose to apply and 0 otherwise. I_2 refers to the decision of the financial institution to accept such credit applicants. Based on the argument of erogeneity, I_2 is defined over the entire population and the model analyzed from truncated sample using binary chance model. Since I_2 exist even for firm to meet credit requirements, we can define I in terms of single expression instead of system of equation. Thus the determinants of access to credit are estimated using logit regression model.

The logit model is used to derive the determinants of access to credit since it provides result which can be more easily interpreted in terms of odds ratios, the model ensures that the probability lies in the interval of 0 and 1. Logit model cannot be used to derive the determinants of efficiency in this work because scope efficiency score as well as economic efficiency scores are continuous variables and the logit model is used for only discrete values.

2.4.4.2 Probit model

Probit models are mostly the same as logit models especially in binary form (0 and 1) however, for three or move outcomes (in this context, its typically ranking or ordering) it operates much differently. It uses a single regression equation in which inferences from marginal effects can only be made on the extreme (upper and lower ranking) with any certainty. To illustrate the probit model, it is assumed that the outcome y=1 or y=0 depends on an unobservable utility index I (also known as latent variable) that is determined by one or more explanatory variables Xi in such a way that the larger the value of index I, the greater the probability of an outcome y=1 if an enterprise does not default in payment of loan and y=0 if enterprise defaults (Essien, 2013).

It is assumed that there is a threshold level of index called I* such that if Ii exceeds Ii* the entrepreneur will default in payment of loan, otherwise he will not. The threshold Ii*

Index Ii is not observable, but if we assume that it is normally distributed with the same mean and variance, it is possible not only to estimate the parameter of the index but also to get some information about the unobservable index itself (Gujarati, 2005).

Given the assumption of normality, the probability that Ii* is less than or equal to Ii can be computed from the cumulative distribution function (CDF) as;

$$P1 = P\left(y = \frac{1}{x}\right) = P(Ii * \leq Ii) = P(Zi \leq \beta 1 + \beta 2x1) = F(\beta 1 + \beta 2x1) \ldots 2.39$$

Where

P(y=1/x) means the probability that an event occur given the value (j) of x and where Zi is the standard normal variables i.e. Z=N $(0.\sigma^2)$ F is the standard normal CDF, since P represents the probability of defaulting on credit is measured by the area of standard normal curve from –ω to Ii (Essien, 2013).

Again this model is not suitable for the derivation of the determinants of efficiency because, the model is used only for discrete values.

2.4.4.3 Tobit model

Tobit models are entirely different from logit and probit models. It has nothing to do with binary or discrete outcomes. Tobit models are forms of linear regression specifically, if continuous dependent variable needs to be regressed, but is sheaved to one direction, the Tobit model is used. Tobit models allows regression of such a variable while censoring it so that regression of a continuous dependent variable can happen. It allows the analysis to specify a lower and upper threshold to censor the regression while maintaining the linear assumptions needed for linear regression. Tobit analysis was chosen for this study by assuming that the concentration of the dependent variable clusters towards the left limit (zero) and because it does not only explain the value of the dependent variables or the probability of limit (point of efficiency) and non-limit (point of inefficiency) response, but also the size (value) of non-limit response (Ogunyinka and Agebefun, 2004). Based on this information, the Tobit model is best suited for the derivation of the determinants of scope efficiency as well as economic efficiency.

The Tobit model is specified as follows;

$$Y_i = \sum_{C=1}^{n} \beta_i X_i + u_i = L_i < \sum_{C=1}^{n} \beta_i X_i + u_i < U_i \quad ...2.40$$

= O if other wise

Where

Y_i = the value of the dependent variable for the i^{th} farm.

X_i = k x 1 vector of explanatory variables for the i^{th} farm.

β_i =k x 1 vector of unknown parameters to be estimated.

u_i= residuals that are independently and normally distributed, with zero mean and common variance ^{2}

L_i and U_i = the distribution's lower and upper censoring points respectively

CHAPTER THREE

METHODOLOGY

3.1 Study Area

This study was carried out in Imo State, Nigeria, which lies between Latitudes $5^0 10'$ and $6^0 35'$ north of the Equator and between Longitudes $6^0 35'$ and $7^0 31'$east of the Greenish Meridian. It is therefore in the tropical rainforest zone of Nigeria. Imo State is located in the South-East region of Nigeria, bounded in the east by Abia State, in the north by Anambra State and in the south by Rivers State. The population of people living is Imo State is about 3.934 million in 2006 (NPC, 2006). The state is divided into 27 administrative units called Local Government Areas, which are grouped into three agricultural zones of Owerri, Okigwe and Orlu. Agriculture is the major occupation of the people of the state. Almost all the farmers are farming either as primary or secondary occupation. Apart from the crops grown by farmers, most farmers tend to keep animals either intensively or extensively. Fish farming are also practiced by most farmers. The integrated farm type common in Imo State are fish and poultry, fish and piggery as well as poultry and piggery. Fish and poultry are important enterprises in this area with high viability, acceptability, marketability, and quality of protein, relatively lower cost of establishments as well as its ability to address the protein deficiency problems in Nigeria.

3.2 Sample Selection:

A multi-stage sampling technique was used in choosing the sample. In the first stage, the study area was stratified into three agricultural zones of Owerri, Orlu and Okigwe as well as three categories of enterprises which included fish enterprises, poultry enterprises and joint fish-poultry enterprises. In each of the blocks, two cells where randomly selected for the study. A pre-survey was initially carried out in each cell to identify poultry farmers, fish farmers and joint fish-poultry farmers.

Table; 3.1 the process of sample selection

3.1.1 Sampling Frame for the three categories of enterprises in each zone

Zone	fish enterprise	poultry enterprise	poultry-fish enterprise	sub-Total
Orlu	71	46	76	193
Owerri	71	53	97	221
Okigwe	71	113	36	220
Total	213	212	209	634

The sampling frame was the list of all these three categories of farmers identified in each cell, this were added up in each agricultural zone comprising of 71 fish enterprises, 46 poultry enterprises and 76 fish-poultry enterprises in Orlu agricultural zone, 71 fish enterprises, 53 poultry enterprises and 97 fish-poultry enterprises in Owerri agricultural zone as well as 71 fish enterprises, 113 poultry enterprises and 35 fish-poultry enterprises in Okigwe agricultural zone.

<u>3.12 Proportionate sample selection in each block according to no of enterprises</u>

Block	fish	poultry	poultry-fish	sub-Total
Ideato south/Oru west	20	13	33	6
Ow north /NgorOkpala	20	15	42	77
Ehime mbano /Obowo	20	32	15	67
Total	60	60	90	210

Two blocks in each zone were purposefully selected based on the availability of the three categories enterprises and accessibility, the blocks include; owerri north and Ngor Okpala in Owerri agricultural zone; Ideato south and Oru west in Orlu agricultural zone; Ehime Mbano and Obowo in Okigwe agricultural zone. Following the work of Festinger & Katz, (1953). Proportionate sampling method for this study was carried out by the following method; nh =Nh(n/N) …3.1

Where nh is the sample size,

Nh is the sampling frame of each enterprise in the zone, n is the sample size for the study,

N is the total sampling frame in each agricultural z

3.13 Random sampling In each cell

Cell	fish	poultry	poultry-fish	sub-Total
Ogboko	5	4	9	18
Isekelese	5	3	8	16
Mgbidi	5	3	8	16
Awomama	5	3	8	16
Emii	5	3	10	18
Ulakwo	5	4	12	21
Amala	5	4	10	19
Umuekwune	5	4	10	19
Anara	5	8	3	16
Amaraku	5	8	4	17
Umulowo	5	8	4	17
Ogwogoroanya	5	8	4	17
Total	60	60	90	210

Source; field survey 2019

proportionate sampling based on concentration of farmers in each agricultural zone followed by random sampling technique were employed to select 20 fish enterprises, 13 poultry enterprises and 33 joint fish-poultry enterprises in Orlu agricultural zone, 20 fish enterprises, 15 poultry enterprises and 42 joint fish-poultry enterprises in Owerri agricultural zone as well as 20 fish enterprises, 32 poultry enterprises and 15 joint fish-poultry enterprises in Okigwe agricultural zone. This process yielded a sample size of 210 respondents consisting of 60 sole fish enterprises, 60 sole poultry enterprises and 90 poultry-fish enterprises. It is believed that this sample is a fair representation of all the three categories of the enterprises considered for this study.

3.3 Data Collection

Primary data were collected by the use of structured questionnaire with interview schedule, alongside personal observations. The data collection instruments elicited response on socio-economic and enterprise characteristics of respondents, cost of feed, cost of labour, capital input, total output, output quantities, and unit prices of output as well as the profit per respondent.

3.4 Data Analyses

Appropriate statistical and econometric tools which included means, frequency distribution, percentages and regression models were used to analyse the data.

On examination of the socioeconomic and farm characteristics of the respondents in the study area, Objective (i) was realized using descriptive statistics which included means, frequency distributions and percentages.

The estimation of cost function from profit function to analyze scope efficiency. Objective (ii) was realized from the normalized profit function specified according to Goa & Feartherstone, (2006) as:

$$\pi = pbo + pb1 * w1 + pb2 * w2 + pa1 * p1 * y1 + pa1 * pa2 + * p2 + 0.5 * pb11 * w12 + pb12 * w1 * w2 * + 0.5 * pb22 * w22 + 0.5 * pc11 * p1 * y1 + pc12 * p2 + 0.5 * pc22 * p2 * y2 + pa11 * w1 * p1 * y1 + pa12 * w1 * p2 * y1 + pa22 * w2 * p2 * y2 \quad \ldots 3.2$$

Where π = profit

Pb0, pb, pa, pc are the parameter estimates of the profit function.

Note that the optimal output y_1 and y_2 were calculated using Hoteling's Lemma, $\partial\pi / (\partial Pi) = y_i$

The following relationship as applied by Goa & Feartherstone, (2006) were used to recover the parameters of cost function from profit function.

$$bo = -Pbo + 0.5 \frac{(Pa_1 + Pa_2) \times (Pa_1 + Pa_2)^1}{Pc_{11} + Pc_{12} + Pc_{22}} \quad \ldots \quad (3.3)$$

$$b1 = -\frac{Pa1 \; x \; Pa11 - Pb1}{Pc\,11}, \qquad b2 = \frac{Pa2 \; x \; Pa22 - Pb2}{Pc\,2} \quad \ldots (3.4$$

$$a1 = \quad Pa1 \quad , \qquad a2 = \quad Pa2 \ldots \quad (3.5)$$

$$Pc\ 11 \qquad\qquad\qquad\qquad\qquad\qquad Pc\ 22$$

$$b11 = Pa11\ x\ (Pa11)1 - P\ , b12 = Pa12\ x\ (Pa12)1 - Pb12, b22$$
$$= Pa22\ x(Pa22)1 - Pb22\ . \ (3.6)$$

$$Pc\ 11 \qquad\qquad\qquad Pc_{22} \qquad\qquad\qquad Pc\ 12$$

$$a11 = Pa11\ ,\ a12 = Pa\ 12\ , a22 = Pa\ 22,\ a\ 21 = Pa\ 21\ \ \ldots\ (3.8)$$

$$Pc11 \qquad\qquad Pc\ 12 \qquad\qquad Pc\ 22 \qquad\qquad Pc\ 21$$

The underlying cost function parameters were recovered using linear algebra computations.

Note: b_o, b, a, c, are the estimated parameters of the cost function.

pb_o, pb, pa, pc, are the corresponding parameters of the profit function.

Estimating the scope efficiency, the quadratic cost function was used as specified:

$$C\ (W, Y) = bo + b1 * w1 + b2 * w2 + a1 * y1 + a2 * y2 + 0.5 * b11 * w12 + b12 * w1 * w2 + 0.5 * b22 * W22 + 0.5 * c11 * y12 + c12 * y1 * y2 + 0.5 * C22 * y22 + a11 * w1 * y1 + a12 * w1\ y2 + a22\ w2 * y2 + a21 * w2 * y1 \ldots (3.9)$$

Where

C (W, Y) = total cost

w_1 = Price of labour (₦)

w_2 = Price of feed (₦)

w_3 = Capital (depreciation of fixed asset in ₦)

P_1 = Price of 1 kg of fish (₦)

P_2 = price of 1 crate of egg (₦)

y_1 = Total fish produce (measured in kg)

y_2 = Total poultry output (measured by the no of creates)

b , a, c = parameters of the cost function to be estimated

Note: The input prices w_1, w_2 and the cost C (W, Y) are normalized on the third input capital.

Note: Capitals are measured by depreciation of fixed Assets using straight line method of depreciation.

Three permutations of equation 3.9 were used to compute scope efficiency for each farm. First, equation 3.9 was estimated for each farm with both fish and poultry joint enterprises. Second, equation 3.8 was estimated for each farm with only fish enterprises and thirdly equation 3.8 was estimated for each farm with only poultry enterprises.

Then scope efficiency was determined using the following formula;

$$\text{Scope efficiency} = \frac{c\,(w, y1) + c(w, y2) - c(w, y)}{C\,(w, y)} \qquad ..3.9$$

Where

C (w, y_1) = the cost of producing only fish

C (w, y_2) = the cost of producing only poultry

C (w, y) = the cost of producing both fish and poultry together by a single multiproduct farm

Estimation of the economic efficiency of the farmers in the study area Objective (iii)

To estimate this objective, the quadratic cost function was used and is specified explicitly as;

$$C\,(W, Y) = bo + b1 * w1 + b2 * w2 + a1 * y1 + a2 * y2 + 0.5 * b11 * w12 + b12 * w1 * w2 + 0.5 * b22 * W22 + 0.5 * c11 * y12 + c12 * y1 * y2 + 0.5 * C22 * y22 + a11 * w1 * y1 + a12 * w1\, y2 + v + ui \qquad ..3.10$$

Following the works of Ehirim, Essien, Ikeoha & Nwachukwu, (2019), Ogundari (2006) and Coto-Millan, Banos-Pino & Rodriguez-Alvarez (2000).

Economic efficiency of the ith farm can be presented as

$$\text{EEF} = \left(\frac{1}{exp\ u}\right) \qquad \ldots 3.11$$

Where U represents cost efficiency

Determination of the relationship between scope and economic efficiency to specific input used and specific output produced. Objective (iv),

To do this, scope efficiency and economic efficiency were correlated with income ratios, expense ratios and farm size. This objective is particularly relevant for gaining understanding of farms that utilizes poultry produce.

Note; income ratios were computed by dividing each enterprise income item by value of farm production, while input ratios were computed by dividing each expense item by value of farm production.

Evaluation of the determinants of scope efficiency of farmers in the study area. Objective (v).

This objective was evaluated using the Tobit model.

The Tobit model is specified explicitly according to Ogunyinka & Agebefun, (2004) as:

$$Yi = Li < b1x1 + b2x2 + b3x3 + b4x4 + b5x5 + b6x6 + b7x7 + b8x8 + b9x9 + u < Ui \quad \ldots 3.12$$

$Yi = 0$ If otherwise

Where

Y_i = Scope efficiency level for each farm

X_1 =Age of the farmer (years)

X_2 = Years of education (years spent in school)

X_3 = Sex (dummy, Male=1; Female=0)

X_4= Farming experience (years)

X_5 =Flock size (no of initial stock before loss due death or sale)

X_6 =Pond size (no of Fingerings before loss due death or sale)

X_7 = farm type (measured using 3 point likert type scale of joint enterprise=3; poultry enterprise=2 and fish enterprise =1)

X_8 = Extension contact (no. of visits by extension agent per annum)

X_9 = Credit obtained (Amount of credit obtained (₦)

X_{10} = Household size (no. of persons)

u_i= residuals that are independently and normally distributed, with zero mean and common variance

L_i and U_i = the distribution's lower and upper censoring points.

Evaluation of the determinants of economic efficiency of farmers in the study area. Objective (vi)

This objective was also evaluated by the use the Tobit model.

The Tobit model is specified explicitly as:

$$Yi = Li < b1x1 + b2x2 + b3x3 + b4x4 + b5x5 + b6x6 + b7x7 + b8x8 + b9x9 + u < Ui \ldots 3.13$$

= 0 if otherwise

Where

Y_i = Economic efficiency level for each farm

X_1 = Age of the farmer (years)

X_2 = years of education (years)

X_3 = Sex (dummy, Male=1; Female=0)

X_4 = Farming experience (years)

X_5 = Flock size (no of initial stock)

X_6 = Pond size (no of Fingerings)

X_7 = farm type (measured using 3 point likert type scale of joint enterprise=3; poultry enterprise=2 and fish enterprise =1)

X_8 = Extension contact (no. of visits by extension agent per annum)

X_9 = Credit obtained (Amount of credit obtained (₦)

X_{10} = Household size (no. of persons)

u_i= residuals that are independently and normally distributed, with zero mean and common variance

L_i and U_i = the distribution's lower and upper censoring points.

3.5 Hypothesis Testing

The following test have been carried out for testing difference in efficiencies, the variables that significantly affect the scope efficiency as well as the determinants of scope and economic efficiency for fish and poultry farmers in the study area.

3.5.1 Test of Hypothesis 1

Ho1: There is no significant difference among efficiencies of the three categories of the enterprises. Following the works of Ohajianya, (2013). This hypothesis was tested using analysis of variance method.

The ANOVA model is mathematically stated as follows

$$F = \frac{MSSb}{MSSw} \quad = \frac{SSb}{SSw}\left(\frac{n-k}{k-1}\right) \qquad 3.13$$

$$SSt = SSb + SSw \qquad 3.14$$

$$SSb = \sum_{j=1}^{n} nj \ (x - x - j)2 \qquad 3.15$$

$$SSw = \sum_{j=1}^{n} nj \sum_{c=1}^{k} (xj - x)\ 2 \qquad 3.16$$

Where

F = value by which the statistical significance of the mean differences in economic efficiencies were judged.

SSb= sum of squared deviations between enterprise efficiencies.

SSw= sum of squared deviations within enterprise efficiencies

n= number of respondents

k=number of samples (different categories of enterprises)

n_j=sample size from enterprise j

x= efficiency of the respondents

$\overline{x}_j$= mean efficiency of enterprises j x=mean efficiency of enterprises

$\overline{x}_{ij}$=ith mean efficiency from enterprises j

k-1= between samples degree of freedom

n-k= within samples degree of freedom

The null hypothesis were to be rejected if the calculated F-value were to be greater than the tabulated F-value and accepted if otherwise;

n = Size of the i^{th} sample

k= Number of samples, that is the number of different categories of enterprises.

<u>Note</u>: the calculated f- ratio was compared with the critical f- value at 5% level of significance to either reject or accept the stated hypothesis.

3.5.2 **Test of Hypothesis 2**

Ho2. The sharable cost such as labour, feed and capital do not significantly and positively affect the scope efficiency in poultry-fish enterprises. This hypothesis was tested with the result obtained for the achievement of objective 4. The significance of the sharable cost and scope efficiency in poultry-fish enterprises were determined to either reject or accept the stated hypothesis.

3.5.2 Test of Hypothesis 3

Ho3. Scope efficiency is not significantly and positively related to the use of specific inputs or the production of specific output in the fish and poultry enterprises. This hypothesis was tested using the result obtained for the achievement of objective 4. The significance of the correlation between expense ratios, income ratios and farm sizes with scope efficiency of poultry-fish enterprises were determined to either reject or accept the stated hypothesis.

3.5.3 Test for Hypothesis 4

Ho4 socioeconomic and farm variables such selected do not significantly and positively determine the level of scope efficiency of sample farmers. The hypothesis were tested using the result of tobit regression analysis performed to achieve objective 5. This result produced t-values, the significant of the t-values for each of the determinants were used to either reject or accept the stated hypothesis.

3.5.4 Test of hypothesis 5

Ho5 socio economic variables selected do not significantly and positively determine the level of economic efficiency of sample farmers. This hypothesis were tested using the result of tobit regression analysis performed to achieve objective 6. This result produced t-values, the significant of the t-values for each of the determinants were used to either reject or accept the stated hypothesis.

CHAPTER FOUR

RESULTs AND DISCUSSION

4.1 Socioeconomic characteristics of Respondents

The selected socio economic characteristics of the respondents considered in the study were: age of the respondents, level of education, gender, marital status, and household size. These were discussed in the subsequent sub-sections.

Table 4.1: **Distribution of Farmers According to Socioeconomic Characteristics**

.	**Fish farmers**			**Poultry farmers**			**Fish-poultry farmers**		
Variable	**freq**	**%**	**mean**	**freq**	**%**	**mean**	**freq**	**%**	**Mean**
Age									
≤40	4	6.3		7	11.5		5	5.6	
41-60	39	65.1		48	80.3		52	58.3	
Above 60	17	28.6		5	8.2		33	36.1	
Total	**60**	**100**	**54**	**60**	**100**	**39**	**90**	**100**	**57yrs**
Education level									
No formal Edu.		0		0	0		0	0	
1-6	14	23.8		12	19.7		9	9.7	
7-12	22	36.5		34	57.4		41	45.8	
13 & above	24	39.7		14	22.9		40	44.5	
Total	**60**	**100**		**60**	**100**		**90**	**100**	
Gender									
Male	34	57.1		37	62.3		60	66.7	
Female	26	42.9		25	37.7		30	33.3	
Total	**60**	**100**		**60**	**100**		**90**	**100**	
Marital status									
Single	2	3.1		5	8.2		4	4.2	
Married	48	80.9		45	75.4		74	81.9	
Widowed	10	16.0		8	13.1		9	9.7	
Divorced	0	0		2	3.3		3	4.2	
Total	**60**	**100**		**60**	**100**		**90**	**100**	
Household size									
1-3	5	7.9		7	11.5		4	4.2	
4-6	39	65.1		33	55.7		58	63.9	
7 & above	16	27.0		20	32.8		28	31.9	

Total	**60**	**100**	**4**	**60**	**100**	**6**	**90**	**100**	**6**

Source: Field Survey, 2019

4.1.1 Age of farmers

The result in 4.1 showed that age group of 41-60 had the highest percentage in all the three categories of farmers, 65.1% for sole fish farmers, 80.3% for sole poultry and 58.3% for joint fish-poultry farmers. These indicated that the age group actively involved in livestock production were in-between 41 -60 years. Implying that majority of the farmers in the three categories of enterprises were advanced in age and almost retiring from active employment and may wish to establish the venture to generate secondary income, so they are still active in the labour force (Ehirim *et al, 2019*). This is contrary to the view of Akinbile (2007), who opined that the age range of 21 -40 years constitutes the active workforce in most rural areas. But in line with the views of (Ohajianya, Mgbada, Onu, Enyia, Henry –Ukoha, Ben-Chendo & Godson-Ibeji, 2013), and Olaoye *et al*. (2013) which considered these age group of 41- 60 years as economically active age group. Age could have economic effect on the contribution of human capital to production, age influences the amount of physical efforts, rate of adoption of new innovation and improved technology. This may portend better future for this form of livestock enterprise because this form of livestock enterprise requires adequate attention and a lot of sense of responsibility.

4.1.2 Level of Education of Farmers

Table 4.1 also indicated that majority of sole fish farmers 39.7% spent 13 years and above in school which implied that they have tertiary education, while majority of sole poultry 57.4% and joint farmers 45.8% spent between 7 to 12 years in school which is secondary school education. This result implied that most of the farmers are literate enough to understand improve production technologies that can improve their farm income. The high level of education in all the three categories of the enterprise is expected to enhance productivity and efficiency of farmers. This is because this form of livestock enterprise requires a lot of technical and scientific knowledge to be successfully undertaken. These conforms with the views of Bamiro *et a.,* (2012) who said that high level of education enhances productivity and efficiency of farmers. One feature that is conspicuous and worthy of being noted is that there is no one that had no formal education. This might not be unconnected with the technical know-how requirement of this form of livestock enterprise. The higher level of education of farmers in the study area were connected with many institutions of learning that are located within the environment. The higher level of education background of majority of the farmers could be advantageous when new innovations are introduced, in terms of their adoption in the nearest future. This is an indication that this farm type production has brighter prospect if the farmers are given necessary motivation and logistic support.

4.1.3 Gender of farmers

Table 4.1 further revealed that majority of the farmers in the three categories of sole poultry (62.3%), sole fish farmers (57.1%) and joint farmers (66.7%) were males. This signifies a typical Nigerian farming system where men are predominant farmers. This conform with the work of Brummell *et al* (2010); in their study on Women's traditional fishing and alternative aquatic resource livelihood strategies in the southern Cameroonian Rainforest; Oluwafemi, Adenegan & Oluwafemi (2012) and the works of Ehirim *et al, (2019),* who revealed that this form of livestock enterprise are mostly dominated by men. This might be due to the physical efforts required by this form of livestock enterprise. Furthermore, Olaoye (2013), asserted that gender plays a very important role in this form of livestock enterprise, in terms of property acquisition such as land and machines. This also can be the reason why more men are involved in this type of business.

4.1.4 Marital status of Farmers

The distribution of respondent according to their marital status in table 4.1 Again showed that most of the farmers in the three categories were married with the joint farmer (81.9%) having the highest number of married people, followed by sole fish farmers (80.9%) and then sole poultry farmers (75.4%). This implied that there should be more commitment to the improvement and growth of the farms in the study area. This finding was confirmed by Olaoye et al (2013), who asserted that marriage engender some level of responsibility and commitment on individual who are married.

4.1.5 Household Size of Farmers

The distribution of respondents according to their household size showed that most of the farmers in the three categories had between 4 to 6 people as their household size. 65.1% of sole fish farmers, 55.7% of sole poultry farmers and 63.9% of joint farmers fell within this range. This conform to the views of Ehirim *et al (2019*) in their studies on Analysis of Economic Efficiency of Egg Production in Imo state. Large household size could be an advantage to farmers in the areas of provision of household labour. This use of household members as source of family labour in the activities of production is a gained advantage in this farm type. In west Africa, especially in Nigeria, farm labour requirements is usually influenced by family size of farmers household thus, Family labour has being the source of labour in production instead of hired labour, (Oluwafemi *et al, 2012*). However, majority of `the farmers do not have large household size. This may be an indication that the more educated an individual is, the less family size that individual will keep. It is obvious in Table 4.1 that more than half of the Respondents had between 4 to 6 people living with them. Umar (2008), reported that household size helps to determine availability of labour for livelihood activities.

4.2 Enterprise Characteristics of Respondents

The selected enterprise characteristics of the Respondents considered in the study were: farming experience, farm size and credit amount used for the business. These are presented in Table 4.2 below and discussed in the subsequent sub- sections.

Table 4.2: **Distribution of Farmers According to Enterprise Characteristics**

.	Fish farmers			Poultry farmers			Joint farmers		
Variable	**freq.**	**%**	**mean**	**freq.**	**%**	**mean**	**freq.**	**%**	**mean**
Farming Experience (years)									
1-5	13	22.2		9	14.8		51	56.9	
6-10	42	69.8		40	67.2		39	43.1	
Above 10	5	8.0		11	18.0		0	0	
Total	60	100	7.6	60	100	8.8	90	100	5.3yrs
Farm size (worth of Farm in Naira)									
100,000 -500,000.	24	39.7		26	42.6		0	0	
501,000-500,000	19	28.6		23	37.7		23	25	
Above 1000,000	19	31.7		11	19.7		57	75	
Total	60	100	99900	60	100	70157	90	100	628971
Amount of Credit (N)									
000	21	28.6		22	37.7		6	7.0	
1000-100,000	13	23.8		21	34.4		10	11.1	
101,000-200,000	13	23.8		6	9.8		15	18.1	
201,000-300,000	13	23.8		7	11.5		40	44.4	
Above 300,000	0	0		4	6.6		18	19.4	
Total	60	100	25460	60	100	9514	90	100	33354

Source: Field Survey, 2019 .

4.2.1 Farming Experience of Respondents

The distribution of respondents according to their farming experience was presented in table 4.2. The table revealed that 69.8% of sole fish farming and 67.2% of sole poultry farmers had between 6 to 10 years of experience in farming. This indicated that the farmers are experienced enough in the production, to understand the rudiments of farming. However, majority (56.9%) of joint farmers had less than six years' experience. This suggested that most of the joint farmers are new in the business, may face risk in their business and may need the assistance of an expert in the business. This assertion conforms to the work of Olaoye *et al*, (2013) who found that farmer with less years of experience especially less than 5 years' experience faced many risk in the early days of their farming business.

4.2.2 Farm Size of Respondents

The distribution of respondents according to farm size is presented in Table 4.2. Following the works of Kehinde *et al (2016),* the farm sizes of both fish and poultry-egg enterprises were standardized by using the worth of farm or their turn over as their farm sizes. the table revealed that most sole fish farmers (39.7%) and sole poultry farmers (42.6%) had between N100, 000 to N500, 000 worth of farm as their farm sizes, indicating that they were operating on a small scale basis, which conform with the view of Ehirim *et al, (2019)*. However, most joint farmers (75%) had above one million naira as worth of their farm indicating that they were operating on a large scale basis, which according to Nnaji (2007) constituted to the constraints of joint production of poultry-fish enterprises in terms of adoption of this farm type, in his view, large scale farmers with stronger financial base usually do not see the need to adopt this farm type. But if adopted, the higher farm size of joint farmers will undoubtedly afford them to enjoy economies of scale. Farm size were measured by worth of farm in Naira. In 1990 budget, the Federal Government of Nigeria defined small scale enterprises for the purpose of commercial loan as enterprises with annual turnover not exceeding N500000 with capital investment not exceeding N2 million (excluding cost of land or a maximum of N5 million) . This was reported in the works of Kehinde *et al (2016).* To this effect, this study viewed any farm with pen size or pond size that worth's less than N500, 000 as small scale farm.

4.2.3 Amount of credit Obtained by Respondents

The distribution of respondents according to the amount of credit borrowed was shown in table 4.2. The table revealed that majority of sole fish farmers (38.2%) and poultry farmers (37.7%) did not borrow credit for their business, 23.8% of fish farmers and 11.5% of poultry farmer were able to borrow credit amount that ranges from N201, 000 to N300, 000. This may be as a result that small scale farmers have limited access to credit, which is in line with the view of (Essien, 2013). In his work on Credit Access and Performance of small scale Agro-Based Enterprises in the Niger Delta Region of Nigeria. However, majority of the joint farmers (44.4%) borrowed credit amount that ranges from ₦201, 000 to ₦300, 000, while only 19.4% borrowed credit amount that is more than N300, 000. This implied that most farmers in the study cannot access large amount of loans to expand their farms.

4.3 Estimation of Cost Functions from Profit Function and Calculation of Scope Efficiency.

The Parameters of Quadratic Profit Function, the True and the Recovered Cost Function, are presented in table 4.3

Table 4.3: Estimated Profit Function, the True and Recovered Cost Function

Estimated parameters in profit function		Recovered parameters in cost function		True parameters in cost function	
Pbo	- 33.09	bo	32.01	bo	32.01
Pb1	- 12. 66	b1	13.05	b1	13.05
Pb2	- 36.59	b2	37.10	b2	37.10
Pa1	- 0.60	a1	0.81	a1	0.81
Pa2	- 0.58	a2	3.02	a2	3.02
Pb11	0.49	b11	0.71	b11	0.71
Pb12	0.52	b12	0.41	b12	0.41
Pb22	0.48	b22	2.69	b22	2.69
Pc11	0.67	c11	3.05	c11	3.05
Pc12	0.58	c12	0.18	c12	0.18
Pc22	0.62	c22	0.15	c22	0.15

Pa11	0.54	a11	0.12	a11	0.12
Pa12	0.59	a12	0.26	a12	0.26
Pa21	0.47	a21	0.16	a21	0.16
Pa22	0.48	a22	0.10	a22	0.10

Source: Estimated from field survey, 2019

Using hotellings lemma, the optimal quantities of output were obtained at each data point. The mean cost was also calculated using equation 3.8

In Table 4.3 the first column are the estimated co-efficient of the profit function using the generated data, the second column are the estimated coefficients of the cost function generated from the profit function and the third column are the true parameters of the cost function that were used to generate the data set. The result showed that all the parameters of the true cost function in data generating process are the same as the parameters of the recovered cost function. This confirmed the process used by Gao & Featherstone (2006), which was started by Mas – Collell *et al.*, (1995) who stated that the unrestricted profit function from profit maximizing problem contains the same information as the cost function from cost minimizing problem. Therefore, it is possible to link the parameters of the profit function to the parameters of the cost function (Lau, 1976).

4.4 Estimation of Scope Efficiency

Given the focus of this study, scope efficiency results discussed below are presented for the farms with fish enterprises, poultry enterprises and fish-poultry joint enterprises. The parameters and variables for estimated scope efficiency are presented in table 4.4

Table 4.4 Parameters and Variables for Estimated Scope Efficiency.

Parameters	**Fish**	**Poultry**	**Joint Fish – Poultry**
b_o	20.15	25.40	32.01
b_1	9.52	7.52	13.05
b_2	30.55	24.48	37.10
a_1	0.16	0.00	0.81
a_2	0.00	-0.15	3.02
b_{11}	0.31	0.29	0.71
b_{12}	-0.89	-0.38	0.41
b_{22}	0.47	0.29	2.69
C_{11}	2.06	0.00	3.05
C_{12}	0.00	0.00	0.18
C_{22}	0.00	0.15	0.15
a_{11}	0.11	0.00	0.12
a_{12}	0.00	0.80	0.26
a_{21}	1.09	0.00	0.16
a_{22}	0.00	0.19	0.10
Variables			
Labour W_1	11.22	39.61	19.11

Feed W_2	0.93	1.76	0.71
Fish Output (Y_1)	899	0	790
Poultry Output (Y_2)	0	990	689
Scope Index	-	-	0.02514

Source Estimated from field Survey, 2019

Using the formular in equation 3.9 the measure of scope efficiency between fish and poultry was calculated to be 0.02514, which indicated that joint production of fish and poultry on the same farm reduced cost approximately by 2.5%. Though scope efficiency here is weak, it showed that farmers will have success if the diversifies into production of fish and poultry. The productions of this farm type will generate efficiency gains due to scope efficiency if farmers have the opportunity to choose activities that complement each other. Intuitively, scope efficiency is low for this sample farm because farmers do not fully utilize the opportunities of choosing those activities that complement each other such as labour, using poultry droppings to fertilize ponds or for growing maggots as well as feeding the fish with left over feeds and poultry carcass. These complementary activities demonstrated the importance of scope efficiency in the production of fish and poultry to enable farmers to realize higher economic returns with reduce risk. But it is observed that despite the feasibility and economic viability of the integrated poultry-fish production, the adoption of this technology is not yet widespread. Nnaji (2007) revealed that the adoption of this farm type is not well spread because large scale farmers with stronger financial base usually do not see the need to adopt it, this farm type is a more complicated system since it involves more than one commodity and a farmer needs basic knowledge of fish ecology like biological and physico-chemical dynamics of the pond water in order to manage it well. Then psychological constraints, which includes the fear of possible transmission of diseases from poultry to fish and then fish to man, if the fish is consumed, and fish from this system being off taste with some farmers believing that fish fed with maggot decay faster than those that were not fed with maggot when harvested. Farmers when interviewed during field survey revealed that their pond produced offensive smells whenever they used poultry droppings as well as feeding their fish with poultry carcass, then some said their fish did not eat bone from poultry carcass, so those bones made it difficult for them during harvest especially when the used net as often times the bones tore their nets. All these contributed to the weak scope efficiency score in Imo state and need to be properly addressed. The evidence of scope efficiency of this farm type may be mostly attributed to the joint utilization labour and capital inputs and not mainly conversion of waste from one enterprise into useful inputs for the other enterprise.

4.5 Estimation of Economic Efficiency in joint Fish-poultry Enterprises.

Table 4.4 Quadratic Cost Function Estimate for Parameters of Economic Efficiency

Variables	Parameters	Estimate	t- Value
Intercept	b0	32.01	--
labour	b1	13.05	3.10**
Feed	b2	37.10	3.63**
Fish output	a1	0.81	3.84**
Poultry output	a2	3.02	7.85**
Labourxlabour	b11	0.36	1.84
Labour x Feed	b12	0.41	2.12*
Feed x Feed	b22	1.35	7.16**
Fish-Fish output	a11	1.53	5.71**
Fish-poultry output	a12	0.18	0.85
Poultry-Poultry output	a22	0.08	0.29
Labour x Fish output	c11	0.12	0.24
Labour x poultry output	c12	0.26	0.93
Feed x Fish output	c 21	0.16	0.49

Feed x poultry output	c22	0.10	0.33
Variance σ^2		0.185	
R^2		0.813	
F-Statistics		36.4	

The estimated cost function gave the R^2 of 0.813 which implies that the entire explanatory variable included in the model were able to explain 81% of the total cost of production. In line with a priori expectation, total cost are expected to increase with increase in cost of feed, labour cost and other cost of production. The function showed that at 1% probability level, the co-efficient of labour (W_1), feed (w_2) fish output (y_1) and poultry output (y_2) were all positively related to total cost indicating that the total cost will increase if you increase these variables. With regards to interaction terms, the co-efficient of labour-feed is significant at 5%, the co-efficient of labour-labour is significant at 1% while the coefficient of fish-fish output is significant at 1%. The co-efficient of all other interaction terms were not significant indicating that they did not influence total cost of production.

4.6 The Efficiency Distribution of Fish, Poultry and Joint Fish-Poultry Enterprise

The efficiency distribution of fish, poultry and joint fish-poultry enterprise is shown in table 4.5

Table 4.5: Frequency Distribution of Fish, Poultry and Joint Fish-Poultry Enterprises according to Economic Efficiency.

Efficiency Index	Frequency In fish	Frequency in poultry	Frequency in Fish - poultry
≤0.49	15	11	22
0.50 - 0.59	17	6	23
0.60 - 0.69	13	19	8
0.70 - 0.79	10	9	20
0.80 & above	5	5	17
Total	60	60	90
Maximum	0.82	0.85	0.88
Minimum	0.40	0.43	0.46

Mean	0.72	0.68	0.77

Source: Estimated from field survey, 2019

The distribution of economic efficiency scores of respondents shown in table 4.5 revealed that fish farmers had efficiency scores ranging from 0.40 to 0.82 with mean efficiency of 0.72. This suggested that most fish farmers in the study area were not economically efficient and that there is a possibility for fish farmers to increase their current output capacity by about 28% given the available technology. In the same manner the efficiency scores for poultry farmers ranged from 0.43 to 0.85 with mean efficiency of 0.68. This showed that poultry farmers on the average can increase their current output capacity by about 32% given the available technology. Again, the efficiency score for joint poultry-fish farmers ranged from 0.46 to 0.88 with mean efficiency of 0.77 which suggested that there is also a possibility for the joint farmers to increase their current output capacity by about 23% given this available technology. Comparing the three categories of farmers in the study area, it is observed that joint fish-poultry farmers are on the average more efficient than the fish farmers while the fish farmers are more efficient than the poultry farmers. This contradicts the works of Bamiro *et al*, (2012), which stated that sole poultry enterprise is more economically efficient than joint poultry-fish enterprises though in tandem with his assertion that joint poultry-fish enterprise are more efficient than sole fish enterprise. Intuitively this result signifies that there is efficiency improving effect of joint production of fish and poultry enterprises which can be gleaned from the study of scope efficiency. The complementarity and the joint utilization of inputs were responsible for the improvement of economic efficiency of this farm type. It is now obvious that joint farmers will have gains if the concentrate on those activities that complements each other to enable farmers to realize higher economic returns, improved productivity as well as addressing the protein deficiency in Imo state and Nigeria at large.

The ANOVA result of the test of significant differences in efficiency of fish enterprises, poultry enterprises and joint poultry-fish enterprises in the study are shown in table 4.6

Table 4.6 result of analysis of variance on test of significant differences in efficiency of fish, poultry and poultry-fish enterprises in the study area

Sources of variation	SS	DF	MSS	F-ratio
Between enterprises	291669	207	1409	6.52
Within enterprises	432	2	216	
Total	292101	209		

$F_{0.5}$ (V_1=2, V_2=207) = 3.04

Source: field survey data, 2019

The result in table 4.6 showed an F-calculated value of 6.52 which is significant at 0.05 level when compared with F- tabulated value 3.04 for V_1=2, v2=207 degrees of freedom. This result led to the rejection of the null hypothesis and to accept that there is significant difference in the individual efficiencies of the three categories of enterprises.

4.7 Relationship between Scope, Economic Efficiency and Specific Inputs or Outputs

The relationship between scope, Economic Efficiency and Specific Inputs or Outputs of the sample farms are presented in table 4.7.

Table 4.7: Correlation between Scope Efficiency and, Income, Expenses and Farm Size of Respondents

Variable	Scope Efficiency	Economic Efficiency
Income Ratio		
Fish output	0.751**	0.668**
Poultry output	0.761**	0.702**
Expenses Ratio		
Feed cost	0.732**	0.637**
Labour cost	0.741**	0.649**
Other cost	0.691**	0.612**
Capital	0.721**	0.629**
Farm size		
Pond size	0.771**	0.741**
Flock size	0.779**	0.766**

Source: Estimated from field survey, 2019

** = significant at 1%

Scope and economic efficiency were correlated with income ratios, expense ratios and farm size measures. This enabled us to determine whether scope efficiency is related to the use of specific inputs or the production of specific outputs. Scope efficiency is significant and positively correlated with all income ratios, expense ratios and farm size measures. The positive correlation of scope efficiency with income ratios implied that scope efficiency improves when the ratio of a particular output to the value of farm production improves. Which suggest that producing both fish and poultry on the same farm results in cost advantage. In this study, both fish income ratios and poultry income ratios are positively related to scope efficiency indicating that their production process have some complementary attributes. Examining the correlation between scope efficiency and expense ratios confirmed that, sharable costs such as labour feed and capital are significantly related with scope efficiency in poultry-fish enterprises. This implied that any improvement in input ratio of labour, feed or capital will lead to improvement in scope efficiency. It is evident that farm with relatively large labour, feed, capital and other expense ratios have higher scope efficiency indices suggesting that farms in the study area makes use of poultry waste to feed fish, jointly utilizes labour and capital to save cost. This result suggests that farm with higher scope efficiency indices use joint production to lower these input cost. This result is very intuitive. Controlling labour expenses, feed expenses and capital expenses, which is an important component of other expense ratio are often cited as reasons for producing joint enterprises (Langemeier, 2011).

Scope and economic efficiency are significant and positively correlated with farm size measures. This suggests that increasing the size of farms will increase the scope efficiency indices in Imo state. This is contrary to the work of Shah, (2010) and the work of Langemeier, (2011) who revealed that the largest farm size category had significantly lower scope efficiency indices. The definition of farm sizes across nations or locations could also be the reason for their different views, as what they referred to as small farms may be big farms here. Kehinde et al, (2016) defined small scale farms in Nigeria as farms that cost not more than N500, 000 including working capital to setup any investment that employs not more than 10 persons. According to Umar (1997) the concept of the small size firm is a relative one and it depends mainly on both the geographical location and the nature of economy activity being performed. According to sizes various countries have different specification, in USA small scale enterprises are those that generally have fewer than 500 employees. In Australia, small scale enterprise is one that has fewer than 15 employees on payroll. Small scale enterprises in Asian countries generally have 100 or fewer employees, but in Africa small scale enterprise is one that has 50 employees or fewer. In general, small scale enterprises are businesses that do not dominate their respective industry. Judging by this analysis, what they are referring as small farms are seen as large farms in Nigeria, so their findings are in line with the findings of this study.

This result whichever way revealed that farms in the study area have not reached their optimum size and there are more potential to increase the farm size and enjoy more cost advantages. Also increasing farm size reduces cost per unit of inputs which is also a source cost economies.

These variables affecting scope efficiency affected the economic efficiency in this study in the same manner and directions which implied that scope efficiency leads to improvement in economic efficiency as stated by Langemeier, (2011) who provided insight into how enterprises with similar technological access and marketing opportunities achieve different levels of economic efficiencies (Parman and Featherstone, 2014).

There were significant and positive correlation between sharable costs such as labour, feed as well as capital and scope efficiency in fish-poultry enterprises.

Therefore, hypothesis 2 which stated that the sharable costs such as labour, feed and capital do not significantly and positively affect the scope efficiency in fish-poultry enterprises is hereby rejected.

There were also significant and positive correlation between scope efficiency with income ratios (fish output and poultry output), expense ratios (feed cost labour cost, other cost and capital) and farm size (pond size and poultry size). Therefore, hypothesis 3 which stated that scope efficiency is not significantly and positively related to the use of specific inputs or production of specific output in fish-poultry enterprises is hereby rejected.

4.8 **Determinants of Scope Efficiency of the sample farms**

After determining that scope efficiency existed in poultry-fish joint enterprises, it was important to identify the socio-economic and farm factors that were associated with greater cost saving from this farm type. Tobit model was used to determine factors associated with scope efficiency. Scope efficiency were hypothesized to be a function of age, educational level, Sex, farming experience, pond size, poultry pen size, farm type, number of extension visits, credit amount and household size.

Table 4.8: Tobit Estimates of Determinants of Scope Efficiency of Respondents

Variables	Parameters	Estimate	t-Value
Intercept	bo	14. 381	4.516**
Age (x_1)	b1	-2. 053	- 1. 068
Educational level (x_2)	b2	0.613	2.914**
Sex (x_3)	b3	0.082	1.342
Farming experience (x_4)	b4	1. 673	3. 190**
Pond size (x_5)	b5	2.301	3. 490**
Pen size (x_6)	b6	1. 653	3. 1746**
Farm type (x_7)	b7	0.031	1. 444
No of extension visit(x_8)	b8	0.0614	1. 161
Credit Amount (x_9)	b9	0.045	2.122*
Household size (x_{10})	b10	0.514	- 1.272
Log likelihood		- 109. 084	
No of observation		90	
Sigma squared		0.853	6.081**
Gamma		0.603	
Lambda		3.083	4.325**

Source: Estimated from field survey data, 2019.

** = significant at 1%

*= significant at 5%

The value of the log-likelihood (-109.084) showed that the combination of model parameter values that maximizes the probability of drawing the sample obtained was suitable for the data and model specification, this implied that the information collected by the use of questionnaire is suitable for analyzing the determinants of scope efficiency and also tobit model specified is a suitable model for this analysis otherwise the value of the likelihood would have a zero value. The estimated sigma square was 0.853 with a t-ratio of 6.081; the variable was significant at 1% level of probability, indicating a good fit and correctness of the specified distributional assumption of the composite error term. The gamma estimate was 0.603 indicating that 60% variation in scope efficiency of producing fish and poultry together resulted from farmer's characteristics. Lambda (λ) was 3.083 with a t-ratio of 4.3251 and significant at 1% level implying that the variation in actual scope efficiency of producing fish-poultry enterprise and the maximum scope efficiency of producing fish-poultry enterprises in the study area mainly arose from difference in farmer's characteristics rather than random variability.

The table revealed that, educational level, farming experience, pond size, number of birds and credit amount are significant and positively related to scope efficiency, this is in line with the *a priori* expectation that scope efficiency should increase with increase in educational level, farming experience, pond size, number of birds and credit amount since these variables are expected to be positively correlated to adoption of improved technology and technique of production if there is availability of capital, experienced farmers who have access to credit tends to commercialize their farms for economies of scale such as reduction in cost of feed and other inputs which led to increase in scope efficiency. The result of this study showed that education level is positive and significantly effects scope efficiency. It is evident from this result that educated farmers understands the technical and scientific methods better and are in a better position to implements the Managerial skills needed in the farm type. Farming experience showed a positive relationship which implied that scope efficiency improves as farmers gain more experience in the business. Farmers with less years of experience face many risks in the early days of their farming business and as such experience less scope efficiency.

Pond size and flock size are significantly and positively related to scope efficiency. This showed that scope efficiency increase with farm size which might be as a result that farms has not reached their optimum size and there are more potentials to expand and also enjoy scope efficiency. Also increasing farm size reduces cost per unit of input which is also a source of scope efficiency.

Finally credit amount shows a positive relationship signifying that access to credit improves scope efficiency. The result however showed that farmers that borrowed more credit are more scope efficient in the production of this farm type. This intuitively may be as a result of more commitment on the part of farmers that borrowed credit and the eager to succeed and repay their credit. This conforms to the works of Essien (2013), which stated that credit source plays a major role in affecting the performance of farmers.

There were significant and positive relationship between scope efficiency with educational level, farming experience, pond size, pen size, and credit amount.

These led to the rejection of hypothesis 4 which stated that the socio-economic and farm variables selected do not significantly and positively determine the level of scope efficiency of the sample farm in respect to Educational level, farming experience, pond size, pen size and credit amount but accepted in respect to the other variables.

4. 9 Determinants of Economic Efficiency of the sample farms

The Socio-Economic and Enterprises Characteristics of Respondents that Determine the Economic Efficiency of the sample farms are presented in table 4.9 Tobit model was used to determine factors associated with economic efficiency. Economic efficiency were hypothesized to be a function of age, educational level, Sex, farming experience, pond size, poultry pen size, farm type, number of extension visits, credit amount and household size.

Table 4.9: Tobit Estimates of the Determinants of Economic Efficiency.

Variables	Parameters	Estimate	t-value
Intercept	b0	- 0.953	4.951**
Age (x_1)	b1	-1. 074	- 3. 235**
Educational level (x_2)	b2	0.583	2.998**
Sex (x3)	b3	- 0.321	1.720
Farming experience (x_4)	b4	0. 844	2. 852**
Pond size (x_5)	b5	0.753	3. 620**
Pen size (x_6)	b6	1.673	3. 263**
Farm type (x_7)	b7	0.660	3. 083**
No of extension visit (x_8)	b8	0.392	2. 410*
Credit Amoun (x_9)	b9	0.483	2.613**
Household size (x_{10})	b10	- 0.578	- 2. 738**
Log likelihood		- 119. 093	
No of observation		90	
Sigma squared		0.844	5.775**
Gamma		0.541	
Lambda		2.193	3.130**

Source: Estimated from field survey data, 2019

** = significant at 1%

*= significant at 5%

The result in table 4.6 showed that the value of the log-likelihood was -119.093. This implied that the combination of model parameter values that maximizes the probability of drawing the sample obtained from the field was suitable for the type of data used in this analysis and the tobit model is correctly specified. The estimated sigma square was 0.844 and with a t-ratio of 5.775, the variable was significant at 1% level of probability indicating a good fit and the correctness of the specified distributional assumption of the composite error term. The gamma estimate was 0.541 implying that 54% of variation in the economic efficiency of producing fish and poultry together resulted from socio-economic and enterprise characteristics of the respondents. Lambda (λ) was 2.193 with a t-ratio of 3.13 and significant at 1% level, implying that the variation in actual economic efficiency of production and maximum economic efficiency of fish-poultry joint farms mainly arose from difference in farmers' characteristics rather than their random variability.

In line with *a priori* expectation, economic efficiency should increase with increase in age of the farmer and household size since these variables are expected to be positively correlated to adoption of improved technology and technique of production. However, the result in the Table revealed that age of the farmers and household size are negatively related with Economic Efficiency. This result suggests that economic efficiency in the study area will decline as farmers grow older. This finding refuted the works of Jatto *et al* (2014) who recorded a positive relationship between age and efficiency. The result showed that efficiency declines as household size increases which conforms with the works of Ekaette *et al* (2018) who attributed the reason of economic efficiency being negatively correlated with household size to the fact that the value of farm products that could have been sold to generate revenue are often consumed directly by the household. They also explained that in a situation where the family size is large and only a small proportion of farm labour is derived from it, the inefficiency effects are expected to be much greater.

The result also showed that level of education is positively related to economic efficiency intuitively, farmers who are educated have a greater ability to adopt new technology and innovations to become more efficient in managing their farms. This conforms to the *a priori* expectations. The result on farming experience is positive showing that economic efficiency will improve with more years of experience in the business.

Pond size and poultry pen size shows a positive relationship with economic efficiency indicating that farm size is a positive factor that affects the economic efficiency of this farm type. This is because the output of the farm mainly depends on the number of birds as well as number of fingerlings in the farm, Effiong & Onyenweaku (2005), Yusuf & Malomo (2007) and Binnomote *et al* (2008).

Farm type shows a positive relationship implying that the more the farmer diversify the more economic efficient the farmer becomes. The number of extension visit also showed a positive coefficient. If farmers receive more extension contact, it could lead to high adoption of production technologies which will translate to improve economic efficiency. Finally, the result shows that access to credit significantly affects the economic efficiency of farmers in Imo State. The result implied that farmers with no access to credit are less efficient compared with farmers with access to credit. This finding is in tandem with apriori reasoning and conform with the works of Ashagidigbi *et al* (2011) however, the result contradict the works of Okike (2009), who reported that receiving credit contributed to farmers inefficiency.

There were significant and positive relationship between economic efficiency with educational level, farming experience, pond size, and pen size, and farm type, number of extension visit and credit amount. Therefore, hypothesis 5 which stated that the socio-economic and farm variables selected do not significantly and positively determine the level of economic efficiency of the sample farm is hereby rejected in respect to educational level, farming experience, pond size, and pen size, farm type, number of extension visit, credit amount and household size but accepted in respect to the other selected variables such as age, sex and household size.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The study analyzed scope and economic efficiency of poultry-fish enterprises in Imo State Nigeria. The specific objectives were to analyze the socio economic and enterprise characteristics of fish and poultry farmers in Imo State; estimate cost function from profit function for fish and poultry enterprises to obtain scope efficiency index; estimate and compare economic efficiencies of fish, poultry and Joint poultry-fish enterprises in Imo State; determine how scope and economic efficiency relates to the use of specific input and the production of specific output; evaluate the determinants of scope and economic efficiency of fish-poultry enterprises in the study area.

A multi-stage sampling technique were used in the study. The study area were stratified into three agricultural zones of Owerri, Orlu and Okigwe as well as the three categories of enterprises. Using proportionate sampling technique followed by random sampling technique, 20 fish enterprises, 13 poultry enterprises and 33 joint fish-poultry enterprises were selected in Orlu Zone. 20 fish enterprises, 15 poultry enterprises and 42 joint enterprises were selected in Owerri Zone while 20 fish enterprises, 32 poultry enterprises and 15 joint enterprises were selected in Okigwe

Zone. This process yielded 210 respondents consisting of 60 sole fish, 60 sole poultry and 90 joint fish-poultry enterprises.

Descriptive statistical tools which included percentages, frequencies and mean were used in analyzing selected socio economic and enterprise characteristics of farmers. The parameters of cost function were recovered from profit function and applied in equation 3.9 to estimate scope efficiency.

The quadratic cost functions specified in equation 3.10 were used to test economic efficiency and ANOVA result were used to test significant differences. Correlation co-efficient were used to test the relationship between scope and economic efficiency with income and expense ratios as well as farm sizes. Tobit model were used to evaluate the determinants of scope and economic efficiency respectively.

The result revealed that most of the farmers fell within the age bracket of 41 to 60 years 65.1% for fish, 80.3% for poultry and 58.3% for joint farmers. Majority of sole fish farmers (39.7%) spent 13 years and above in school while majority of sole poultry (57.4%) and joint farmers (45.8%) respectively spent 7 years to 12 years in school. Also the study revealed that most farmers 62.3% in poultry, 57.1% in fish and 66.7% in joint enterprises were male. 81.9% of joint farmers, 80.9% of fish farmers and 75.4% of poultry farmers were married while 65.1% of fish farmers, 55.7% of poultry farmers and 63.9% of joint farmers had a household size of between 4 and 6 people. Distribution according to farming experience revealed that fish farmers (69.8%) and poultry farmers (67.2%) had 6 to 10 years farming experience while 56.9% of joint farmers had less than 6 years farming experience. Most poultry farmers (42.6%) and fish farmers (39.7%) were small scale farmers while most joint farmers (75%) were large scale farmers. About 28.6% of fish farmers and 37.7% of poultry farmers did not borrow credit for their business while 44.4% of joint farmers borrowed credit amount that ranged from N201,000 to N300,000.

The parameters of cost function used in this study were recovered from unrestricted profit function which enabled the calculation of scope efficiency. There were evidence of scope efficiency (0.025) for fish and poultry joint enterprises; this revealed that production cost would be reduced by 2.5% if poultry and fish were produced on the same farm.

Data analysis using quadratic cost function to estimate economic efficiency of farmers revealed that economic efficiency for fish enterprises ranged from 0.40 to 0.82 with mean efficiency of 0.72, poultry enterprises ranged from 0.45 to 0.85 with mean efficiency of 0.68 while for joint fish and poultry enterprises, efficiency ranged from 0.46 to 0.88 with mean efficiency of 0.77, suggesting that there were chances to increase output without additional resources in all three categories of enterprises.

The correlation of scope and economic efficiency with income ratios, expenses ratios and farm size measures revealed that there are positive relationship between scope and economic efficiency with poultry output and fish output which implied that producing fish and poultry on the same farm results in cost advantages. The correlation of scope and economic efficiency with expense ratios revealed that farms with higher scope and economic efficiency indices used joint production to lower their input ratios. The positive correlation of scope and economic efficiency with farm size measures revealed that larger farms had more scope and economic efficiency scores than smaller farms. The analysis of data using the tobit model to evaluate the determinants of scope efficiency and economic efficiency showed that scope efficiency is significantly determined by Educational level, farming experience, pond size, pen size as well as credit amount at 1% while economic efficiency significantly determined by number of extension visits at 5% as well as Age, educational level, farming experience, pond size, pen size, farm type, credit amount and household size at 1%.

5.2 Conclusion

It is concluded from this study that most of the farmers were within the economically active age bracket with high level of educational status. Scope efficiency existed for fish and poultry joint enterprises and the existence of scope efficiency led to the improvement of economic efficiency. But the scope efficiency score is very low in Imo state because most Farmers when interviewed during field survey revealed that they do not adopt all the cost saving strategies that convert waste from poultry to useful inputs for fish as they believed that fish from this system are off taste, decay faster, produced offensive smells and often times the bones from poultry carcass tore their nets during harvest. The findings of this work showed that educational level, farming experience, pond size, pen size and credit amount are factors the can improve this farm type.

5.3 Recommendations

1. The study showed that most farmers are educated and within the economically active age bracket. The government both in state and local government should design appropriate educational packages and training that will exploit the dissemination of information relating to the volume of poultry droppings that should be applied in fish pond, proper stocking density, water quality, types of nutrients in the pond and their volumes are necessary for this farm type. These undoubtedly will increase efficiency and productivity of farmers.
2. Given that farmers in the area had poor access to credit and most joint farmers are new in the business, the federal Government through the central bank of Nigeria should enact policies that will encourage financial institutions to improve on the volumes and terms of loan extended to the operators of joint fish-poultry enterprises to enable them expand their scale of operation and to use the advantage of their cost saving strategy to boost efficiency and productivity of their farms.
3. Scope efficiency on the average was very weak for the sample farms. It is therefore, recommended that agricultural research institutes should focus critically on identifying and improving on activities that complement each other especially in integrated livestock farms. These complementary activities

demonstrates the importance of scope efficiency in the production of fish and poultry enterprises to enable farmers realize higher economic returns with cost and risk reduction strategies. Also a widespread adoption strategy of this farm type should be encourage by extension workers to increase the no of farmers that will embark on this farm type, so as to improve protein supply in the markets.

4. As combination of poultry and fish enterprises lead to improvement in economic efficiency which entails higher economic returns, farmers in Imo State and by extension, Nigeria should concentrate on the integration of this farm as a business strategy. In addition, state governments through Agricultural Development Programmes (ADP) should support and encourage extension service supports that will ensure that farmers have adequate level of expertise and that best practice management and production techniques are implemented.

5. Given that pond size and pen size significantly and positively affected scope efficiency of the sample farm, federal Government through agricultural research institutes should invest more in improving the quality of fingerlings and day old chicks as well as making them readily available at reduced cost. This will increase their contribution to output, which will in turn improve farmers profitability as well as making animal products affordable in the market.

6. Government at all levels should use socio-economic variable such as level of education, farming experiences, pond size and poultry pen size which significantly determine scope efficiency of this farm type as one of the major criteria for selecting farmers who will benefit from any programme intended to

improve this farm type. Such programmes as disbursement of loans, improve breeds as well as subsidizing input. These will in turn guarantee sustainable and improve productivity of this farm type.

5.4 Contribution to knowledge

It is evident from the study that scope efficiency existed for poultry and fish enterprises. So farmers will have gains if they diversifies into the production of poultry and fish enterprises together in one farm, therefore researchers should improve on this study by finding out other joint enterprises that can also improve economic efficiency of farmers through scope thereby improving productivity which in turn addresses the inadequate protein supply in Imo State and in Nigeria at large.

The knowledge that scope efficiency existed and the isolation of variables that significantly relates to scope efficiency is necessary for the identification of those activities which compliments each other. These will help researchers in the analysis of what enterprises that can be integrated for the purpose of higher economic returns with reduced risk.

It is now known from this study that production will improve if farmers are educated as well as trained on those activities that complement each other in this farm type, so research should then focus critically on identifying and improving on activities that complement each other to increase the adoption level of these activities.

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