FLEXIBILITY IN ENTERPRISE SWITCHING AS RELATIVE PRICES CHANGE IN NIGERIAN AGRICULTURE

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Abstract

The problem of the study is that in spite of mixed farming system that is dominant in Nigerian agriculture when analyzing farming activities in the country, attention is usually focused on the technical and economic efficiencies of separate enterprises (crops or livestock or fishery) in isolation, negligent of the fact that farmers operate the enterprises as a system, and make decisions concerning each enterprise with due consideration to the interrelationships that exist between various outputs (crops, livestock and fishery) and the various inputs involved in the system. The main objective of the study is to analyze mixing farming system of agriculture in Nigeria as a joint production of enterprises using the transcendental logarithmic (translog) variable profit function to generate the parameters of the relationships between the enterprises; and between the enterprises and inputs (fixed and variable); applying truly exogenous variables (prices) as the choice variables. The study covers the entire Nigerian agriculture but limited by the period 1981 to 2012 and the enterprises involved are: crops, livestock and fishery and the inputs used are: labour, working capital and land. This study specified the normalized transcendental logarithmic variable profit function; derived the system of output supply and input demand equations and estimated the system of equations using the Zellner (1962) Seemingly Unrelated Regressions (ZSUR) approach. The data used in the study is nationwide secondary time series data on values and index prices of crops, livestock and fishery contributions to the Gross Domestic Product (GDP) published in the Statistical Bulletin by the National Bureau of Statistics (NBS) from 1981 to 2012. The estimated trasnlog variable profit function satisfied the monotonicity requirement of non-decreasing in the prices of variable output and non-increasing in the prices of variable inputs. Based on the observed values of the coefficients of determination, the signs of the estimated coefficients and the t-values, it was concluded that prices substantially influence the supply of crops, livestock and fishery; and the demand for labour and working capital in Nigerian agriculture. It was evident from the study that as at 2012 crops and livestock; and crops and fishery enterprises had complementary relationships which implied that there was no switching from crops to livestock and vice versa or from crops to fishery and vice versa as the crops prices changed. However livestock and fishery had competitive relationship consequently, as the prices of the fishery increases farmers tend to switch from livestock to fishery and vice versa.The elastic price of agricultural labour is not unexpected because as more states are being created and many towns are being urbanized agricultural labour gets scarcer as other modern-sector enterprises compete for the available labour. The inelasticity of the price demand for working capital reflects the non-readily availability of the SGCF loan irrespective of the farmers willingness to pay back. The study recommended that government should stimulate increase production of crops, livestock and fishery by inducing increases in their selling prices. This could be achieved through price incentives to producers. Government should implement policies that will attract youths to the farm. This could be achieved by providing rural infrastructures, removal of drudgery in agricultural work and price incentives. Government, agricultural and commercial banks should provide soft loans for agricultural purposes.

Key words: Analyze mixed farming system; transcendental logarithmic variable profit function

Introduction

Mixed farming is the dominant system of agriculture in Nigeria. Irrespective of scale, a farmer usually has some crop enterprises along with some livestock, artisanal or aquaculture fishery. The advantages are bound because in a season of failure in one enterprise, the farmer will compensate with the other enterprises. The semi-subsistence agriculture in the country has evolved a farming system wherein various crops mature at various times of the year and serve primarily as food and secondly as sources of income for the farm family. Small ruminants (goats and sheep) and poultry as well as fishery mature at various months of the year and are mainly sold for cash or used for food. A waste from one enterprise is usually ploughed into another enterprise as an input thereby minimizing costs and maximizing profits. The various agricultural policies implemented to accelerate agricultural production in the country advocate and encourage the mixed farming system of agriculture. However, in analyzing farming activities in the country, attention is usually focused on the technical and economic efficiencies of separate enterprises (crops or livestock or fishery) in isolation, negligent of the fact that farmers operate the enterprises as a system, and make decisions concerning each enterprise with due consideration to the interrelationships that exist between various outputs (crops, livestock and fishery) and the various inputs involved in the system. The traditional analysis also concentrate on input versus output analysis of an enterprise: this type of analysis is fraught with simultaneity bias since both the inputs and output are endogenous variables determined in the system. None of them is truly exogenous. There is therefore the need to analyze the mixed farming agriculture as a system of joint production of enterprises using truly exogenous variables as choice variables. This will express the interrelationships between the enterprises; and between the enterprises and inputs (fixed and variable) more efficiently and permit better understanding for policy formulation to accelerate the growth of agricultural production in the country.

Problem Statement

The problem of the study is that in spite of mixed farming systems of agriculture that prevail throughout Nigeria, when analyzing farming activities in the country, attention is usually focused on the technical and economic efficiencies of separate enterprises (crops or livestock or fishery) in isolation, negligent of the fact that farmers operate the enterprises as a system, and make decisions concerning each enterprise with due consideration to the interrelationships that exist between various outputs (crops, livestock and fishery) and the various inputs involved in the system. This study analyzes mixing farming system of agriculture in Nigeria as a joint production of enterprises using the transcendental logarithmic (translog) variable profit function to generate the parameters of the relationships between the enterprises; and between the enterprises and inputs (fixed and variable); applying truly exogenous variables (prices) as the choice variables. Yotopoulos and Lau, (1971) emphasized the superiority of translog variable profit function over the production function approach especially in terms of overcoming estimation bias. The application of the Hotelling's and Shepherd's lemma to the translog variable profit function will enable us to obtain product–supply and input-demand equations with ease and these were not possible via the production function approach.

Research Questions

This study is geared at answering the following research questions:

1) Is there an appropriate model to describe the mixed farming agriculture in Nigeria using truly exogenous variables as choice variables?
2) Can the parameters that explain the 'enterprise versus enterprise' relationships in the mixed farming agriculture in Nigerian be identified and estimated?
3) Can the parameters that explain the 'enterprises versus inputs (variable and fixed)' relationships in the mixed farming agriculture in Nigerian be identified and estimated?
4) Can the parameters of disembodied technological bias of outputs and inputs in the mixed farming enterprise relationship in Nigerian be identified and estimated?

Objectives of the Study

The main objective of this study is to specify a transcendental logarithmic (translog) variable profit function to analyze the mixed farming agriculture in Nigeria. The derived objectives include determining:

1) The enterprise output supply and derived input demand functions for crops, livestock and fishery in Nigeria using the translog variable profit function.
2) The enterprise-enterprise relationships under the mixed farming system.

3) The responses of production of these enterprises to the changes in output prices.
4) The derived input demand functions
5) The elasticity's of production of the enterprises to key inputs such as land, labour and capital.
6) The disembodied technological bias over time of outputs and inputs in the mixed farming enterprises in Nigeria

Scope of the study

This study covers the entire Nigerian agriculture. The scope of this study is limited by the period of study (1981 to 2012) and the enterprises involved namely: crops, livestock and fishery as well as the inputs used in the study namely: labour, working capital and land.

Significance/Relevance of the Study

It is apparent that the various governments (federal and state) and the planning institutions do not fully understand the objective function and the production possibilities of the Nigerian farmer given his economic environment. Knowledge of the ease with which the farmer can switch from one enterprise to another and alter the quantity of each input he uses is necessary for fully assessing the likely effects of changes in the input prices or the prospects of meeting the growing industrial and consumption needs of country. Information on the relative intensities in the usage of the inputs for the production of each enterprise in a mixed farming system is necessary for assessing the likely effects of the own and cross price changes on the composition of the enterprises. Very few econometric studies have been carried out in the Nigerian agricultural sector. In spite of the mixed farming systems that prevail all over Nigeria analysis of farm production as a system of joint production has been commonly overlooked probably due to the limitations associated with the traditional functional forms. Moreover, the few studies on production functions were based on single output functional forms. The inherent aggregation problems and the consequent masking of the influences of some key variables in this approach are significant limitations. Aided by the current developments in econometric theory, this study applies the robust technique of the duality theory via the translog variable profit function to the analysis of the product-product and input-input relationship in the farm firm, in order to obtain more efficient parameters requisite for planning for increased productivity and output.

Limitations of the Study

The data used in this study were secondary time series data which were primarily collected by the National Bureau of Statistics (Statistical Bulletin 2012). In collecting the data NBS did not have this study in mind consequently, some modifications (adjustments) had to be made for the data to suit this study. The enterprises in this study were aggregate values. The aggregation may be associated with masking effects. Disaggregated data of the members of the enterprises may produce more efficient results. The price indices used in the study were composite variables which could be associated with masking effects that could lead to inefficiencies. Annual data for farm labour, wages and farm land were estimated from studies carried out by other scholars and this could be sources of error. In this study only the 'variable quantity' share equations were estimated. Non-inclusion of the 'fixed input' share equations may not permit the estimation of some fixed input relationships and could lead to some inefficiency; but according to Mckay (1981) these are negligible.

Literature Review

In this study we reviewed relevant recent literature on the studies of mixed farming in Nigeria and elsewhere; with special emphasis on applications of the profit functions in agricultural production analysis. The review highlighted achievements made so far in the areas of agricultural production analysis; the limitation of the reviewed studies and some areas of improvement to be incorporated into the current study. Few econometric studies have been carried out on the relationships of enterprises under mixed farming in Nigeria. The few studies that were carried out were based on production functions which have been criticized due to the associated simultaneous equation bias because the input variables are endogenous. The profit function approach avoids these problems. Consequently, this study is focused on the profit function approach.

Some notable studies of Nigerian agriculture which applied the profit function approach included: Oladeebo et al (2012), Nwachukwu, Ifeanyi Ndubuto and Onyenweaku, C.E (2007), Akinwumi et al (1997), Okoruwa et al (2009), Ugwumba, C. O. A et al (2010) and Okoruwa V.O et al (2009).

On studies about analysis of multi-product agriculture, there are no rigorous studies that jointly analyzed multi-output and multi-input relationships. Ugwumba, et al (2010), studied types of integrated farming system (IFS), profitability of IFS and its impact on farm cash income in Awka agricultural zone of Anambra State, Nigeria. They collected cross sectional data from 84 respondents selected by random sampling technique and employed the techniques of gross margin and net farm income, profit function and multiple regression methods. They concluded that farm cash income was significantly influenced by level of farmer's education, years of experience, type of integration and cost of farm inputs. They neither estimated systems of supply relationships for jointly produced outputs nor the systems of demand relationships for jointly utilized inputs in production. This study is focused on the specification of these relationships and estimation of their parameters.

Okoruwa V.O et al (2009) studied the production efficiencies of small and large scale rice farmers in Niger State in order to identify ways of improving the farmers' production efficiencies to the highest possible level. They analyzed cross sectional data collected from 143 rice farmers in Niger state, Nigeria using seemingly unrelated regression (SURE). Their primary conclusion was in agreement with the findings of Yotopoulos and Lau (1971 and 1973) that small farms are relatively more economic-efficient than large farms. They also concluded that the use of modern rice varieties significantly increased profits; that the coefficient of seed, fertilizer, capital and sex of respondent which were not significant in ordinary least square (OLS), were found significant in the profit function. Akinwumi and Djato, (1996) applied the profit function in studies of Farm size, relative efficiency and agrarian policy in Cote d'Ivoire and concluded that the profit function provides a better measures of differences in relative efficiency. Akinwumi, et al (1997) also studied the relative efficiency of women as farm managers using the profit function analysis in Cote d'Ivoire. These studies used the single equation method and did not analyse the multi-output and multi-input relationships as a system. This study specifies and estimates a system of output supply and input demand equations.

From the literature review it is apparent that the few econometric studies that have been carried out on agricultural production relationships in Nigeria were either based on production functions which have been criticized due to the associated simultaneity bias because the input variables are endogenous or they analyzed the production relationship with respect to a single crop or single input. This may not be adequate considering the mixed farming and integrated farming system that characterize agriculture in Nigeria. This study specifies the normalized transcendental logarithmic variable profit function; derives the system of output supply and input demand equations and estimates the system of equations using the Zellner (1962) Seemingly Unrelated Regressions (ZSUR) approach.

Methodology

The production process in the mixed farming systems in Nigeria is very complex and the underlying production function is not known and any production function specified would be complex yet at best be an approximation to reality. In order to minimize the complexity of the process and allow for flexibility and simplicity in estimation and yet obtain the required parameters, this study invokes the duality between output maximization in production and profit maximization. It considers it better to specify directly a particular functional form of a variable profit function as a second order approximation to the variable profit function. Provided that the regularity requirements detailed in the analytical framework below are satisfied it is assured that an equivalent production function which is dual to the variable profit function does exist. The translog variable profit function is specified and applied to the time series data of crops, livestock, fishery and input quantities and prices in Nigeria from 1981 to 2012.

The data used in the study is nationwide secondary time series data on values and index prices of crops, livestock and fishery contributions to the Gross Domestic Product (GDP) published in the Statistical Bulletin by the National Bureau of Statistics (NBS) from 1981 to 2012. The enterprises are aggregate values. For example crops are made up of many items including yam, rice, cassava, cowpea, maize etc. The prices used were not actual market prices but index of the prices at 1990 constant prices as computed by NBS. However, this may not be a serious issue since the indices are monotonic transformation of the aggregated market prices. Annual data for farm labour was obtained as 15 percent of the rural population. Data on wages were derived from Oni Timothy Olukunle (2013). In that study, the average rural monthly wage from 1980 to 2012 was summarized on five yearly averages. These periodic averages were intra-polated assuming compound growth rate (Ae^{rt}) to obtain the series of average monthly wage of rural labour from 1981 to 2012. It was estimated that 50 percent of the rural population were involved in agriculture. Given that the dominant agricultural regime in Nigeria is rain fed agriculture, it was assumed that farm work is carried out on the average 5 months in the year. The estimated monthly wage is multiplied by 5 to obtain the annual wage rate. This series was converted to index number with 1990 (100) as the base. The later value is multiplied into the rural farm population to obtain the value of rural labour.

Annual data for land utilized for agriculture was estimated using the annual percentage land under cultivation in Nigeria as published by the World Development Index (WDI); and the total land under farming in Nigeria was estimated as 33 percent of the Nigerian land area of 923768 sq km.

Data for working capital: The total loan given to agriculture in a particular year by the Agricultural Credit Guarantee Fund (ACGF) was used as the data for working capital for the year. The price of loan was derived as total value of loan divided by the quantity of loan. This price series was converted to index number with 1990 (100) as the base.

The data were extracted into Excel worksheet from where they were managed, thereafter exported to Limdep9 Econometric Software for detailed econometric analysis.

The output and input profit share equations are obtained via Hotelling's Lemma: i.e. differentiating the specified translog variable profit function with respect to the prices of outputs and variable inputs. These profit share equations contain only exogenous variables as explanatory variables and are linear in unknown parameters. They constitute a system of Seemingly Unrelated Equations (SUE). With a suitable specification of residuals, and data on the prices and inputs these equations can be estimated. In this study an addictive disturbance term is postulated. When the production process is not instantaneous, as in farming, a stochastic component is included because when time is required for the production process to occur, there is no certain level of output achievable from given inputs. The exact level of output achievable will depend on the technical efficiency and luck (Zellner et al 1966). The estimation technique adopted in the study is Zellner's (1962) method of estimating Seemingly Unrelated Regressions (ZSUR). It views the system of SUE as a single large equation which is efficiently estimated using the generalized least square (GLS) technique. The computer programme applied in the analysis is the SURE as detailed in Limdep9 Econometric Software by Green W.H (1986-2007).

Analytical Framework

The analytical framework for this study is based upon the duality that exists between the production (transformation) function, the variable profit function and the production possibility set of the farmer. As indicated by Baumol W.J (1977), the characteristics of the production technology can be examined through the dual approach which is computationally easier to manipulate and yields amongst others a set of optimal choices that are determined by the variables that are exogenous to the individual farms. Under regularity conditions, the duality theorems establish that if producers maximize profit, the variable profit function contains sufficient information to completely describe the production technology (McKay 1982).

The duality concept indicates that corresponding to any production function: $y = f(x,z)$ satisfying assumptions (i) to (iv) below, there exists a unique profit function: $\Pi = g(p,z)$ satisfying the constraints (a) to (d) below and vice versa (Lau 1969). Given the production function: $y = f(x,z)$ where y = vector of the variable outputs, x = vector of the variable inputs, z = vector of the fixed inputs:

(i) The production function is continuous in x and z and twice differentiable in x and once differentiable in z,

(ii) The production function is strictly increasing in x and z ie $\frac{dy}{dx} > 0, \quad \frac{dy}{dz} > 0; \ and \quad x_i \lim \to 0, \quad \frac{df}{dx_i} \to \infty$

(iii) The production function is strictly concave in the non-negative quadrant,

(iv) The function $y = f(x,z)$ is finite for all finite x and z; the function is unbounded as x and z approach infinity.

The profit function dual to the technology is $\Pi = g(p,z)$ where π = the variable profit, p = vector of prices, and z = vector of the fixed inputs:

(a) The profit function is continuous in the prices p_i and the fixed input quantities z_j. It is twice differentiable in the p_is and once differentiable in the z_js,

(b) The profit is non-decreasing in the p_is and strictly increasing in the z_js. Implicit in this is the fact that the profit function is increasing in the money prices of the outputs and decreasing in the money prices of the variable inputs.

(c) The profit function is strictly convex in the p_is and concave in the z_js.

(d) The profit function is finite for all finite prices and non-positive as all prices approach infinity.

A standard profit function, which follows assumptions (a) to (d), is chosen, then the assumptions (i) to (iv) holds for the production process. The production function and the normalized profit function are related to one another in one to one correspondence. We therefore start by choosing the functional form, which conforms to the conditions in (a) to (d) and be sure that the conditions (i) to (iv) hold for the production process. This study chooses the transcendental logarithmic variable profit function. By applying the Hotelling's lemma, the output supply and the input demand functions are obtained.

The Functional Form

The functional form of the transcendental logarithmic variable profit function specified is as follows:

$$\ln \pi(P,Z,T) = A + A_{1t} lnT + A_{tt}(lnT)^2$$

$$+ \sum_{i}^{I} a_{i0} lnP_i + \frac{1}{2}\sum_{i=1}^{I}\sum_{h=1}^{I} a_{ih} lnP_i lnP_h + \sum_{i=1}^{I} a_{iz} lnP_i lnZ + \sum_{i=1}^{I} a_{it} lnP_i lnT$$

Alternatively:

$$\ln\pi(P,Z,T) = A + A_t lnT + A_{TT}(LnT)^2 + a_{10}\,LnP_1 + a_{20}LnP_2 + a_{30}LnP_3 + a_{40}LnP + a_{50}LnP_5 + \frac{1}{2}a_{11}(LnP_1)^2 + a_{12}LnP_1LnP_2 + a_{13}LnP_3 + a_{14}Ln\,P_1LnP_4 + a_{15}LnP_1LnP_5 + a_{1z}LnP_1LnZ + a_{1t}LnP_1LnT$$

$$+\ \frac{1}{2}a_{22}(LnP_2)^2 + a_{23}LnP_2LnP_3 + a_{24}LnP_2LnP_4 + a_{25}LnP_2LnP_5 + a_{2z}LnP_2LnZ + a_{2t}LnP_2LnT +$$

$$\frac{1}{2}a_{33}(LnP_3)^2 + a_{34}LnP_3LnP_4 + a_{35}LnP_3LnP_5 + a_{3z}LnP_3LnZ + a_{3t}LnP_3LnT$$

$$+\ \frac{1}{2}a_{44}(LnP_4)^2 + a_{45}LnP_4LnP_5 + a_{4z}LnP_4LnZ + a_{4t}LnP_4LnT$$

$$+\frac{1}{2}a_{55}(LnP_5)^2 + a_{5z}LnP_5LnZ + a_{5t}LnP_5LnT$$

Where $\pi(P,Z,T)$ is the variable profit (total returns minus variable costs),
Pi, P_h = the prices of variable quantities (i,h,=1,…,I),
Z, = quantity of fixed input (land)
T, = Time (years) surrogate for disembodied technology

The Translog form is a second order approximation to arbitrary functional forms. It has local second order approximation properties since it is a Taylor series expansion in the logarithms to an arbitrary twice-differentiable function.

Convexity Requirements

Convexity of the Translog variable profit functions requires that the direct coefficients of fixed inputs; the coefficients of output prices; quadratic coefficients of the variable input prices are greater than zero also the coefficients of the prices of the variable inputs; the quadratic coefficients of the fixed inputs and output are greater than zero.

When these requirements are met and the overall set of coefficients satisfies the regularity conditions, then the variable profit function is non-decreasing and convex in the prices of the variable quantities and increasing in the output prices and the quantities of fixed inputs.

Symmetry Requirements

In order to ensure symmetry of the matrix of the second order derivatives of a twice-differentiable continuous function and permit the parameters of the share equations to be identified, the following restrictions are imposed (Diewert 1974):
$a_{ih} = a_{hi}$: i,h, = 1,…,i

Homogeneity Requirements

In order to ensure linear homogeneity of the variable profit function in prices (P) and fixed inputs (Z), the following restrictions are imposed:

$$(i)\quad \sum_{i=1}^{I} a_{i0} = 1;\quad \sum_{i=1}^{I} a_{ih} = 0;\quad for\ all\ h \neq 0;\quad \sum_{j=1}^{I} b_{i0} = 0;\quad for\ all.$$

Derivation of the Share Equations

The output and the input share equations are obtained via the application of the Hotelling's lemma, by differentiating the Translog variable profit function with respect to the prices of the outputs and the variable inputs. The Share equations are:

$$S_i = a_{i0} + \sum_{h=1}^{4} a_{ih} \ln\left(\frac{P_h}{P_5}\right) + a_{iZ} lnZ + a_{iT} lnT + e_i \qquad i = 1 \ldots 4$$

Where S_i = Share of net output or variable input i in the variable profit = $\frac{p_i y_i}{\pi}$ or $\frac{w_i x_i}{\pi}$ where 'w' denotes the price of variable input.

The usual convention of denoting disembodied technology with time is applied.

Estimation of the Equations

The share equations are estimated jointly using data on the prices and quantities of outputs and inputs as well as additive specification of the residuals. Apparently, the shares of both variable inputs and outputs sum to unity by definition. These lead to singularity of the residual covariance matrix. This anomaly is overcome by omitting one of the variable net input share equations (working capital). According to Mckay (1982), if there is reason to doubt that the market prices of the relatively fixed inputs such as land correspond closely with the non-observable shadow prices, consideration could be given to estimating only the variable net output share equations alone. This is what is done in this study since we do not have the price of the fixed inputs (land). We applied Zellner's (1962) method of estimating Seemingly Unrelated Regression Equations (ZSURE). It is a special application of the Generalized Least Squares (GLS) and a variant of the Three Stage Least Squares, which takes explicit account that the correlation of error terms across the share equations may not be zero. ZSURE is a full information estimation technique and the estimator is consistent and asymptotically efficient. ZSURE and the relevant algebra is detailed in many Econometric textbooks and applied works including: Kmenta (1971), Johnston (1991), Pindyck and Rubinfeld (1982).

Computation of the Elasticities

The output-output, output-input and input-input relationships are discussed in terms of such familiar concepts as elasticity's of transformation and intensity.

Elasticities of Transformation between Variable Quantities

Elasticity of transformation Θ_{ih} between variable quantities y_i and y_h is computed as follows:

$$\theta_{ih} = 1 + \frac{a_{ih}}{S_i S_h} \qquad for\ i, h\ = 1, \ldots 5, 1 \neq h$$

$$\theta_{ih} = 1 + \frac{a_{ii}}{S_i^2} - \frac{1}{S_i} \qquad for\ i, \ldots, 5$$

Where Si is the profit share of the variable quantity i.

The elasticity of transformation Θ_{ih} between the variable quantities Y_i and Y_h measures the proportionate change in Y_i for a proportionate change in Y_h. It is a scale invariant normalization of $\frac{dY_i}{dP_h}\ (i, h, = 1, \ldots, 5)$.

Symmetry restriction ensures that $\Theta_{ih} = \Theta_{hi}$ for all $_h$ and $_i$.

Partial Elasticity of Output i with respect to Price P_h

An alternative means of describing the characteristics of the technology is in terms of the associated partial elasticities. The Partial Elasticity of Output i with respect to Price P_h $\in_{ih}$ (P, Z, T) is the conventional elasticity of demand if i is an input and elasticity of supply if i is an output. Due to the assumed homogeneity of the variable profit function in the prices of $\sum_{h=1}^{i} \in_{ih} = 0$

For the translog variable profit function the partial elasticity of output with respect to price p_h:

$$\epsilon_{ih} = S_h + \frac{a_{ih}}{S_i} \quad i,h = \quad 1,\ldots,5 \; i \neq h,$$

$$\epsilon_{ih} = S_i + \frac{a_{ii}}{S_i - 1} \quad i = \quad 1,\ldots,5$$

It is interpreted as the conventional elasticity of output i to the price h.

The system of share equations estimated contains three variable outputs: crops (y_1), livestock (y_2), and fishery(y_3), two variable inputs: labour $(-y_4)$, and materials and services$(-y_5)$, and the fixed input is land(x_1).

Disembodied Technical Change

The time coefficient is used to indicate the bias of technical change. A positive value for an output share equation indicates that technical change has been biased in favour of that output but a positive value for a variable input share equation it indicates that the technical change has been biased to that variable input saving. Conversely, A negative value for an output share equation indicates that technical change has been biased against that output but a negative value for a variable input share equation indicates that the technical change has been biased to using that variable input.

Results and Discussion

Goodness of fit

As a measure of goodness of fit for the equations; the coefficient of determination R^2, and the F-statistics are presented in table 6.1. The R^2 range from 0.696 for the fishery share equation to 0.796 in the labour share equation when the unrestricted multivariate regression (OLS) is applied to the data. When the restricted ZSUR is applied, the R^2 ranged from 0.619 for the livestock share equation to 0.747 for the labour share equation. It follows therefore, that between 62 percent and 75 percent of the variations in the dependent variables are explained by the variations in the explanatory variables. The $F - statistics$ ranged from 5.7 for the crops share equation to 16.2 in the labour share equation when the unrestricted multivariate regression (OLS) is applied to the data. When the restricted ZSUR is applied, the $F - statistics$ ranged from 6.8 for the livestock share equation to 12.3 for the labour share equation. The critical F-statistics at 95 percent level of confidence, with 6 (upper) and 25 (lower) degrees of freedom is 2.59. Since all the estimated F-statistics were greater than the critical value then there is valid regression.

The Signs of the Estimated Coefficients

In the output share equations the own price coefficients for all the outputs except crops enterprise were all positive while that of the variable inputs are all negative. These imply that the corresponding trasnlog variable profit function satisfies the monotonicity requirement of non-decreasing in the prices of variable output and non-increasing in the prices of variable inputs.

The sign of the partial own price elasticity's are as would be expected positive for all the variable outputs$(i.e. i = h;\; i,h \; = \; 1, 2 \; and \; 3)$; and negative (except for working capital) for the variable inputs. This indicated that the estimated translog variable profit function is convex in the prices of the outputs at the mean exogenous prices and also concave in the prices of the variable inputs. This implies that the dual production possibility set is defined.

Statistical Significance of the Explanatory Variables

Evident from table 6.1, the vast majority of the parameter estimates are significantly different from zero at the 95 percent level of confidence. The critical (tabulated) two-tailed 't' value at 95% level of confidence with 25 degrees of freedom is 1.7.

In the crop share equation (equation 1), except for fishery prices, wages and time, all the t-statistics for the regressors were greater than the critical value; indicating that at 95% level of confidence, all the regressors except fishery prices, wages and time were empirically significant in explaining the changes in the crop share.

In the livestock share equation (equation 2), except for wages and time, all the t-statistics for the regressors were greater than the critical value; indicating that at 95% level of confidence, all the regressors except wages and time were empirically significant in explaining the changes in the livestock share.

In the fishery share equation (equation 3), only livestock price was empirically significant in explaining the changes in the fishery share.

In the labour share equation (equation 4), except for livestock and fishery prices and time, all the t-statistics for the regressors were greater than the critical value; indicating that at 95% level of confidence, all the regressors except livestock and fishery prices and time were empirically significant in explaining the changes in the livestock share.

From the two-tailed t-tests at 95% confidence level, it is apparent the share equations have been significantly responsive to changes in the relative prices.

Based on the observed values of the coefficients of determination, the signs of the estimated coefficients and the t-values, it is concluded that prices substantially influence the supply of crops, livestock and fishery; and the demand for labour and working capital in Nigerian agriculture.

Elasticities of Transformation

The elasticity of transformation which is a scale invariant transformation of $\frac{dY_i}{dP_h}$ $(i, h = 1, \ldots, 5)$ measures the rate of change in the production of a variable output say crops for a change in the price of another variable output say livestock. It is therefore a measure of the responsiveness of the supply of an output to the change in the supply of another output. The sign if positive indicates complementary relationship; if equal to zero indicates supplementary relationship; and if negative indicates competitive relationship between the outputs. It is evident from the study that as at 2012 crops and livestock; and crops and fishery enterprises had complementary relationships. This implied that there was no switching from crops to livestock and vice versa or from crops to fishery and vice versa as the crops prices changed. However livestock and fishery had competitive relationship consequently, as the prices of the fishery increases farmers tend to switch from livestock to fishery and vice versa. The details are in table 1.

Table 1: Estimated Partial Elasticities of Transformation between Output and Output Prices

Enterprises in 2012	Elasticity of Transformation	Relationship
Crops-Livestock	0.916	Complementary
Crops-Fishery	1.151	Complementary
Livestock-Fishery	-2.989	Competitive
Crops-Crops' price	0.414	
Crops-Livestock's price	0.916	
Crops-Fishery's price	1.151	
Livestock-Crops' price	0.916	

Livestock-Livestock's price	-3.658	
Livestock-Fishery's price	-2.989	
Fishery-Crops' price	1.152	
Fishery-Livestock's price	-2.989	
Fishery-Fishery's price	-11.452	

Partial Elasticity's of Supply

The partial elasticity of supply measures the 'ceteris paribus' proportionate change in the quantity of output supplied for a proportionate change in price; it is the conventional measure of the partial elasticity of supply $\frac{dlnY_i}{dlnP_h}$ when $i = h$, but referred to as cross price Elasticities of supply if i is not equal to h. The estimated own price supply elasticities were as would be expected all positively signed. The estimated own price supply of crops was elastic while that of livestock and fishery were inelastic. The details are in table 2. Since the own price supply elasticity's were all positively signed, it implies that the production increases with increases in the selling price. Government could there increase production of crops, livestock and fishery by inducing increases in their selling prices. This could be achieved through price incentives to producers.

Table 2. Estimated Partial Elasticities of Supply

Enterprises in 2012	Partial Elasticity of Supply	Status
Crops-Crops' price	1.660	Elastic
Crops-Livestock's price	0.127	Inelastic
Crops-Fishery's price	0.082	Inelastic
Crops-Labour's wage	1.077	Elastic
Crops-Working capital's price	0.134	Inelastic
Livestock-Crops' price	1.732	Elastic
Livestock-Livestock's price	0.082	Inelastic
Livestock-Fishery's price	-0.213	Inelastic
Livestock-Labour's wage	1.078	Elastic
Livestock-Working capital's price	0.112	Inelastic
Fishery-Crops' price	2.178	Elastic
Fishery-Livestock's price	-0.414	Inelastic
Fishery-Fishery's price	0.063	Inelastic
Fishery-Labour's wage	1.029	Elastic
Fishery-Working capital's price	0.226	Inelastic

Partial Elasticity's of Demand

The partial elasticity of demand measures the 'ceteris paribus' proportionate change in the quantity of input demanded for a proportionate change in price; it is the conventional measure of the partial elasticity of demand $\frac{dlnY_i}{dln\,P_h}$ when $i = h$, but referred to as cross price elasticities of demand if i is not equal to h. The estimated own price elasticity of demand for labour was as would be expected negatively signed but that of working capital was positively signed. The estimated own price demand for labour was elastic while that of working capital was inelastic. The details are in table 2. The elastic price of agricultural labour is not unexpected because as more states are being created and many towns are being urbanized agricultural labour gets scarcer as other modern-sector enterprises compete for the available labour. It is recommended that government should implement policies that will attract youths to the farm. This could be achieved by providing rural infrastructures, removal of drudgery in agricultural work and price incentives. The inelasticity of the price demand for working capital reflects the non-readily availability of the SGCF loan irrespective of the farmers willingness to pay back. It is recommended that government, agricultural and commercial banks should provide soft loans for agricultural purposes.

Table 3. Estimated Partial Elasticities of Demand in 2012

Enterprises in 2012	Partial Elasticity of Demand	Status
Labour-Crops' price	1.941	Elastic
Labour-Livestock's price	0.142	Inelastic
Labour-Fishery's price	0.070	Inelastic
Labour-Labour's wage	-1.198	Elastic
Labour-Working capital's price	0.107	Inelastic
Working capital-Crops' price	4.922	Elastic
Working capital-Livestock's price	0.304	Inelastic
Working capital-Fishery's price	0.312	Inelastic
Working capital-Labour's wage	2.174	Elastic
Working capital-Working capital's price	0.300	Inelastic

Disembodied Technical Change

It is apparent that during the study period (1981-2012), technical change was biased in the favour of producing crops, livestock and fisheries. Technical change was labour saving and capital using. These finding were not unexpected considering the fact that during the period under study (1986-2012), the Federal Government of Nigeria (FGN) has been vigorously pursuing agricultural policies that are capital intensive and labour saving geared at increased production of crops, livestock and fisheries using improved and environmentally friendly technologies. Notable among these policies include the various Fadama projects and the National Programme for Food Security.

Conclusions

The coefficient of determination R^2 indicated that between 62 percent and 75 percent of the variations in the dependent variables are explained by the variations in the explanatory variables and the $F-statistics$ ranged from 6.8 for the livestock share equation to 12.3 for the labour share equation. Since all the estimated F-statistics were greater than the critical value then there is valid regression.

The estimated trasnlog variable profit function satisfied the monotonicity requirement of non-decreasing in the prices of variable output and non-increasing in the prices of variable inputs.

The own price elasticities for the variable outputs and inputs were correctly signed. This indicated that the estimated translog variable profit function is convex in the prices of the outputs at the mean exogenous prices and also concave in the prices of the variable inputs as such implies that the dual production possibility set is defined.

The two-tailed t-tests at 95% confidence level, showed that the share equations have been significantly responsive to changes in the relative prices.

Based on the observed values of the coefficients of determination, the signs of the estimated coefficients and the t-values, it is concluded that prices substantially influence the supply of crops, livestock and fishery; and the demand for labour and working capital in Nigerian agriculture.

It is evident from the study that as at 2012 crops and livestock; and crops and fishery enterprises had complementary relationships. This implied that there was no switching from crops to livestock and vice versa or from crops to fishery and vice versa as the crops prices changed. However livestock and fishery had competitive relationship consequently, as the prices of the fishery increases farmers tend to switch from livestock to fishery and vice versa. Since the own price supply elasticity's were all positively signed, it implies that the production increases with increases in the selling price.

The elastic price of agricultural labour is not unexpected because as more states are being created and many towns are being urbanized agricultural labour gets scarcer as other modern-sector enterprises compete for the available labour. The inelasticity of the price demand for working capital reflects the non-readily availability of the SGCF loan irrespective of the farmers willingness to pay back.

Evidently, during the study period (1981-2012), technical change was biased in the favour of producing crops, livestock and fisheries. Technical change was labour saving and capital using. These finding were not unexpected because during the period under study the Federal Government of Nigeria (FGN) was vigorously pursuing agricultural policies that were capital intensive and labour saving in order to increase the production of crops, livestock and fisheries through improved and environmentally friendly technologies.

Recommendations

The following recommendations emerged from the study:

i. Government should stimulate increase production of crops, livestock and fishery by inducing increases in their selling prices. This could be achieved through price incentives to producers.

ii. Government should implement policies that will attract youths to the farm. This could be achieved by providing rural infrastructures, removal of drudgery in agricultural work and price incentives.

iii. Government, agricultural and commercial banks should provide soft loans for agricultural purposes.

iv. The government should promote technologies that are less capital intensive in Nigerian agriculture to attract the youths (school leavers and under graduates) who have little or no capital into agriculture.

Appendix 1: Unrestricted Equations

R SQ=0.7898		F=5.66 (6,25)					
CRS	Constant	LNCP	LNLP	LNFP	LNWR	LLV	LTEC
Coefficient	-16.789	1.034	-0.704	-0.033	-0.366	1.519	0.169
Std Error	18.086	0.543	0.915	1.194	0.210	1.492	0.255
b/St.Er.	18.086	1.902	-0.770	-0.029	-1.745	1.018	0.664
R SQ=0.699		F= 9.68 (6,25)					
LIS	Constant	LNCP	LNLP	LNFP	LNWR	LLV	LTEC
Coefficient	-1.357	0.062	0.008	-0.051	-0.022	0.123	0.004
Std Error	1.186	0.036	0.060	0.078	0.014	0.098	0.017
b/St.Er.	-1.440	1.731	0.140	-0.655	-1.601	1.254	0.213
R SQ=0.6964		F= 9.56 (6,25)					
FIS	Constant	LNCP	LNLP	LNFP	LNWR	LLV	LTEC
Coefficient	-0.079	0.060	-0.065	0.017	-0.021	0.014	0.008
Std Error	0.866	0.026	0.044	0.057	0.010	0.071	0.012
b/St.Er.	-0.091	2.337	-1.481	0.298	-2.053	0.193	0.613
R SQ=0.7962		F= 16.2 (6,25)		MEAN LAS=0.7843			
LAS	Constant	LNCP	LNLP	LNFP	LNWR	LLV	LTEC
Coefficient	-13.634	1.108	-0.684	0.167	-0.550	1.215	0.031
Std Error	17.923	0.539	0.906	1.183	0.208	1.479	0.252
b/St.Er.	-0.761	2.058	-0.755	0.141	-2.644	0.822	0.121

Where:

CRS = Crop Share
LIS = Livestock Share
FIS = Fishery Share
LAS = Labour Share
LNCP = Logarithm of Crop Price
LNLP = Logarithm of Livestock Price
LNFP = Logarithm of Fish Price
LNWR = Logarithm of Wage rate
LLV = Logarithm of Land Value
LTEC = Logarithm of Technology

Appendix 2: The Restricted Equations							
R SQ=0.7334		F=11.46 (6,25)		MEAN CRS= 1.6322			
CRS	Constant	LNCP	LNLP	LNFP	LNWR	LLV	LTEC
Coefficient	-33.456	-0.206	-0.022	0.020	0.051	2.818	0.313
Std Error	16.098	0.038	0.008	0.013	0.030	1.350	0.230
b/St.Er.	-2.078	-5.391	-2.706	1.598	1.703	2.087	1.358
R SQ=0.619		F= 6.78 (6,25)		MEAN LIS= 0.1281			
LIS	Constant	LNCP	LNLP	LNFP	LNWR	LLV	LTEC
Coefficient	-2.396	-0.020	0.049	-0.039	0.004	0.204	0.012
Std Error	1.062	0.008	0.011	0.014	0.004	0.089	0.015
b/St.Er.	-2.255	-2.706	4.373	-2.907	0.970	2.289	0.793
R SQ=0.643		F= 7.52 (6,25)		MEAN FIS= 0.0575			
FIS	Constant	LNCP	LNLP	LNFP	LNWR	LLV	LTEC
Coefficient	-0.783	0.020	-0.039	0.008	-0.002	0.069	0.015
Std Error	0.787	0.013	0.014	0.020	0.005	0.066	0.011
b/St.Er.	-0.996	1.598	-2.907	0.395	-0.302	1.041	1.324
R SQ=0.747		F= 12.31 (6,25)		MEAN LAS= 0.7843			
LAS	Constant	LNCP	LNLP	LNFP	LNWR	LLV	LTEC
Coefficient	-30.518	0.051	0.004	-0.001	-0.112	2.528	0.195
Std Error	15.950	0.030	0.004	0.005	0.027	1.338	0.228
b/St.Er.	-1.913	1.703	0.970	-0.302	-4.138	1.889	0.854

Where:

CRS = Crop Share
LIS = Livestock Share
FIS = Fishery Share
LAS = Labour Share
LNCP = Logarithm of Crop Price
LNLP = Logarithm of Livestock Price
LNFP = Logarithm of Fish Price
LNWR = Logarithm of Wage rate
LLV = Logarithm of Land Value
LTEC = Logarithm of Technology

References

Baumol, W.J (1977). Economic Theory and Operations Analysis, Prentice Hall International Editions, United Kingdom, 4th Ed.

Diewert, W.E (1974). An Application of the Shephard Duality Theorem: Frontiers of Quantitative Economics Vol 2 Edited by M.D. Intrilligator and David Kendrick Amsterdam: North Holland Publishing Company. Journal of Development Economics, Vol 6, pp 299-341.

Green, W. H. (1986-2007). Limdep9 Econometric Software, Inc., Econometric Software, Australia, 215 Excelsior Avenue, Castle Hill NSW 2154, Australia, Email: hgroup@optusnet.com.au

Enwere, (1998). Monthly Series, National Bureau of Statistics, Abuja, Nigeria.

FAO, Library (2002). Report on the Baseline Survey of the National Special Programme On Food Security, (Unpublished), No 3, Oguda Close, Lake Chad Crescent, Maitama, Abuja, Nigeria.

Johnston, J (1991). Econometric Methods, McGraw-Hill, Kogakusha Ltd, Tokyo.

Kmenta, J. (1971). Econometrics, McGraw-Hill, Kogakusha Ltd, Tokyo pp331-465.

Lau, L.P (1969). Some Applications of Profit Functions: Memorandum No 86, Research Center in Economic Growth, 43 Enaina Hall, Stanford University, Californi.a

McKay, etal (1982). Production Flexibility and Technical Change in Australia's Wheat/Sheep Zone, Review of Marketing and Agric. Economics Vol 50 No 1.

Okoruwa V.O. Akindeinde A.O. & Salimonu K.K,(2009). Relative Economic Efficiency of Farmers in Rice Production: A Profit Function Approach in North Central Nigeria, Tropical and Subtropical Agroecosystems, 10: 279-286.

Projects Coordinating Unit, (2002). Crops Area and Yield Survey, Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria.

Pindyck, R.S & Rubinfeld, D.L (1981). Econometric Models and Forecasts, McGraw-Hill, International Book Co. London, pp323-537.

World Development Indicators, United Nations, World Urbanization Prospects.

http://data.worldbank.org/indicator/SP.RUR.TOTL?page=6&display=default 10/12/2014

Zellner, A. (1963). Estimators of Seemingly Unrelated Regressions: Some Exact Finite Sample Results, Journal of American Statistical Association, Vol 58, pp977-992.