PRODUCTION RISK AND TECHNICAL EFFICIENCY IN SMALL HOLDER CASSAVA PRODUCTION IN IMO STATE, NIGERIA

Ohajianya D.O[1], Nwibo S.U[2], Umeh G.N[3], Nzeh E.C[4], Unaeze H.C[5] and Nwachukwu E.U[6].

1,6 Department of Agricultural Economics, Federal University of Technology Owerri, Imo State

2,3 Department of Agricultural Economics, Management and Extension, Ebonyi State University, Abakaliki, Ebonyi State.

4 Department of Agricultural Economics and Extension, Enugu State University of Science and Technology, Enugu State.

5 Department of Agricultural Economics & Extension, University of Port Harcourt, Rivers State.

ABSTRACT

This study analyzed production risk and technical efficiency in smallholder cassava production in Imo State, Nigeria. Data were collected with questionnaire from 152 proportionately and randomly selected smallholder cassava farmers. Data were analyzed using descriptive statistics, econometric and statistical tools. Results show that mean age of farmers was 41.3years while mean farm size was 1.23 hectares. The value of production risk was 9.23 indicating that cassava production was associated with risk. Parameters of production factors such as cassava cuttings, labour, fertilizer and capital were significant at 5% in the technical efficiency model estimated without production risk. These factors were also significant alongside production risk at 5% level when technical efficiency was estimated with production risk as a factor. The mean technical efficiency was 0.73 when production risk was not incorporated, but the mean technical efficiency reduced to 0.48 with the integration of production risk. Sources of inefficiency were level of education, farming experience, credit access and age. Incorporation of production risk in estimating technical efficiency will give a better and unbiased results since agricultural production is inherently risky.

Keywords: Production Risk, Technical Efficiency, Smallholder, Cassava, Imo State.

INTRODUCTION

Agricultural production is stochastic and this poses a major source of risk. Agriculture is often characterized by high variability of production outcomes. Variability in outputs is not only explained by factors outside the control of the farmer such as input and output prices but also by controllable factors such as varying levels of inputs (Fufa & Hassan, 2003). Most sources of agricultural risks affecting cassava farmers in developing countries do not differ as they basically stem from weather, market, and institutional and political-related risks and these are not exclusive to any particular country (Koesting *et al*, 2014).

Production risk can be defined as a situation whereby agricultural producers such as cassava farmers cannot predict with certainty the amount of output their production process will yield, due to external factors such as weather, pests and diseases (World Bank, 2005; Linnerooth-Bayer *et al*, 2011).
It is generally accepted that for a given technological frontier, there are two types of efficiencies – technical and allocative (Farrell, 1957). Technical efficiency may be defined as the ability to achieve the highest level of output possible given a level of production inputs.

The small holder cassava farmers tend to resist or avoid production risk, because the farmers are not thinking to maximize profits, but to produce the level of output that will meet their household needs (Harold, 2013). The behavior of farmers against the risk can be a crucial issue, especially related to farming activities and decision making as well as input use and resultant technical efficiency (Kumbhaker, 2002). Not recognizing the existence of risk in smallholder cassava production will result in biases of parameter estimates and technical efficiency cause yields to be higher for farmers that avoided risk and lower for farmers that incorporated risk, and consequently cause problems when interpreting the results of analyses (Kumbhaker, 2002).

Most of the studies on efficiency focused on resource use efficiency, technical, allocative and economic efficiency (Amaza, 2000; Ohajianya, 2005; Ohajianya, 2006; Onyenweaku & Nwaru, 2005; Onyenweaku & Ohajianya, 2007; Onyenweaku & Okoye, 2007; Ajibefun & Abdukadri, 2004; Ukwuaba & Inono, 2012), while most of the studies on risk focused specially on risk in livestock industry (Ogundari & Akinbogun, 2010), risk and insurance (Battese et al, 1997) and management of production risk in agriculture (Bokusheva & Hockmann, 2006; Futa & Hassan, 2003). Studies on production risk and technical efficiency have been relatively scanty, and known few studies analyzed production risk at farm level (Gardebroak *et al*, 2010; Kumbhaker, 2002), and none of these studies incorporated production risk into technical efficiency model. This study intends to bridge this gap in knowledge.

It is feasible and practical to incorporate technical efficiency analysis with Just & Pope's (1979) risk function approach. For instance, Bokusheva & Hockmann (2016) incorporated production risk into technical efficiency model in Russian arable farms, and found that there was wide fluctuation in yields, which implies that a production function that takes into account the effects of inputs and production risk on technical efficiency is preferred to reflect production technology than just an analysis of technical efficiency. This study aims at determining the level of risk associated with smallholder cassava production, estimate the level of technical efficiency among smallholder cassava farmers, and determine the influence of smallholder cassava farmers' risk level and other factor inputs to the level of technical efficiency.

It is hypothesized that there is no significant relationship between level of farm inputs and production risk level and level of technical efficiency of smallholder cassava farmers in Imo State.

METHODOLOGY

This study was carried out in Imo State which is one of the five states of South-East Nigeria. It covers an area of 5100.10 square kilometers, and lies between latitudes $5^0 40^I$ and $6^0 31^I$ N and longitudes $6^0 35^I$ and $7^0 45^I$ E. The state is bounded on the east by Abia state, on the south and southwest by Rivers state, on the Northeast by Delta state and in the North by Anambra and Enugu states (Imo Calender, 2007). Imo state is divided into three agricultural zones of Owerri, Orlu and Okigwe. Owerri zone consist of 10 Local Government Areas (LGAs) namely: Owerri West, Owerri North, Owerri Municipal, Ikeduru, Mbaitoli, Aboh Mbaise, Ezinihitte Mbaise, Ahiazu Mbaise, Ohaji/Egbema, and Ngor-Okpala; Orlu agricultural zone is made up of 11 LGAs namely: Oru East, Oru West, Ideato North, Ideato South, Orsu, Amaigbo, Nwangele, Nnenasa, Oguta, Orlu and Nkwere; and Okigwe agricultural zone comprises of 6 LGAs namely: Okigwe, Onuimo, Isiala Mbano, Ehime Mbano, Obowo and Ihitte-Uboma.

According to the National Population Commission (NPC) (2016) projected population, the State's population was 4,812,445 people.

The rainfall distribution pattern and the tropical equatorial climate of the state gives rise to two distinct seasons namely; rainy season from March to October and dry season from November to February. The temperature varies with season, and the hottest period occurs between the months of March and April, with temperatures varying between 27^0 C and 35^0 C. The soil type of the state is sandy-loam which favours the cultivation of root crops such as yam, cassava, cocoyam and vegetables (Okoli *et al*, 2005). Cassava is produced in both smallholder and large scale, but this study focused on small holder production.

A multi-stage sampling procedure was used to select smallholder cassava farmers. In the first stage, two rural LGAs were purposively selected from each agricultural zone to get six LGAs based on their high cassava production records (Imo FADAMA III, 2013).
In the second stage, five communities were randomly selected from each selected LGA, making a total of 30 communities. In the third stage, the list of registered smallholder cassava farmers was collected from the Agricultural Development Project (ADP) extension agents. From this sampling frame totaling 434 smallholder cassava farmers composed of 222 from Orlu agricultural zone, 142 from Owerri zone and 70 from Okigwe zone. In the fourth stage, proportionate and random sampling methods were employed to select 152 farmers composed of 78,50 and 24 from Orlu, Owerri and Okigwe agricultural zones respectively.

The proportionate sampling model used to select the smallholder cassava farmers as stated by Ohajianya (2006) is;

$$n_h = N_h\left(\frac{n}{N}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where, n_h = Sample size selected from each agricultural zone
N_h=Sampling frame of smallholder cassava farmers in each agricultural zone, n=Sampling size of smallholder cassava farmers selected for the study, N = Total Sampling frame of smallholder cassava farmers in the study area.

Data were collected with the aid of structured questionnaire on smallholder cassava farmers' production activities during the 2017 Cropping Season. Data were also collected on the farmers' socioeconomic characteristics, production inputs, outputs and prices.

Data were analyzed using descriptive statistics and econometric tools. The socioeconomic characteristics were realized using descriptive statistics such as mean, standard deviation, frequency distribution and percentages. Risk level of smallholder cassava farmers was achieved using standard deviation model expressed as follows;

$$\sigma = \sqrt{}P_1(X_1 - Ev)^2 + P_2(X^2 - Ev)^2 + \ldots + P_n(X_n - Ev)^2 \ldots\ldots\ldots\ldots\ldots(2)$$

where,
σ = Standard deviation, P=Probability of outcome of output (x)
X = Value of the output, Ev =Expected value of output

Technical efficiency of individual smallholder cassava farmers was estimated using the stochastic frontier model. (Khumbhakar, 2002; Onyenweaku & Ohajianya, 2007; Onyenweaku & Nwaru, 2005). The multiplicative stochastic production function is of the form

$$Y_i = f(X_{k;}\beta)^{\varepsilon i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

I = l......n; k= 1........k,
Where,
Y_i = Output of the i^{th} farm,
X_k = Vector of k^{th} input of the i^{th} farm,
B = Vector of parameters.
E_i = Error term
This stochastic frontier is also called a 'composed error' model because the error term is composed of two independent elements:

$$\varepsilon_i = v_i - u_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

The symmetric component V_i permits random variation in output due to factors outside the farm such as weather and disease as well as the effects of measurement error in the output variable, left out explanatory variables from the model and stochastic noise. It is assumed to be independently and identically distributed as $v \sim N(0, \sigma^2_v)$. A u_i is a one-sided non-negative ($u_i > 0$) random variable which reflects the technical efficiency relative to the stochastic frontier, $f(X_{k;}\ \beta)e^{vi}$, thus $u_i = 0$ for any output lying on the frontier and is strictly positive for any output lying below the frontier representing the amount by which the frontier exceeds the actual output of firm i. u_i is assumed to be identically and independently distributed as (u_i~[N(0, σ^2_u]); that is, the distribution of u is half normal.

It follows that the maximum likelihood of equation 1 yields estimate for β and λ where β was as earlier defined and

$\lambda = \sigma_u/\sigma_v$……………………… (5)

and

$\sigma^2 = \sigma^2_v+\sigma^2_u$ .... (6)

Battese & Coelli (1992) on the other hand defined as the total variation in output from the frontier which is attributable to TE: that is

$\gamma = \sigma^2_u/\sigma^2$ .... (7)

so that $0 \leq \gamma \leq 1$. An estimate of γ can be obtained from estimates of σ^2 and λ.

The frontier production functions 3 and 4 is defined by the logarithm of production, thus the production for the ith farm is exp (Y_i). The measure of technical efficiency (TE) for the ith farm is thus:

$TE_i = \exp(-u_i)$ .... (8), so that $0 \leq TE_i \leq 1$.

This measure of technical efficiency is equivalent to the ratio of the production for the ith farm, exp (Y_i) =exp ($X_i\beta + v_i - u_i$) to the corresponding production value if the effect of Y_i was zero, exp ($X_i\beta + v_i$). The technical efficiency measure (8) is not dependent on the level of factor input for the given firm.

The mean technical efficiency of the farms that corresponds to the measure of equation (8) is:

$TE = \{1 - \Phi\ \{\sigma-(\mu/\sigma)\}/1 - \Phi(-\mu/\sigma)\ \}\ \exp(-\mu + ½\ \sigma^2)$………………… (9)

Where,

Φ (.) represents the density function for the standard normal random variables.

The frontier production function specified for the yam enterprises in the prevailing state was defined by $\ln Y_i = \beta_0 + \beta_1\ln X_{1i} + \beta_2\ln X_{2i} + \beta_3\ln X_{3i} + \beta_4\ln X_{4i} + \beta_5\ln X_{5i} + v_i - u$, ...,..(10)

Where the subscript i (i=1, ... ,152); Y denotes the logarithm of output of cassava (kilogram); X_{1i} denotes logarithm of the hectares of land cultivated; X_{2i} denotes logarithm of the quantity of cassava cuttings (in kilogram); X_{3i} denotes logarithm of the quantity of labour used (in man-days); X_{4i} denotes logarithm of the expenditure on fertilizer used (in kilogram); X_{5i} denotes logarithm of the depreciation on capital items (in Naira). The random variables V_i and u_i in model (4) were assumed to have the properties specified for the corresponding unobservable random variables in the frontier production function model (3) and (4). u_i which denotes inefficiency effects is defined thus:

$\mu_i = \delta_0 + \delta_1\ell_nZ_1 + \delta_2\ell_nZ_2 + \delta_3\ell_nZ_3 + \delta_4\ell_nZ_4 + \delta_5\ell_nZ_5 + \delta_6\ell_nZ_6$.......................... (11) where,

Z_1 = Level of education (years)

Z_2 = Farming experience (years)

Z_3 = Credit access (dummy variable, 1 for access, 0 for non-access)

Z_4 = Extension contact (number of visits per annum)

Z_5 = Household size (number of persons)

Z_6 = Age (years)

Given functional and distributional assumptions, the variance parameters defined by equations (6) and (7), the technical efficiency defined by equation (8) and the maximum-likelihood (ML) estimates for all parameters of the stochastic frontier production and inefficiency model defined by equations (10) and (11) were simultaneously estimated using the program, LIMDEP.

The influence of cassava farmers' risk level and other factor inputs on the level of technical efficiency was determined by incorporating risk level into technical efficiency model as follows;

$Qi = f(X_1,\beta) + R_l + V_i - U_i$ ………………………..(12)

The production technology of smallholder cassava farmers was assumed with a Cobb-Douglas production function of the form;

$\ell_n Q_i = b_0 + b_1 \ell_n X_1 + b_2 \ell_n X_2 + b_3 \ell_n X_3 + b_4 \ell_n X_4 + b_5 \ell_n X_5 + b_6 \ell_n R\ell_6 + V_i - U_i$ ……………..(13)

Where,

Q = Output of smallholder cassava farmers (kg)

i = ith smallholder cassava farmer

X_1 = Farm size (Ha)

X_2 = Expenditure on cassava cuttings (₦)

X_3 = Labour input (man days)

X_4 = Expenditure on fertilizer (₦)

X_5 = Depreciation on capital input (₦)

$R\ell$ = Risk level of smallholder cassava farmers (measured using standard deviation)

ℓ_n = Natural logarithm

b_0 = Constant

$b_1 - b_6$ = Parameters estimated

V_i and U_i = Error terms

The U_i which denotes inefficiency effects is defined thus;

$U_i = a_0 + a_1 \ell_n Z_1 + a_2 \ell_n Z_2 + a_3 \ell_n Z_3 + a_4 \ell_n Z_4 + a_5 \ell_n Z_5 + a_6 \ell_n Z_6$ …………………… (14)

Where,

Z_1 = Level of education (years)

Z_2 = Farming experience (years)

Z_3 = Credit access (dummy variable, 1 for access, 0 for non-access)

Z_4 = Extension contact (number of visits per annum)

Z_5 = Household size (number of persons)

Z_6 = Age (years)

The hypothesis was tested using the results of this analysis, which produced t-values that were compared with t-critical values to determine variable significance needed to test the hypothesis.

RESULTS AND DISCUSSION

A summary statistics of the socioeconomic characteristics of the smallholder cassava farmers is as given in Table 1.

Table 1. Summary statistics of socioeconomic characteristics of smallholder cassava farmers

Variable	Mean	Standard Deviation	Minimum value	Maximum value
Net Revenue (N/Ha)	287,159	62,552	201,332	403,114
Farm size (Ha)	1.23	0.74	0.75	3.82
Labour (mandays)	257	93	192	413
Fertilizer (kg/Ha)	275	112	55	850
Cassava cuttings (N/Ha)	14,350	1,339	7045	23546
Age (years)	41.3	18	30	67
Farming experience (years)	8.5	3.6	5.2	21
Level of education (years)	7.8	4.2	0	16
Access to credit (N)	42,615	1,553	5000	109000
Extension contact (Number of visits)	0.38	0.12	0	2
Household size (Number of persons)	7	3	4	13

Source: Survey Data, 2018

The farm size of the farmers ranged between 0.75 – 3.82 Hectares with mean of 1.23 Hectares confirming that the cassava farmers are smallholders.

The age of the farmers ranged between 30 to 67 years with a mean of 41.3 years, which implies that smallholder cassava farmers in the area are in their active stage of life, a stage that may positively influence their production which is labour – intensive.

Table 2. Distribution of smallholder cassava farmers according to cassava output

Cassava output (tonne)	Frequency	Percentage
≤10	39	25.7
11 – 15	73	48.0
16 – 20	25	16.4
21 – 25	11	7.2
26 – 30	4	2.7
Total	152	100
Mean (Expected value)	12.89	
Standard deviation (Risk)	9.27	

Source: Survey Data, 2018

The risk associated with smallholder cassava production was determined using the standard deviation, and the results are presented in Table 2. The mean output of smallholder cassava farmers or expected value was 12.89 tonnes per hectare, while the standard deviation or risk was 9.27. This implies that cassava production in Imo State is a risky enterprise since the standard deviation was not found to be zero. However, the risk level is high and this is expected to increase the level of technical inefficiency of smallholder cassava farmers.

Estimates of Parameters of Production Factors and Sources of Inefficiency

Table 3. Maximum Likelihood Estimates of Parameters of the stochastic production function

Variable	Coefficient	t-value
Production factor		
Constant	14.216	5.027*
Farm size	0.328	1.833
Cassava cuttings	0.273	2.914*
Labour	0.339	3.016*
Fertilizer	0.205	2.973*
Capital	0.412	3.042*
Inefficiency effects		
Constant	-11.089	-3.603*
Level of education	-0.713	-2.916*
Age	-0.294	-2.403*
Extension contact	-0.339	-1.844
Household size	-0.289	-1.513
Farming experience	-0.811	-3.044*
Credit	-0.538	-2.462*
Diagnostic statistics		
Likelihood ratio	-112.43	
Sigma square (σ^2)	32.16	3.162*
Gamma (ϒ)	0.95	4.179*

*significant at 5% level
Source: summary of computer printout of survey Data, 2018

The parameters and related statistical test results obtained from the stochastic frontier production function analysis are presented in Table 3. All the coefficients in the model have the expected a priori signs and they are statistically significant at 0.05 level. The estimated coefficient for cassava cuttings was positive and significant at 5% level. Thus, the 0.273 elasticity of cassava cuttings with respect to output implies that a 1% increase in cassava cuttings, ceteris paribus will lead to an increase of 0.273% in the quantity of cassava output and vice versa. The coefficient of labour was 0.339 which was significant at 5% level. This elasticity of 0.339 implies that a 1% increase in labour input will lead to an increase of 0.339% in cassava output. Similar results were obtained for fertilizer and capital. The sources of technical inefficiency were found to be level of education, farming experience and credit access. These variables are statistically significant at 5% level.

Technical Efficiency of smallholder cassava farmers

Table 4. Distribution of smallholder cassava farmers according to technical efficiency

Technical Efficiency	Frequency	Percentage
≤ 0.65	15	9.9
0.66 – 0.70	26	17.1
0.71 – 0.75	28	18.4
0.76 – 0.80	33	21.8
0.81 – 0.85	23	15.1
0.86 – 0.90	16	10.5
0.91 – 0.95	9	5.9
0.96 – 1.00	2	1.3
Total	152	100
Mean Efficiency	0.74	
Minimum Efficiency 0.47		
Maximum Efficiency 0.98		

Source: Computed from MLE Result

The estimated technical efficiency of smallholder cassava farmers are presented in Table 4. The technical efficiency of the individual farmers was less than one. The predicted technical efficiencies for the smallholder cassava farmers ranged from 0.47 to 0.98 with a mean of 0.74. The relatively wide differential in technical efficiency of the least practice and the best practice farmer was an indication of potential for efficiency improvement. A possible explanation to this variation could be the varying socioeconomic characteristics of the farmers that must have contributed to the observed variation in their technical efficiency levels. A mean level of technical efficiency for the farmers was estimated to be 74%, which implies that cassava outputs fall 26% short of the maximum possible level and 24% from the 'best' practice farmer.

Influence of smallholder cassava farmers' risk level and other factor inputs to the level of technical efficiency

Table 5.Maximum Likelihood Estimates for parameters of the Cobb-Douglas stochastic frontier production function for smallholder cassava farmers

Variable	Coefficients	t – ratio
Production factors		
Constant	5.603	3.192*
Farm size	0.422	2.803*
Cassava cuttings	0.245	2.712*
Labour	-0.159	-3.805*
Fertilizer	0.092	2.512*
Capital	0.147	2.883*

Production Risk	-0.426	-2.612*
Diagnostic statistics		
Model variance (σ^2)	0.037	2.318*
Variance Ratio (ϒ)	0.971	4.106*
Log likelihood	-114.205	
Inefficiency variables		
Constant	4.165	2.802*
Level of education	-0.726	-2.416*
Farming experience	-0.413	-2.339*
Credit access	-0.044	-2.168*
Extension contact	-0.038	-1.703
Household size	0.052	1.814
Age	0.167	2.593*

*Significant at 5% level

Source: Computer printout of survey Data, 2018

The parameters of the production factors and related statistical test results obtained from the Cobb-Douglas Stochastic Frontier production function are presented in Table 5. From the results, all production factors except labour and production risk had the expected positive sign. All the production factors were significant at 5% level, leading to the rejection of the hypothesis. This suggested that more output of cassava would be obtained from the use of additional quantities of these variables, ceteris paribus. This finding supports those of Shehu et al (2010), who found that output of yam in Benue State increases with use of more quantities of factor inputs. The coefficient of production risk was negative and significant at 5% level, implying that if the risk level increases, output of cassava will be low. This is expected to reduce the technical efficiency of the farmers, and cause variability of cassava output among the farmers. The elasticity of 0.426 for production risk suggests that production risk contributes about 43% of the total variance in cassava output among the farmers. The variance ratio (Y), was 0.971 which means that about 97% of total variability of cassava output was due to differences in technical efficiencies. The sources of inefficiency were found to be level of education, farming experience, credit access, and age.

The technical efficiencies of the small holder cassava farmers are presented in Table 6.

Table 6. Distribution of smallholder cassava farmers according to technical efficiency

Technical Efficiency	Frequency	Percentage
≤ 0.40	42	27.6
0.41 – 0.50	47	30.9
0.51 – 0.60	25	16.4
0.61 – 0.70	17	11.2
0.71 – 0.80	14	9.3
0.81 – 0.90	5	3.3
0.91 – 1.00	2	1.3
Total	152	100
Mean Technical efficiency 0.48		
Minimum Technical efficiency	0.34	
Maximum Technical efficiency	0.93	

Source: computed from MLE Result

The technical efficiencies of the smallholder cassava farmers were less than one. The predicted technical efficiencies for the cassava farmers ranged from 0.34 to 0.93 with a mean of 0.48.

The low technical efficiencies and wide variations in technical efficiencies of the smallholder cassava farmers were due to the incorporation of production risk into the technical efficiency model. This result presents the real picture of technical efficiency unlike the high levels of technical efficiency obtained in the results on Table 4 where the technical efficiency model was specified without incorporation of production risk. This finding is consistent with that of Just & Pope (1978), who reported that production risk causes reduction in technical efficiency of farmers.

CONCLUSION

Stochastic frontier production function was estimated for smallholder cassava farmers in Imo State, Nigeria in two separate models. In the first model, farm size, cassava cuttings, labour, fertilizer and capital were the explanatory variables. Cassava cuttings, labour, fertilizer and capital were found to be significant factors that influence cassava output.

The technical efficiency ranged between 0.47 to 0.98 with mean of 0.74. In the second model, production risk was incorporated into the technical efficiency model with other factor inputs of farm size, cassava cuttings, labour, fertilizer and capital. Cassava cuttings, labour, fertilizer, capital and production risk were found to be significant factors that influence cassava output.

The technical efficiency was low, and ranged between 0.34 to 0.93 with mean of 0.58. A model of inefficiency effects was jointly estimated with the technical efficiency model to ascertain the farmer-specific variable such as level of education, age, extension contact, household size, farming experience and credit access that influence technical efficiency. All the farmer-specific variables except household size and extension contact significantly accounted for the observed variation in technical efficiency among small holder cassava farmers in Imo State.

RECOMMENDATIONS

The implication of this study, is that incorporation of production risk into technical efficiency model will give a better and unbiased results of technical efficiency than when it is excluded since agricultural production is inherently risky.

REFERENCES

Ajibefun I.A. & Adbukadri, A.O (2004). Impact of size of farm operation on resource use efficiency in small-scale farming: Evidence from South western Nigeria. *Food and Environment*, 2(1), 359 – 100

Amaza, P.S. (2000). “Resources- use Efficiency in Food Crops Production in Gombe State, Nigeria. Unpublished Ph.D Thesis, University of Ibadan Nigeria.

Battese, G.E & Coelli, T.J. (1992). Frontier production functions, technical efficiency and panel data. Invited paper presented in the “productivity and efficiency analysis” sessions at the Operations Research Society of America and the Institute of Management Sciences (ORSA/TIMS) 30th Joint National meeting, Philadelphia, 29 – 31 October, 1990.

Battese, G.E., Rambaldi, A.N & Wan, G.H (1997). A stochastic production function with flexible risk properties. . *Journal of Productivity Analysis,* 8 (1), 269 – 280.

Bokusheva, R., & Hockmann, H. (2006). Production risk and technical efficiency in Russian agriculture European review of Agricultural Economics, 33(1), 93 – 118. Htt://doi.org/10.1093/erae/jbi036.

Effiong E. O. & C. I. Idiong (2008). Measurement and Sources of Economic efficiency in rabbit production in Akwa Ibom State, Nigeria (a stochastic frontier profit function approach). *Nigerian Agricultural Journal*. 39 (1), 8-15.

Farrell, M. J. (1597). The Measurement of Production Efficiency. *Journal of the Royal Statistical Society*. Series A (General) 120, 253-290. http://dx.doi.org/10.230/72343100.

Fufa, B., & Hassan, R.M. (2003). Stochastic Maize Production Technology and

Production Risk Analysis in Dadar District, East Ethiopia. Agrekon, 42(2), 116-128.http://doi.org/l0.1080/03031853.2003.9523615

Gadebroek, C., Chavez, M. D. & Oude Lansink, A. (2010). Analysing production technology and risk in organic and conventional Dutch arable farming using panel data", *Journal of Agricultural Economics,* 61 (1), 60 75.

Imo State Fadama III (2013). Fadama III project midline report, Imo State.

Just R.E., & R.D. Pope. (1978). Stochastic Representation of Production Functions and Econometric Implications. Journal of Econometrics, 7:67-86.

Just, R.E., & R.D. Pope. (1979). Production function estimation and related Risk considerations *American Journal of Agricultural Economics*, 61:276-284.

Koesting, M, Ebbesvik, M., Lien, G., Flaten, O., Valle, P. S. & Arntzen, H. (2004). Risk and risk management in organic and conventional cash crop farming in Norway, *Ada Agricultural Scaneliuuviai C- Food Economics,* 1(1), 195-206.

Kumbhakar, S.C. (2002). Specification and estimation of production risk, risk preferences and technical efficiency. *.American Journal of Agricultural Economics*, 84(1), 8-22.

National Population Commission (NPC) (2016). Population Figure, National Population Commission, Abuja, Nigeria.

Ogundari, K., & Akinbogun, O.O.(2010). Modeling Technical Efficiency with Production Risk: A Study of Fish Farms in Nigeria. Marine Resource Economics, 25(3): 295-308. http://doi.org/l 0.5950/0738-1360-25.3.295

Ohajianya, D.O., Onu, P.N., Ugwu, JN., Osuji, M.N., Nwaiwu, I.U., Orebiyi, J.S., Godson-Ibeji, EC- & Enyia, C.O. (2013). Technical efficiency of table egg producers in Imo State, Nigeria. *Asian Journal of Agricultural Extension, Economics and Sociology.* 2(2): 118-127, Ohajianya, D.O (2005). "Profit Efficiency among Cocoyam Producers in Imo State; Stochastic Translog Profit Frontier Approach" proceeding of the 39 conference of the Agricultural Society of Nigeria, Benin, Nigeria, 39: 332 -335.

Ohajianya, D.O. (2005). Economic Efficiency among small scale poultry farmers in Imo State, Nigeria " Stochastic frontier production Model Approach*" International Journal of Agriculture and Rural Development*, 6 (1), 19-25.

Ohajianya, D.O. (2006). Resources use efficiency of land owners and Tenants in food crops production in Imo State. *Journal of sustainable tropical Agricultural research*, 17:26-30.

Onyenweaku C.E., C.E., & J.C Nwaru (205) Application of A Stochastic Frontier Production Function to the Measurement of Technical Efficiency in food Crop production in Imo State, Nigeria. *Nigerian Agriculture J*ournal, 36: 1-12.

Onyenweaku, C.E. & D. O. Ohajianya (2007). Technical Efficiency of Rice Farmers in south Eastern Nigeria. *Indian Journal of Economics*, LXXXVII (2006-2007): 344-347.

Onyenweaku, C.E. & B.C. Okoye (2007). Technical efficiency of small holder cocoyam farmers in Anambra State, Nigeria. A translog stochastic frontier production function approach. *International Journal of Agriculture and Rural Development*, 9 (1), 1-6.

Shehu J. F, J. T. Iyortyer, S.I. Mshelia & A.A.U. Jongur (2010). Determinantsof yam production and Technical Efficiency among yam farmers in Benue state, Nigeria. *Journal of Social Sciences,* 24 (2), 143-148

Ukwuaba, S.I. & Inono, O.E. (2012). Resource-use efficiency in small-holder broiler production in Oshimili North Local Government Area, Delta State. *International Journal of Poultry Science,* 11(11), 700-705

World Bank (2005). Managing Agricultural Production Risk: Innovations in Developing Countries, World Bank Agriculture and Rural Development Department, World Bank Press.

World Bank. (2016). World Bank Database. Retrieved from
http://data.worldbank.org/indicator/si.agr.empl.zs?locations=b