IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 14, Issue 6 Ser. II (June 2021), PP 20-30
www.iosrjournals.org

Stochastic Cotton Production Technology and Risk Production Analysis: A Case Study of Northeast Zone, Nigeria

[1-]Muhammad Bala
[2-]Mad Nasir Shamsudin
[3=]Alias Radam
[4=]Ismail Abd. Latif
[5-]Umar Muktar

1-Department Agricultural Economics and Extension, Faculty Agriculture, Taraba State University, Jalingo, Nigeria.
2,4-Department of Agribusiness and Information System, Faculty of Agriculture, Universiti Putra Malaysia, UPM Serdang Malaysia
3-Department of Management and Marketing, Faculty of Economics and Management, Universiti Putra Malaysia, UPM Serdang, Malaysia
5- Department Agricultural Economics and Extension, Faculty Agriculture, Federal University, Dutse, Jigawa State, Nigeria.

Abstract
Stochastic Cotton Production Technology and Risk Production Analysis was using Trans log model. The result shows that the variance parameters of sigma square ($\delta^2 = \delta v^2 + \delta u^2$) *and lambda*($\lambda = \delta_u/\delta_v$) *are jointly 0.0226 and 2.2003. The lambda value (2.2003) which is greater than zero, is testifying that variation in the observed output from the frontier is due to technical inefficiency and random noise. Likewise, the result reveals that variation in output as explained by technical inefficiency is relatively greater than the deviation in output explained by the pure noise component of the composed error term. The Gamma [* $\gamma = \lambda^2/(1+\lambda^2)$*] is a parameter that express the degree level of inefficiency in the variance parameter, and is estimated to be 0.924 at 1% level of significant. This, in the actual sense, explains that 92.4% of the total variations of the cotton output in the study area are due to technical inefficiency. The results of the output elasticities are all positive, with the exception of labour, which has a negative sign. The positive sign signifies that increase in these variables will increase output while the negative sign means that increase in the variable will decrease the level of output. Sequentially, the output elasticity for seed, fertilizer, agrochemicals and labour are 0.412 percent, 0.243 percent, 0.134 percent and -0.256 respectively. Furthermore, the elasticity result indicated that seed has the highest contribution to cotton production, followed by fertilizer and agrochemicals. On the other hand, labour has higher percentage too but with negative sign, indicating that the farmers in the study area should be watchful in using high labour as it may lead to a decrease of cotton output. The Mean Estimates of Marginal Output Risk results reveals that on average, apart from labour that is risk increasing, other variables that include seed, fertilizer, and agrochemicals, they are risk decreasing variables. These estimated results hint that effective use and proper management of seed, fertilizer, and agrochemicals, unlike labour, can help in reducing output variance. On the other hand, the result for labour, being the risk increases variable. This, hypothetically, indicated that an average risk-averse farmer in the study area is anticipated to employ less labour due to the inputs ability to cause high fluctuation in output, instead, he should go ahead in using seed, fertilizer, and agrochemicals, compare to a risk-neutral farmer that is insensitive to risk, regardless of whether it is high or low risk, to reduce output volatility.*

Key Words: *Stochastic, Risk, Cotton, Gama, Lambda, Frontier.*

Date of Submission: 06-06-2021 Date of Acceptance: 20-06-2021

I. Introduction:

Usual approach in modeling technological relationships in production is based on mean levels of input and output. This is because, the firm's decision problem is solved by equating the Marginal Value Product (MVP) of output to Marginal Cost MC). However, it is widely recognized that agricultural products, especially crop yields, are stochastic (random) in nature, and the levels of inputs used influence higher moments, like variance of distribution of output [1] (de Janvry, 1972). If producers are concerned about risk involved in the use of inputs, optimal choices may depend on moments of the mean. It is a known fact that the stochastic nature of agricultural production is a major source of risk. Thus, variability in yield is not only explained by factors outside the control of the farmer, like weather and wind, varying the levels of inputs [2] (Just &Pope, 1979). In such situation, a risk-averse farmer thus uses more (less) of a risk-neutral firm. It therefore follows that risk has an important bearing in the design and transfer of new technologies as its rate of adoption does not only depend on the farmer's yield levels but also on their risk effects [3] Hassan & Hallam, 1990).

On the other hand, production decisions are also influenced by market risks that are associated with the uncertainty about the future of inputs/outputs prices and reliability of input supplies [4] (Hardaker, Hurine & Anderson, 1997). Though market risks are essentially exogenous, farmers' choice of inputs can affect yield variability and the distribution of returns in a given enterprises or a combination of enterprises. Thus, production risks have a tremendous impact on agriculture in general, as well as in the production patterns and supply behavior of small-scale farmers in particular.

II. Material And Methods

2.1. Study Area The study was conducted in the North-East Zone of Nigeria that covers close to one-third (280,419km2) of Nigeria's land area of (909,890km2). The zone comprises six states, namely: Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe. Three states (Adamawa, Gombe and Taraba State) were purposively selected for the study. In each state, concentration was given to areas where cotton production is the predominant occupation of the people in the area. In Adamawa state, the study was carry out in cotton growing areas of Yola south, that comprises Numan Lamure, Demsa and Guyuk and this constitute Zone three and four, of the Adamawa state Agricultural Development Project. Therefore, at least four privately owned ginneries are located within the cotton belt. The presence of these companies has intensified cotton production in the area. Most cotton out-growers are registered with these private ginneries.

Similarly, in Gombe state cotton growing belt, Gombe South and North, Akko, Billiri and Kaltungo are the areas that cotton is being cultivated. In Taraba state, as in the other two states, the local governments that cotton are being farmed are Lau, Gassol and Karim Lamido. These areas are cotton producing areas, hence attention was given to them for the purpose of this study. Three hundred and sixty registered cotton out-growers were randomly selected from registered out-growers with the help of the extension officers of the private ginneries in the cotton belt areas. Projections for 2011 by the [5] National Bureau of Statistics shows that these States have 13.5% (i.e. 23,558,674) of Nigeria's population which is put at 173,905,439 and has been a major contributor to national net food production, [6].Abiayi, et al.

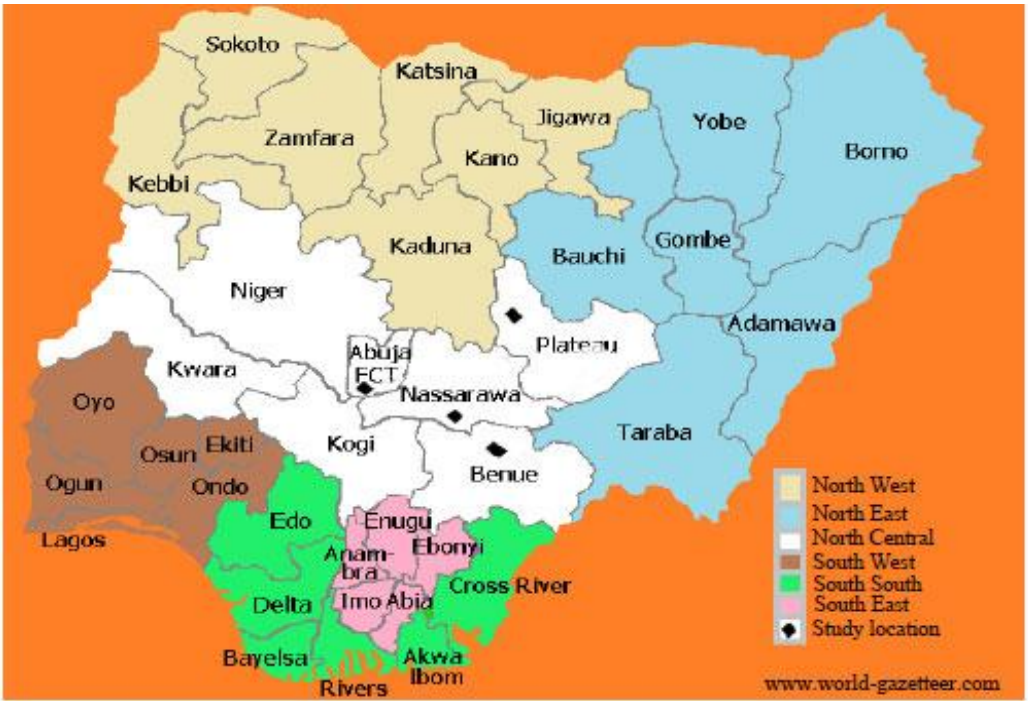

Figure 1: Map of Nigeria, showing the study area in the Northeast
Source: [6] (Abiayi et al., 2015)

2.2. Data Collection

Primary data was mainly used as the source of data for the study. The data were collected with the aid of questionnaires, primarily quantitative input-output variables from a sample of 349 households. Information on socio-economic variables such as age, education, farming experience, extension contact, credit access, off farm activities were also collected from the respondents.

2.3. Sampling Techniques

The sampled States were Adamawa, Gombe and Taraba State. Adamawa state has twenty-two (22) local governments and five [5] were selected. Gombe State has eleven (11) local governments and three [3] were selected, while Taraba State has a total number of sixteen (16) local governments and four [4] were selected. The list of the cotton farmers was obtained from Afcott out-growers scheme. A total of twelve [12] local governments were selected at the first stage for the study through randomized sampling design out of forty-nine [49] local governments in the study area (Table1.1). At the final (second) stage a total of 165 cotton farmers were selected out of 501 farmers in Adamawa state. While in Gombe State 102 cotton farmers were selected out of 520, and 93 cotton farmers were selected from Taraba State out of 338 cotton farmers in the area. This gives the total of 360 sampled respondents out of 1359 cotton producers in the study area (Table1.2).

Table 1.1: Selected Local Government from the study area

State	Local Government	Local Government Selected
Adamawa	22	5
Gombe	11	3
Taraba	16	4
Total	**49**	**12**

Source: Field Survey data, 2016

Table 1.2: Sample Design Outlay for the Study

State	Selected Local Govt	Cotton Growers	Farmers
Adamawa	5	501	165
Gombe	3	520	102
Taraba	4	338	93
Total	**12**	**1359**	**360**

Source: Field Survey data, 2016

Following the formula in calculating sample size as proposed by [7] (Yamane, 1967), the study arrived at its sample size based on the population of cotton farmers available in the study area. The formula used is specified as follows:

$$\boldsymbol{n = \frac{N}{1+N(e^2)}} \qquad \textbf{[1]}$$

Where n = sample size, N = population size and e = level of precision.
The total sample size of cotton farmers is determined as:
N = 4000, e = 0.05 (0.95 confidence interval). Therefore:
$n = 4000/1+4000(0.05)^2$
= 360 respondents in all.
The sample of the respondent in each state in the study area was determined as:
N= 1359, e = 0.05 (95% confidence interval). Therefore:
Adamawa sample size
n = 501/1359 x 360= 165 farmers
Gombe State sample size
n = 520/1359 x 360= 102 farmers
Taraba State sample size
n = 338/1359 x 360= 93 farmers

2.4. Data Analysis

In this paper, trans-log stochastic production function model was employed with flexible risk specification. This is because, trans-log functional form is known to be less restrictive, and it is permitting for the combination of squared and cross product terms of the exogenous variable inputs with the view of having goodness of fit of the model. The variables were estimated using the estimation procedure of [8] Frontier version 4.1

2.5. Theoretical Framework

The parametric production analyses were employed to examine the performance of cotton production in the study area. This is because, the parametric analysis is the stochastic frontier analysis (SFA) with flexible risk specification. The observed farm's output likelihood function is specified based on the assumptions of the random error as follows:

$\delta^2 = \delta^2 v + \delta^2 u,\ \gamma = \frac{\delta^2 u}{\delta^2 v}$ [9] Aigner and Chu (1968). [2]

On the other hand, the framework proposed by [10] Battese and Corra (1977) remedy the antecedent obstacle. The new specification is given as:

$$\delta^2 = \delta^2 v + \delta^2 u, \qquad [3]$$

and

$$\gamma = \frac{\delta^2 u}{\delta^2 v} = \frac{\delta^2 u}{\delta^2 v + \delta^2 u} \qquad [4]$$

The log likelihood function gives the maximization estimates of the appropriate model. These estimates are very useful for testing the relevant hypothesis to validate the adequacy of the inefficiency model.

2.6 Risk in Agricultural Production

Production risks are the dominant concern of the farmers in their daily routine, as the production process is their outstanding sole responsibility. There are many and varied risks in the production process which can reduce the farmer's profitability if it compared with those that may occur in the subsequent activities of farming processes of marketing and consumption. It is a known fact that agricultural Production is generally a risky operation that is combined with negative payoff continuing from unskillfully foreseeable biological, climate changes and price fluctuation of the variable inputs. There are variables that include natural disaster like pests and diseases and climatic variables which cannot be control by the producers of agricultural produce and adverse changes in both input and output prices [11] (Wanda, 2009).

Of all the risks in agricultural production, its stochastic nature in most cases, are their major sources. [12] Färe et al., (2013) uphold that yield variability is explained by factors that are outside the control of the farmer like input and output price and the factors that are manageable like varying level of inputs. Risk and uncertainty in production have continued to use the technique for the analysis of production and adoption of technologies.

In agricultural production, generally risk can be categorized into production risk, and it is characterized by high variability of production outcomes price's risk that usually resulting from the variability of the prices of output as well as inputs prices. Expert in this area mentioned that the effect of risk and uncertainty are more dominant in the developing countries because of their market imperfections, asymmetric information and poor communication networks, [13] Fufa and Hassan, (2003). Contrary to what we can physically see, in most cases many risks are as a result of the uncontrollable physical forces of the nature that mostly do damage to the farm's produce through wind storms, floods, droughts, earthquakes and even volcanic actions. But others are with the opinion that due to the stochastic nature of agricultural production, there is another source of risk in production as there are other factors outsides the control of the farmers which may also affect yield variability [14] (Antle, 1983). This is further explained by [15] Pope and Kramer (1979) that a farmer who is a risk-averse uses more variable inputs, in other word a risk-decreasing factors of production, than a risk-neutral farmer, since some inputs like pesticide may decrease the level of output while others may increase it [16] (Asche and Tveterås 1999).

[17] Just and Pope (1978) production function is mathematically represented as shown below:

$$\boldsymbol{y_i = h(x_i;\alpha) + \exp\ g(x_i;\varphi)v_i} \qquad \textbf{[5]}$$

Where $g(x_i;\varphi)v_i$ Represent the idiosyncratic component of production risk as a result of farm specific factors. The mean output function is given as $E(y_i) = h(x_i)$ while the variance of output is $v = g^2(x_i)$. In addition, the marginal production risk formula is given as:

$$\boldsymbol{\frac{\delta var(y_i)}{\delta x_i} = 2g(x_i;\omega)} \qquad \textbf{[6]}$$

From the above equation, it is expected that the marginal risk using a differential technique can either be positive or negative, depending on the signs of $g(x_i;\omega)$, by finding the derivative of the of g with respect to input i. If a marginal risk is positive, the input risk has an increasing effect on the output risk and when the value is negative, the input risk has a decreasing effect on the output risk [2] (Just and Pope, 1978). Therefore, estimating efficiency to account for production risk depends on the input level. A lot of effort work has been done in an attempt to provide empirical evidence on how risk influence the nature of decisions in agricultural production.

2.7 Incorporation of Production Risk in The Stochastic Frontier Model

The adopted model in estimating stochastic production technology must account for production risk and technical inefficiency. Works in this research have employed one of the three outlined variations. The various models differed in accordance to how the inefficiency effect has been incorporated into the model.[18] Battase & Broca, (1997) unfold that there is a possibility for the integration of production risk and the technical inefficiency in a model to add the inefficiency effect of the variance function together with the random noise component that represents the effects of uncertainty as shown in the below equation:

$$\boldsymbol{y_i = h(x_i;\alpha) + g_i(x_i;\beta)(v_i - u_i)} \qquad \textbf{[7]}$$

According to [19] Kumbhakar (2002), the second possibility for production risk and technical inefficiency to be incorporated in a model is that of the multiplicative form where the inefficiency effect should be added to the mean output function as shown in the below equation:

$$\boldsymbol{y_i = h(x_i;\alpha)(1 - u_i) + g(x_i - \beta)v_i} \qquad \textbf{[8]}$$

Here, the additional assumption; $\exp\{-u_i\} = 1 - u_i$ has been incorporated in the model. The third possibility for the production risk and technical inefficiency to be incorporated in a model is the flexibility form of that model suggested by[19] Kumbhakar (2002). For explaining technical inefficiency, therefore, the additional function q(x) was introduced in the model. This can be shown by the formula below:

$$\boldsymbol{y_i = h(x_i;\alpha)(1 - u_i) + g(x_i - \beta)v_i - q(x_i;z)u_i} \qquad \textbf{[9]}$$

Where $h(x_i;\alpha)(1 - u_i)$ represent the mean production function, $g(x_i - \beta)v_i$ represent the risk production function, α represent the vector of mean production parameters and β represent the vector of output risk parameters. While v_i represent the stochastic term, u_i represent the non-negative inefficiency variable. $q(x_i;z)u_i$ explains technical inefficiency with xi's as the input variables.

2.7.1 Deterministic Frontier Approach stochastic production

The early efforts in frontier estimation begin with the work done by[9] Aigner & Chu (1968). These scholars are the pioneer and the forefront researchers to estimate the deterministic frontier production using a Cobb-Douglas production function. Their argument was that among several industries, producers may differ from each other in terms of their production processes as a result of a certain technical parameters in the industry with differences in scale of operation and organizational structures. In a cross-section perspective, the deterministic frontier model is mathematically defined as:

$$\boldsymbol{y_i = h(x_i;\alpha)\exp(u_i)} \qquad \textbf{[10]}$$

Where y_i represents the potential level for the i-th sample farm surrounded by deterministic component $h(x_i;\alpha)$ that is suitable for the vector x inputs and the ith farm, and the vector α of the unknown parameters. In addition, u_i is a non-negative random variable representing the inefficiency in the production process. In the case of deterministic frontier, technical efficiency of individual firms is defined as the ratio of observed output y_i to the corresponding estimated frontier output or the maximum feasible output, and was Mathematically represented as $y_i^* = h(x_i;\alpha)$.

For the deterministic approach therefore, the technical efficiency is denoted by:

$$\boldsymbol{TE_i = \frac{y_i}{y_i^*} = \frac{h(x_i;\alpha)\exp(u_i)}{h(x_i;\alpha)} = \exp(-u_i)} \qquad \textbf{[11]}$$

The value of technical efficiency is measured between zero and one. A unitary technical efficiency value is insinuating that the producers are fully producing efficiently, and in the same way, it signifies that the observed output reaches its maximum attainable value. Technical efficiency with value less than unity indicates that there is a shortfall of the observed output from its maximum feasibility. Even though the deterministic frontier technique is subjected to statistical analysis, it haphazardly regards all deviations in output as technical inefficiency effects due to the fact that the deviations in the output might be contributed by random errors including weather effects and errors of measurement or merely statistical noise that are beyond the control of the producer. The limitation or drawback in the deterministic frontier modelling approach is addressed by the stochastic frontier model. This was an attempt to measurement errors or statistical noise not only to account for technical inefficiency.

2.7.2 Stochastic Frontier Approach (SFA)

Here, we are going to explain the second approach of parametric frontier called Stochastic Frontier Approach (SFA). It is the alternative method for estimating technical efficiency scores that was originally developed and independently proposed by two different authors:[20] Meeusen & Van den Broeck (1977) as published in International Economic Review in June while [21] Aigner , Lovel, & Schmidt et al. (1977) published in July in Journal of Economics. To adopt SFA technique, the production firm is assumed to be fully efficient and the functional form must be appropriate and fit to the desired data. Although Stochastic Frontier Analysis can function as Ordinary Least Square (OLS) in research study that involves production investigation, there are still existing differences between them. In Stochastic Frontier Analysis, maximum likelihood estimation is used while simple regression estimation is used in stochastic frontier analysis square.[22] Coelli et al. (2005), pointed out that there are many desirable large sample properties (i.e. asymptotic) in maximum likelihood estimators. But simple regression analysis is employed to discover mean of production function.

In simple regression production function, inefficiency and error term are recognized as total observed residual variation in stochastic production frontier approach that are handle or treated as one error term. To incorporate this total observed variation in stochastic frontier, another random variable that represents statistical noise or measurement errors was introduced. Hence, the basic stochastic model therefore, should include a composite error term that sum up two-sided error term which allow the measurement of all effects that cannot be control by the producers, while the one-sided non-negative error term measure the technical inefficiency. A producer can lie on the frontier or within and the distance between the actual output and the frontier output represents inefficiency. This however, can be seen clearly as specified in the stochastic frontier production function below:

$$\boldsymbol{y_i = h(x_i; \alpha)\mathbf{exp}\,(\varepsilon_i)} \qquad \textbf{[12]}$$

Where i= 1,2,3…. N, y_i is the output realized by firm I and is bounded above by the stochastic component $h(x_i; \alpha)\exp\,(v_i)$. The $h(x_i; \alpha)$ is the production frontier, the x_i's represent the vector of inputs, α is a vector of the unknown technology parameters. The composed error term is $\varepsilon_i = v_i - u_i$, where v_i captures the effect of the pure noise in the data that are attributed to measurement error, extreme weather conditions, etc. and the one-sided inefficiency effects are denoted as u_i. The technical efficiency of an individual firm from the stochastic frontier perspective is termed as the ration of the output observed to the corresponding input used by the firm given the levels of inputs of the stochastic frontier. In this way, the firm's technical efficiency in the context of the stochastic frontier production function is given by:

$$\boldsymbol{TE_i = \frac{y_i}{y_i^*} = \frac{h(x_i;\alpha)\mathbf{exp}\,(u_i)}{h(x_i;\alpha)} = \mathbf{exp}\,(-u_i)} \qquad \textbf{[13]}$$

In the deterministic approach, all the deviations in output are viewed as technological inefficiency effects, that is, $\varepsilon_i = u_i$ regardless of the fact that the deviations in output might be contributed by random errors including weather effects and the measurement errors which are over and above the control of the farmers. Therefore, the basic stochastic model separates the pure noise component from the technical inefficiency effects.

The Figure 2.1 below depicted the basic structure of the stochastic frontier function, where A and B are considered as the representative of the productive activities of two farms. The output obtains in farm A is (Y_A) with the given values by the vector (X_A) using the variable inputs. The frontier output (Y_A^*) exceeds the value of the deterministic production function (X_A, β). Therefore, its productive activity is associated with positive conditions at which the random error V_A is also positive. On the other hand, farm B the variable inputs use with the given values by the vector (X_B) obtains the output (Y_B) and its corresponding frontier output (Y_B^*) is less than the value on the deterministic production function. The conditions for the random error is negative, meaning that its productive movement is unfavorable. Therefore, the observed production values are less than the corresponding frontier values and the frontier production values that are linked with the involved farms lie around the deterministic production function as shown in Figure 2.1 below:

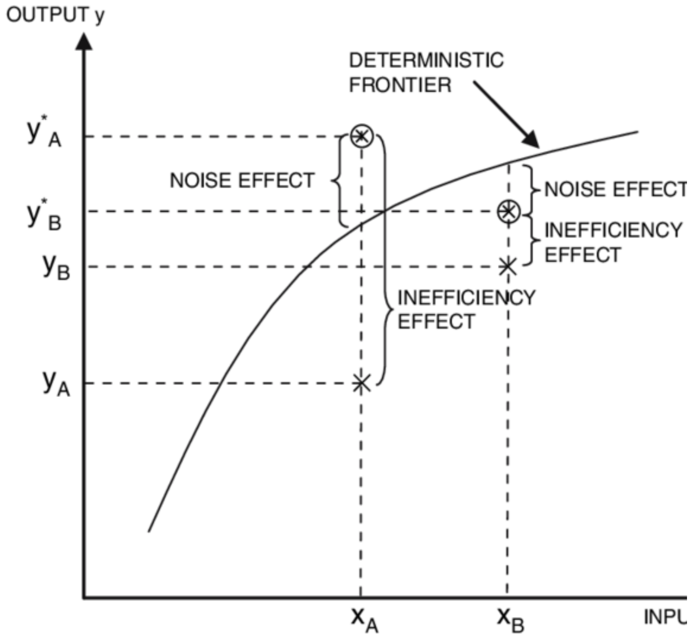

Figure Error! No text of specified style in document.**.1: Deterministic Stochastic Frontier Function**

Though the technical efficiency of a farm is allied with deterministic or stochastic frontier models, it is vital to equally know that the values from the two models are different. As we can see from Figure 2.1 that the technical efficiency of farm B under the stochastic frontier model is greater than in the deterministic frontier model as explained by their ration as: $(Y_B/Y_B^*\ ) > \{\ Y_B/f(X_B;\beta)\}$. Therefore, we can conclude that farm B is technically more efficient (V_B < 0) when relative to the unfavorable conditions allied with its productivity, than if its production is judge with relative to the maximum value which is associated with the value of the deterministic function, $f(X_A;\beta)$. But farm A is judged technically less efficient with relative to its favorable conditions than if its production is relatively judged to its maximum value associated with the value of the deterministic function, $f(X_A;\beta)$. By fitting the deterministic frontier, the given set of data are obtained to estimate the technical efficiencies and is to be less than those obtained by fitting the stochastic frontier. This is because the deterministic frontier is to be estimated so that no output values will exceed it.

2.7.3 Variance Production Function Specification

Marginal risk of an input is considered positive when an increased quantity of that input result in an increased output variance, hence the input is termed as risk-increasing input. Likewise, marginal risk of an input is considered negative when an increase in quantity of an input initiates a decrease in output variance, thus the input is called risk-decreasing input [23] (Ogundari & Akinbogun, 2010). After so many years, [17] Just and Pope, 1978 Model underwent many modifications by researchers. [19] Kumbhakar, (2002) had proposed his own generalized stochastic model with flexible risk specification that can recognize inputs which are either directly related or inversely related to output variance in a stochastic frontier analysis as stated in model [12] above.

Relating to equation [12], the linear production risk function is specified as:

$$\boldsymbol{lnv_i^2 = \omega_0 + \sum_{w=1}^{4} \omega_w lnx_{wi}} \qquad \textbf{[14]}$$

Where:

X_i's represents input variables, v_i^2's is pure noise effects, ω_0's and ω_w's are the estimated risk model parameters, x_1 is amount of seed used measured in kg/ha, x_2 denotes quantity of fertilizer measured in kg/ha, x_3 means agrochemicals used measured in lt/ha and x_4 is labour used measured in man days/ha. The input variables that is seed, fertilizer, agrochemicals and labour can either decrease output or input it. Thus, ω_w's are the marginal production risks of individual inputs and when it is positive it implies that the respective input is a risk increasing input (increasing output variance). However, when ω_w becomes negative it indicates that the respective input is risk decreasing (reduces output variance).

III. Empirical Results

3.1. ESTIMATION PROCEDURE

Here, we are going to explain the result of maximum likelihood estimates for the parameters using Translog production function, Return to Scale and the Elasticity of Production the mean estimates of marginal output risk and the estimated risk parameters.

3.2.1 Maximum Likelihood Estimates for Parameters using Translog model

Table 1.3 shows the analysis of the diagnostic statistics based on the estimated parameters of the stochastic frontier production function. From this table, we can see that the coefficient of the variable inputs, apart from labour with negative sign, are all positive, meaning that these coefficient is expressed positive relationship with the output. In addition, their increase will increase the level of output. But in the case of labour, it shows the negative influence towards output, that is, more labour less output. This is in line with [24] Pavelescu (2011) in his research on the topic Some aspects of Translog production function estimation dealing with the computation of the Gross Domestic Product elasticity and average elasticity of scale related to employed population, that decrease in the output level in conditions of increase in quantity allocated and decrease in productivity of the analyzed production factor.

From the assessments of the stochastic frontier production, the variance parameters of sigma square $(\delta^2 = \delta v^2 + \delta u^2)$ and lambda$(\lambda = \delta_u/\delta_v)$ are jointly 0.0226 and 2.2003. These values are significantly different from zero thus indicating a good fit of the model and the correctness of the specified distributional assumptions. In other word, the lambda value (2.2003) which is greater than zero, is further testifying that variation in the observed output from the frontier is due to technical inefficiency and random noise. Likewise, the result reveals that variation in output as explained by technical inefficiency is relatively greater than the deviation in output explained by the pure noise component of the composed error term. The Gamma [$\gamma = \lambda^2/(1+\lambda^2)$] is a parameter that express the degree level of inefficiency in the variance parameter, and is estimated to be 0.924 at 1% level of significant. This, in the actual sense, explains that 92.4% of the total variations of the cotton output in the study area are due to technical inefficiency. The estimated coefficients in table 1.3 are in line with the result realized by [25] (Villano and Fleming 2006; [26] Ogundari and Akinbogun 2010; and [27] Kaka 2015).

Table 1.3 Maximum Likelihood Estimates for Parameters using Translog

Variable	Parameter	Coefficient	Std Error	P-Value
Constant	γ_0	-2.0862*	0.6873	0.002
lnseed	γ_1	0.2789***	0.0438	0.000
lnfert	γ_2	0.2753***	0.0277	0.000
lnchem	γ_3	0.2046**	0.1212	0.092
lnlabour	γ_4	-0.2558	0.2565	0.319
lnseedsq	γ_5	0.4508***	0.1004	0.000
lnfertsq	γ_6	-0.0069	0.0410	0.865
lnchemssq	γ_7	-0.0158	0.0196	0.148
lnlaboursq	γ_8	0.0430	0.0274	0.117
(lnseed)(lnfert)	$\gamma_1 \gamma_2$	-0.2626*	0.1022	0.010
(lnseed)(lnchem)	$\gamma_1 \gamma_3$	-0.0154	0.0396	0.696
(lnseed)(lnlabour)	$\gamma_1 \gamma_4$	0.0398	0.0631	0.528
(lnfert)(lnchem)	$\gamma_2 \gamma_3$	0.0481	0.0392	0.220
(lnfert)(lnlabour)	$\gamma_2 \gamma_4$	-0.0735	0.0562	0.191
(lnchem)(lnlabour)	$\gamma_3 \gamma_4$	-0.0554*	0.0218	0.011
Variance Parameters				
Sigma-Square (u)		0.0842		
Sigma-Square (v)		0.0241		
Lambda $(\boldsymbol{\lambda = \delta_u/\delta_v})$		3.4937		
Sigma^2$(\boldsymbol{\delta^2 = \delta v^2 + \delta u^2})$		-12.3979		
$\boldsymbol{Gamma}$ $(\boldsymbol{\gamma = \lambda^2/(+\lambda^2)})$		0.924		

Source: Field Survey data 2016. **Note** *, ** and *** denote significance at 5%, 10% and 1% level respectively.

The maximum likelihood estimates of the parameters of trans-log stochastic frontier production function are presented in Table 4.9. Despite the fact that the study employed trans-log production function, the function is not likely to interpret elasticity directly from the coefficients of production function as applied to Cobb-Douglass production function, as argued by [28] Sharma & Leung (1999). Therefore, the elasticity of trans-log production function is determined by using equation 3.21 to 3.25. Accordingly, the discussion of the parameters was done in consequence based on output elasticity.

3.2.2 Return to Scale and the Elasticity of Production

The method of elasticity can be used in the production function to consider the production stage, to know the stage in which the cotton farmers are operating. The elasticity of cotton output with respect to the various inputs used is the amount of the resource productivity of cotton farmers. Subsequently, the output elasticity indicates the degree of responsiveness of cotton output to the changes in the various input variables. The gathering of the partial elasticity of the various input variables with respect to output is a measure of the return to scale of the cotton farms.

Table 1.4 shows the measurement of elasticity of output with respect to inputs of production. From this result, we can see that the parameters of the stochastic frontier model of the output elasticities are all positive, with the exception of labour, which has a negative sign. The positive sign signifies that increase in these variables will increase output while the negative sign means that increase in the variable will decrease the level of output. Sequentially, the output elasticity for seed, fertilizer, agrochemicals and labour are 0.412 percent, 0.243 percent, 0.134 percent and -0.256 respectively. Furthermore, the elasticity result indicated that seed has the highest contribution to cotton production, followed by fertilizer and agrochemicals. On the other hand, labour has higher percentage too but with negative sign, indicating that the farmers in the study area should be watchful in using high labour as it may lead to a decrease of cotton output.

Table 1.4: Elasticity for outputs in the Stochastic Frontier Production

Variable	Elasticity
Seed	0.412
Fertilizer	0.243
Chemical	0.134
Labour	-0.256
Return to Scale (RTS)	**0.533**

Source: Field Survey data, 2016.

Also, the Table shows that a percentage increase in seed employed per hectare will increase yield by 0.412 percent and vice versa. This finding is in reliable with the study of [29] Odedokun (2015) where he found seed to be positive. The result further reveals that a percentage increase in the quantity of fertilizer applied per hectare will result to increase in the quantity of output by 0.243 percent, and its signifies that there is a positive relationship between increase usage of fertilizer with the cotton output. [30] Odedokun et al, (2015) have found the similar result on fertilizer in their study which shows that a percent increase in agrochemicals employed per hectare will increases yield by 0.134 and vice versa. This result tally with [29] Odedokun (2015) in his unpublished Thesis. On the other hand, a subsequent percentage decrease in labour will result in output decrease by -0.256 percent highlights that labour is less importance in the study area as its lead to a decrease in the level of output. The labour estimates are similar to the finding of the study conducted by [29] (Odedokun, 2015).

The severity of responsiveness of output in relation to the sum of coefficients variable inputs used in production pinpoint the nature and pattern of returns to scale. The sum of the elasticity or else known as a return to scale (RTS), that justifies the returns to scale, was gathered from the analysis as 0.533. This portray that when all inputs were increased by 1% the output increased by 0.53% and justifying that the resources employed in cotton production were inelastic. The economic judgement of the captured RTS exhibits decreasing return to scale and is used to determine the stage of the powerful production process in the production possibility frontier. The value 0.53 is greater than zero but less than one, defining that production is in stage II; a stage of positive decreasing returns to scale where every farmer set-to be so as to maximize profit and minimize the cost of production.

On the ground that the phase of positive decreasing returns to scale is a more efficient production phase where resource allocation and utilization can be adequately adjusted and subsequently profit can be fully maximized in the production possibility frontier. [31] Sadiq (2015) in the research conducted, presents the empirical study on technical efficiency of cotton production in Kano State, in Nigeria. While using stochastic frontier production function analysis, the results show that there is a relative presence of increasing returns to scale among the respondents in the study area, which is an indication that the farmers are operating in stage I of production surface, considering the size of their farms. The result also shows that the mean technical efficiency scores of 0.53 (53%) indicated that an average farm in the sample area is below the frontier, which signifies that farmers are relatively efficient in allocating their scarce resources.

3.2.3 Mean Estimates of Marginal Output Risk

[17] Just and Pope (1978) approach separate between an input effect on output and its impact on output variability using mean estimates of Marginal output risk estimation. Moreover, output variability in the production process has been determined by the inputs factors. Some of these inputs are risk-reducing while others are risk increasing which can be used to sustain cotton production in the study area. Information of Marginal Output Risk Estimate of inputs is presented in Table 1.5.

Table 1.5: Marginal Production Risk estimates for Variance Function

Variable	Parameter	Coefficient	Std Error	P-Value
Constant	β_0	17.2258	2.9774	0.000**
lnSeed	β_1	-4.2386	1.2059	0.000**
lnFertilizer	β_2	-2.3372	1.1645	0.045*
lnChemicals	β_3	-0.1234	0.4844	0.799
lnLabour	β_4	0.1299	0.6446	0.840

Source: Field Survey data 2016. **Note** * and ** denote significance at 5% and 1% level respectively.

The above Table (1.5) reveals that on average, apart from labour that is risk increasing, other variables that include seed, fertilizer, and agrochemicals, they are risk decreasing variables. These estimated results hint that effective use and proper management of seed, fertilizer, and agrochemicals, unlike labour, can help in reducing output variance. On the other hand, the result for labour, being the risk increases variable, is consistent with the obtained result of the study done by [32] Picazo-Tadeo and Wall (2011), [25] Villano and Fleming (2006) and [27] Kaka (2015) respectively. This, hypothetically, indicated that an average risk-averse farmer in the study area is anticipated to employ less labour due to the inputs ability to cause high fluctuation in output, instead, he should go ahead in using seed, fertilizer, and agrochemicals, compare to a risk-neutral farmer that is insensitive to risk, regardless of whether it is high or low risk, to reduce output volatility.

IV. Conclusions

Maximum likelihood estimates of the parameters of trans-log stochastic frontier production functions is not likely to interpret elasticity directly from the coefficients of production function as applied to Cobb-Douglass production function. Therefore, the elasticity of trans-log production function is determined by using equation 3.21 to 3.25. Accordingly, the discussion of the parameters was done in consequence based on output elasticity. Mean estimates of Marginal output risk showed that the output variability in the production process the inputs used are risk-reducing while others are risk-increasing, meaning that they can be used to sustain cotton production in the study area.

References

[1]. de Janvry A (1972). Optimal levels of fertilization under risk: The potential for corn and wheat fertilization under alternative price policies in Argentina. American Journal of Agricultural Economics 54:1-10.

[2]. Just, R. E., & Pope, R. D. (1979). Production function estimation and related risk considerations. American Journal of Agricultual Economics, 61(2), 276–284.

[3]. Hassan M R & Hallam A (1990). Stochastic technology in a programming framework: A generalized mean-variance farm model. Journal of Agricultural Economics 41:196-206.

[4]. Hardaker Jb, Hurine Bm & Anderson Jr (1977). Coping with risk in agriculture. CAB International, London.

[5]. National Bureau of Statistics. (2015). Nigeria in 2014: Economic Review and 2015-2017 Outlook.

[6]. Abiayi, E. A., Inabo, H. I., Jatau, E. D., Makinde, A. A., Sar, T. T., Ugbe, D. A. & Okewole, P. A. (2015). Knowledge, attitudes, risk factors and practices (KARP) that favor Leptospira infection among abattoir workers in North Central Nigeria. Asian Journal of Epidemiology, 8(4), 104-13.

[7]. Yamane, T. (1973). Statistics: An introductory analysis, 2nd Ed. New York: Harper & Row.

[8]. T. J. Coelli, "A guide to frontier version 4.1: A computer program for stochastic frontier production and cost function estimation," CEPA Working Papers WP7/96, University of Queensland, 1996.

[9]. Aigner, D.J. and Chu, S. F. (1968). Estimating the Industry Production Function American Economic Review, 58, 826–839.

[10]. Battese, G. E., & Corra, G. S. (1977). Estimation of a production function model with application to the pastoral zone of Eastern Australia. Australian Journal of Agricultural Economics, 21(3), 169–179.

[11]. Wanda, O. (2009). Production risk and input use in banana production in Uganda. A Thesis for the Degree of Master of Science in Agricultural and Applied Economics of Makerere University.

[12]. Färe, R., Grosskopf, S., & Lovell, C. K. (2013). The measurement of efficiency of production (Vol. 6). Springer Science & Business Media.

[13]. Fufa, B., & Hassan, R. M. (2003). Stochastic maize production technology and production risk analysis in Dadar district, East Ethiopia. Agrekon, 42(2), 116-128.

[14]. Antle, J. (1983). Testing the Stochastic Structure of Production: A Flexible moment-based approach. Journal of Business & Economic Statistics, 1(3), 192–201.

[15]. Pope, R.D. & Kramer, R. A. . (1979). Production Uncertainty and Factor Demands for the competitive firm. Southern Economic Journal, 46(2), 489–501.

[16]. Asche, F., & Tveterås, R. (1999). Modeling production risk with a two-step procedure. Journal of Agricultural and Resource Economics, 24(4), 424-439.
[17]. Just, R. E., and Pope, R. D. (1978). Stochastic specification of production functions and economic implications. Journal of Econometrics, 7(1), 67–86.
[18]. Battese, G. E., & Broca, S. S. (1997). Functional forms of stochastic frontier production functions and models for technical inefficiency effects: a comparative study for wheat farmers in Pakistan. Journal of productivity analysis, 8(4), 395-414.
[19]. Kumbhakar, S. C. (2002). Specification and estimation of production risk, risk preferences and technical efficiency. American Journal of Agricultural Economics, 84(1), 8–22.
[20]. Meeusen, W., & van Den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. International economic review, 20(2), 435-444.
[21]. Aigner, D., Lovell, C. K., & Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. Journal of econometrics, 6(1), 21-37.
[22]. Coelli, T. J., Rao, D.S.P., O'Donnell, C. J., & Battese, G. E. (2005). An introduction to efficiency and productivity analysis. Spring Science & Business Media, Springer, Boston, MA.
[23]. 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.
[24]. Pavelescu, F. M. (2011). Some aspects of the Tran slog production function estimation. Romanian Journal of Economics, 32(1), 41.
[25]. Villano, R., & Fleming, E. (2006). Technical inefficiency and production risk in rice farming: evidence from Central Luzon Philippines. Asian economic journal, 20(1), 29-46.
[26]. 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.
[27]. Y. Kaka, M. N. Shamsudin, A. Radam, and I. A. Latif, "Profit efficiency among paddy farmers: A Cobb-Douglas stochastic frontier production function analysis," Journal of Asian Scientific Research, vol. 6, pp. 66-75, 2016.
[28]. Sharma, K. R., Leung, P., & Zaleski, H. M. (1999). Technical, allocative and economic efficiencies in swine production in Hawaii: a comparison of parametric and nonparametric approaches. Agricultural economics, 20(1), 23-35.
[29]. Odedokun, V. O.,(2015). Economic analysis of cotton production and supply trend estimation in Zamfara, State(unpublished PhD Thesis,Department of Agricultural Economic and Extension, ABU, Zaria.
[30]. Odedokun, V. O., Ahmed, B., Omolehin, R. A., & Atala, T. K. (2015). Application of grafted polynomial model as approximating functions in forecasting cotton production trends in Zamfara State, Nigeria [1995-2013]. International Journal of Current Research and Review, 7(16), 68.
[31]. Sadiq, M. S. (2015). Application of Dual Stochastic Production Function in Estimating Technical Efficiency in Cotton Production in Kano State, Nigeria. Krishi Sanskriti Publications, 2(3), 393-397.
[32]. Picazo-Tadeo, A. J., & Wall, A. (2011). Production risk, risk aversion and the determination of risk attitudes among Spanish rice producers. Agricultural Economics, 42(4), 451-464.

Muhammad Bala, et. al. "Stochastic Cotton Production Technology and Risk Production Analysis: A Case Study of Northeast Zone, Nigeria." *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 14(6), 2021, pp. 20-30.