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Neoclassical Test of Cost Efficiency in Sorghum Production Among Small-Scale Farmers in Niger State, Nigeria

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ABSTRACT: *This research presents empirical analysis of parametric Neoclassical test of cost efficiency in small scale sorghum production in Niger State of Nigeria, using multi stage sampling technique to elicit farm level survey data from 100 farmers in the study area via interview schedule and administration of validated pre-tested questionnaire. Cobb-Douglas cost stochastic frontier function was used to analyze the data collected. The results shows that there is a relative presence of economies of scale among the farmers meaning that an average farm in the sampled area produce at a minimum cost considering the size of the farm which is an indication that they operates in stage II of production surface (stage of efficient utilization of resource).This result was further justified by the mean cost efficiency of 1. 42 obtained from the data analysis which reveals that an average farm in the sample area is about 42% above the frontier cost, indicating that they are relatively efficient in allocating their scarce resources. The result of the analysis indicate the presence of cost inefficiency effects in sorghum production as depicted by the significant estimated gamma coefficient of about 0.46 and the generalized likelihood ratio test result obtained from the result.*

Key words: *Parametric, Neoclassical, Cost efficiency, Small-scale, Sorghum, Nigeria.*

INTRODUCTION

According to RPCA (2013) cereal production in the Sahel and West Africa is 57.01 million tonnes. This is equivalent to the production seen in 2012-13, but it is 11% higher than the average of the last five years. For the Sahel, production is 19.596 million tonnes, which is equivalent to the average of the past five years but 12% down compared to production in 2012-2013, when production was strong. For Gulf of Guinea countries, cereal production is estimated to be 37.414 million tonnes, which represents an increase of 8% compared to 2012-13 and a 17% increase compared to the average of the past five years. However, per capita production in the region is the same as the average of the past five years.

Sorghum is a genus of numerous species of grasses, one of which is raised for grain and many of which are used as fodder plants either cultivated or as part of pasture. The plants are cultivated in warmer climates worldwide. Species are native to tropical and subtropical regions of all continents in addition to the South West Pacific and Australasia. One species, *Sorghum bicolor* known as '*Dawa*' in Hausa; '*Aepkan*' in *Nupe* languages respectively, of Northern Nigeria, is an important world crop, used for food (as grain and in sorghum syrup or "sorghum molasses"), fodder, the production of alcoholic beverages, as well as biofuels (Miller Magazine, 2014). Sorghum production in 2012/13 was forecasted at 6.9 million tons, up from 6.8 million tons in 2011/12. Crop yield has increased because of the growing acceptance by farmers of improved varieties developed by local research institutes. These include two sorghum varieties bred by the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) which are higher yielding and earlier maturing (FEPSAN, 2012).

Nigeria is the largest sorghum producer in West Africa, accounting for about 71 percent of the total regional sorghum output, 30-40 percent of total African production, and is the third largest world producer after the United States and India. About 90 percent of sorghum produced by United States and India is utilized for animal feed production, leaving Nigeria as the world's leading food grain sorghum producer (GAIN, 2014). Sorghum ranks third after corn and millet in term of cereal production in Nigeria

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and is the primary food crop across northern Nigeria (CGIAR, 2013). Sorghum millet and maize are widely consumed by most households, especially in the North, and are used by various industries (FMARD, 2012; FEWSNET, 2014), but demand from industry is the main drive behind increases in sorghum production. Sorghum is used extensively in brewing and industrial demand for sorghum for beer production is rising steadily, as beer demand rises (GAIN, 2013). Today, sorghum and millet are two of the most basic foods for the poor and rural people in the dry regions that are poor in terms of other grains. When the production regions of these products are reviewed, it is seen that Africa, Central America and South Asia are at the front; used in various fields such as human food, feed and biofuel; these products are an important food source for the African countries that are especially poor in terms of other grain products (GRAIN AFRICA, 2014).

In Nigeria small scale farmers in general have been reported to be inefficient in resource use (Sadiq, 2014). In these studies, the efficiencies of the individual farmers were determined primarily by the use of the traditional response function technique, and making it impossible to quantify some factors that have influenced farmers levels of efficiency using this technique. The Stochastic Frontier Analysis (SFA) developed independently, by Aigner and Meeusen and van den Broeck (Aigner *et al.*, 1977; Meeusen *et al.*, 1977) and modified by Jondrow (Jondrow *et al., 1982*) have been used in determining farm level efficiency using cross-sectional data. In this method, the cost frontier is accounted for by cost inefficiency, measurement error, statistical noise and non-systematic influences, unlike the OLS that attributes all the deviations to inefficiency (Dia *et al.*, 2010). The analytical method also makes it easy to ascertain policy variables that can be used to address cost inefficiency of farmers. Available literature indicates that agriculture in Nigeria is yet to benefit significantly from application of the stochastic cost frontier model in estimating efficiency. This may be connected with the fact that the model extension is relative new that has only recently started gaining attention as a complement to the incorporated technical efficiency. Furthermore, empirical studies that have made use of this model in determining efficiency in crop production in Nigeria is increasing, but there are relatively fewer studies on sorghum production in the country. In addition, no studies have been documented for sorghum production in Niger state. Therefore, the center piece of this paper is to contribute towards better understanding of small scale farmers' production efficiency in Nigeria with a view of predicting allocative efficiencies (a measure of firms ability to produce at a given level of output using cost minimization input ratio) of sorghum farmers in Niger State, Nigeria using stochastic cost frontier analytical approach rather than the partial vision of technical efficiency with a view to derive policy implications for proper policy recommendations. Also studies on sorghum production in Nigeria using this neo-classical model exclusively focused on technical efficiency of farmers, e.g Abba (2012); Zalkuwi *et al.*, (2014). In addition this paper investigated and provides empirical information on factors that determine the cost efficiency of the farmers as well as economies of scale of the farmers.

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Three types of efficiency are identified in the literature; these are technical efficiency, cost efficiency and overall or economic efficiency (Erhabor and Ahmadu, 2013). Technical efficiency is the ability of a firm to produce a given level of output with minimum quantity of inputs under a given technology. Cost efficiency is a measure of the degree of success in achieving the best combination of different inputs in producing a specific level of output considering the relative prices of these inputs. Economic efficiency is a product of technical and cost efficiency. In one sense, the efficiency of a firm is its success in producing as large an amount of output as possible from given sets of inputs. Maximum efficiency of a firm is attained when it becomes impossible to reshuffle a given resource combination without decreasing the total output. Since the seminal work of Farrell in 1957, several empirical studies have been conducted on farm efficiency. These studies have employed several measures of efficiency. These measures have been classified broadly into three namely: deterministic parametric estimation, nonparametric mathematical programming and the stochastic parametric estimation. There are two non-parametric measures of efficiency. The first, based on the work of Chava and Aliber (1983) and Chava and Cox (1988) evaluates efficiency based on the neoclassical theories of consistency, restriction of production form, recoverability and extrapolation without maintaining any hypothesis of functional form. The second, first used by Farrell (1957) decomposed efficiency into technical and allocative. Farrell *et al.,* (1985) extended Farrell's method by relating the restrictive assumption of constant returns to scale and of strong disposability of inputs. Several approaches, which fall under the two broad groups of parametric and non-parametric methods, have been used in empirical studies of farm efficiency. These include the production functions, programming techniques and recently, the efficiency frontier. The frontier is concerned with the concept of maximality in which the function sets a limit to the range of possible observations (Amodu *et al.,* 2011). Thus, it is possible to observe points below the cost frontier for firms producing less than the minimum possible cost but no point can lie above the cost frontier, given the technology available. The frontier represents an efficient technology and deviation from the frontier is regarded as inefficient. The literature emphasizes two broad approaches to cost frontier estimation and cost efficiency measurement: (a) The non-parametric programming approach, and (b) the statistical approach. The programming approach requires the construction of a free disposal convex hull in the input-output space from a given sample of observations of inputs and outputs (Abba, 2012). The convex hull (generated from a subset of the given sample) serves as an estimate of the cost frontier, depicting the minimum possible cost. Cost efficiency of an economic unit is thus measured as the ratio of the actual cost to the minimum cost possible on the convex hull corresponding to the given set of input proces. The statistical approach of cost frontier estimation can be sub-divided into two, namely, the neutral shift frontiers and the non-neutral shift frontiers. The former approach measures the minimum possible total cost and then cost efficiencies by specifying a composed error formulation to the conventional cost function. The non-neutral approach uses a varying coefficients cost function formulation. The main feature of the stochastic cost frontier is that the disturbance term is composed of two parts, a symmetric and a one-sided component. The symmetric (normal) component, Vi captures the random effects due to the measurement error, statistical noise and other non symmetric influences outside the control of the firm. It is assumed to have a normal distribution. The one-sided (non-positive) component, Ui with Ui $\geq$ 0, captures cost inefficiency relative to the stochastic frontier. This is the randomness under the control of the firm. Its distribution is assumed to be half normal or exponential. The random errors, Vi are assumed to be independently and identically distributed as N (0, σ^2) random variables, independent of Uis. The Uis are also assumed to be independently and identically distributed as, exponential, half normal, truncated normal and gamma.

The stochastic frontier function is typically specified as:

$$Yi = f\,(Xij;\,ß) + Vi - Ui \quad (i = 1, 2, n) \qquad \dots (1)$$

Yi = Total cost of the ith firm;

Xij = Vector of actual jth inputs prices used by the ith firm;

ß = Vector of input price coefficients to be estimated;

Vi = Random variability in the costs that cannot be influenced by the firm and;

Ui = Deviation from minimum potential Total costs attributable to cost inefficiency.

The model is such that the possible total cost Yi, is bounded above by the stochastic cost, f (Xi; ß) exp (Vi), (that is when Ui = 0) hence, the term stochastic frontier. Given suitable distributional assumptions for the error terms, direct estimates of the parameters can be obtained by either the Maximum Likelihood Method (MLM) or the Corrected Ordinary Least Squares Method (COLS). However, the MLM estimator has been found to be asymptotically more efficient than the COLS (Abba, 2012), thus, the MLM has been preferred in empirical analysis. In the context of the stochastic frontier cost function, the cost efficiency of an individual firm is defined as the ratio of the observed total cost to the corresponding frontier total cost, conditional on the levels of inputs used by the firm. Thus, the cost efficiency of firm is:

$$C_{EEi} = \exp(-Ui) \qquad \dots (2)$$

$$C_{EEi} = Yi/Yi^* \qquad \dots (3)$$

$$= f\,(Xi;\,ß)\exp(Vi - Ui)\,/\,f\,(Xi;\,ß)\exp(Vi)\exp(-Ui).$$

C_{EEi} = Cost efficiency of farmer i;

Yi = observed total cost; and,

Yi* = frontier total cost.

The cost efficiency of a firm ranges from 1 and above. Optimal efficiency in cost has a value of 1.0. Higher values represent more than optimal efficiency in production.

Several empirical applications have followed the stochastic frontier specification. These studies are basically based on Cobb-Douglas function and transcendental logarithmic functions that could be specified either as production or cost or profit function. The first application of the stochastic frontier model to farm level data was by Battese and Corra (1977) in which the technique was applied to the pastoral zone of eastern Australia; Aigner *et al*. (1977) in which the model was applied to U.S. agricultural data; Kalirajan (1981) in which the technique was applied to rice farmers in India, and Bagi (1984) in which the technique was applied to small, large crop and mixed enterprise farms in West Tennessee.

The use of the stochastic cost frontier analysis in studies in agriculture was first used in Nigeria in year 2005. Such earlier studies include that of Ogundari and Ojo (2005), Ogundari *et al*., (2006), Ohajianya *et al*., (2010), Dia *et al.,* (2010), Umar (2011) and Sadiq *et al*., (2013), in which they offer a comprehensive review of the application of the stochastic cost frontier model in measuring of agricultural producers in developing countries. The production technology can be represented inform of cost function. The cost function represents the dual approach in that technology is seen as a constant towards the optimizing behavior of firms (Chambers, 1983). In the context of cost function any error of optimization is taken to translate into higher cost for the producers. However, the stochastic nature of the production frontier would still imply that the theoretical minimum cost frontier would be stochastic. The cost function can be used to simultaneously predict both technical and economic efficiency of a firm (Coelli, 1995). Also, it can be used to resurrect all the economically relevant information about farm level technology as it is generally positive, non-decreasing, concave, continuous and homogenous to degree one to one input prices (Chambers, 1983).

METHODOLOGY

Study Area

This study was based on the farm level data on small scale sorghum farmers in Niger State, Nigeria. Niger State is in the North-central part of Nigeria and lies in between longitude 3^0 30^1 and 7^0 20^1 east of the Greenwich Meridian and latitude 8^0 20^1 and 11^0 30^1 north of the equator (Sadiq and Yakasai, 2012) .The land area is about 80,000 square Kilometre with varying physical features like hills, lowland and rivers. The state enjoys luxuriant vegetation with vast Northern guinea savannah found in the north while the fringe (southern guinea savannah) in the southern part of the state. The people are predominantly peasant farmers cultivating mainly food crops such as yam, cassava, sorghum maize and rice for family consumption, and markets (Sadiq, 2014).

Sampling technique and Data Collection

The data for the study was drawn from primary source with the aid of pre-tested questionnaire coupled with interview schedule. The questionnaires were administered on 100 sorghum famers selected through multistage sampling procedure. The first stage involved the purposive selection of one Agricultural zone out of the three Agricultural zones in the state, namely, Kontagora for its prominence in sorghum production. In the second stage, two local government areas, namely Kontagora and Rijau were purposively selected due to preponderance of small scale sorghum producers. The third stage involved random selection of five villages from each LGAs. Lastly, 10 respondents were drawn from each of the villages, thus, given a total sample size of 100 respondents'.

Empirical model

In this study, Battese and Coelli (1995) model was used to specify a stochastic frontier cost function with behavior inefficiency component and to estimate all parameters together in one step maximum likelihood estimation. This model is implicitly expressed as:

$$\text{In } C = g\,(P_i, Y_i; \beta) + (V_i - U_i) \qquad \text{... (4)}$$

Where Ci represents the total production cost, g is a suitable functional form such as Cobb-Douglas; Pi is a vector variable of input prices (labour, seed, fertilizer, herbicides and depreciation on capital items). Y_i is the value of sorghum produced in kg, β is the parameters to be estimated. The systematic component, V_i represents random disturbance costs due to factors outside the scope farmers. It is assumed to be identically and normally distributed mean zero and constant variance as N $(0, \sigma^2 v)$. U_i is the one-sided disturbance form used to represent cost inefficiency and is independent of V_i. Thus, $U_i = 0$ for a farm whose costs lie on the frontier, $U_i > 0$ for farms whose cost is above the frontier and $U_i < 0$ for farm identically and independently distributed as $N(0, \sigma^2 u.)$. The two error terms are proceeded by positive signs because inefficiencies are always assumed to increase cost. Moreover, for the study the cost efficiency of an individual farm is defined in terms of the ratio of observed cost (C_b) to the corresponding minimum cost (C_{min}) given the available technology. That is:

Cost Efficiency (**CEE**)

$$C_b = g\,(P_i, Y_i; \beta) + (V_i + U_i) = \exp\,(U_i) \qquad \text{... (5)}$$

$$C^{min}\, g\,(P_i, Y_i; \beta) + (V_i)$$

Where the observed cost (C_b) represents the actual total production cost while the minimum cost (C_{min}) represents the frontier total production cost or least total production cost level.CEE takes value 0-1(Umoh, 2006; Ohajianya *et al*.,2010); 1 or higher (Ogundari *et al*.,2006), with 1 defining cost efficient farm. And, following the adoption of Battese and Coelli (1995) framework for data analysis, the explicit Cobb-Douglas function for the sorghum farms in the study area is therefore specified as follows:

$$\ln C = \beta_0 + \beta_1 \ln P_{1i} + \beta_2 \ln P_{2i} + \beta_3 \ln P_{3i} + \beta_4 \ln P_{4i} + \beta_5 \ln P_{5i} + \beta_6 \ln Y_i + (V_i + U_i) \quad \ldots (6)$$

Where;

C_i = Total production cost in naira (Naira);
P_1 = Cost of labour (Naira);
P_2 = Cost of fertilizer (Naira);
P_3 = Cost of seed (Naira);
P_4 = Cost of herbicides (Naira)
P_5 = Annual depreciation cost of farm tools (Naira); and,
Y_i = Output of sorghum in (kg).
β_0 = Constant co-efficient
β_{1-n} = Co-efficients of parameters to be estimated.

The choice of the Cobb-Douglas is based on the fact that the methodology requires that the function be self-dual as in the case of cost function in which this analysis will be based on.

The inefficiency model (U_i) is defined by:

$$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} \quad \ldots (7)$$

Where;

Z_1 = Age (in years);
Z_2 = Education (in years);
Z_3 = Household size (in numbers);
Z_4 = Farming experience (in years);
Z_5 = Co-operative membership (Yes = 1, otherwise = 0); and,
Z_6 = Extension contact (Yes = 1, otherwise = 0).

δ_0 and δ_{1-n} are scalar parameters to be estimated.

These socioeconomic variables are included in the model to indicate their possible influence on the cost efficiency of the farmers. The δ_0 and δ_{1-n} are scalar parameters to be estimated. The variance of the random error, $\sigma^2 v$ and that of the cost inefficiency effects $\sigma^2 u$ and the overall variance of the model σ^2 are related as follows: $\gamma = \sigma^2 u / \sigma^2 v + \sigma^2 u$.The gamma ($\gamma$) measures the total variation of total cost of production from the frontier cost which can be attributed to cost inefficiency (Battese and Corra, 1977).

The test for the presence of cost inefficiency using generalized likelihood-ratio statistics λ defined by: $\lambda = -2 \ln (H_0/H_a)$, where, H_0 is the value of the likelihood function for the frontier model in which parameters restriction specified by the null hypothesis, H_0 are imposed; and H_a is the value of the likelihood function for general frontier model. If the null hypothesis is true then scalar has approximately a mixed chi-square distribution with degree of freedom equal to the number of parameters excluded in the unrestricted model.

Economies of Scale (Es)*:** Economies of scale may be defined in terms of elasticity of cost with respect to output. However, in a multi-product setting, economies of scale (Es***) is defined as those reduction in average cost when all output are increased proportionally holding all other input prices constant. ***Es*** mathematically is equivalent to the inverse of sum of all the elasticities of total production cost with respect to all output. Economies of scale prevail, if ***Es*** is greater than 1 and, accordingly diseconomies of scale exist if ***Es*** is below 1. In the case of Es = 1 no economies of scale or diseconomies of scale exist. Return to scale and economies of scale are equivalent measures if and only if the product is homothetic (Chamber, 1988). If Cobb-Douglas function is used, this assumption is imposed.

RESULTS AND DISCUSSION

Summary statistics of the variables in stochastic frontier model

The summary statistics of the variables for the frontier estimation was presented in Table 1. They include the sample mean and the standard deviation for each of the variables. The mean value of ₦ 27,723.00 as total cost of producing 1,230 kg of sorghum per annum was obtained from the data analysis with a standard deviation of ₦6, 243.25. The small size of the standard deviation conforms to the fact that most farms operate at the same scale of operation. Analysis of cost variables of the farms shows that cost of labour accounts for 45% of the total cost due to the fact that there is large size number of the household members participating in farm operation since most farmers hardly send their children to proper efficiently educational schools due to poverty. Hence, farmers depend heavily on family labour to do most of the farming operations, thus justify the medium cost expended on hired labour. Cost of herbicides account for 20%, annual depreciation cost accounts for 17%, cost of fertilizer accounts for 15% of the total cost, while cost of seed accounts for 3%.

Variable representing the demographic characteristics of the farmers employed in the analysis of the determinant of cost efficiency include; age of the farmers, education, farming experience and household size. The average age of the farmers were 45 years meaning that the farmers were relatively young and within the active productive age recommended by FAO. The year of schooling was 6.1 years meaning that the literacy level in the study area was very low, i.e hardly exceed secondary education. The average years of farming experience was 5.32 years, with a fairly large household size of 6 members.

Table 1
Summary statistics of the variables in stochastic cost frontier model

Variables	*Mean*	*Standard deviation*	*% Total cost*
Total production cost (₦)	27,723.00	6,243.25	
Cost of labour (₦)	12,475.35	1,140.25	45
Cost of fertilizer (₦)	4,158.45	435.71	15
Cost of seed (₦)	831.69	57.22	3
Cost of herbicides (₦)	5,544.60	734.19	20
Annual depreciation cost (₦)	4,712.91	587.23	17
Sorghum output (kg)	1230	72.21	
Age of farmers (years)	45	3.21	
Education (years)	6.1	2.21	
Farming experience (years)	5.32	1.34	
Household size (number)	6	1.86	

Source: Field survey, 2014.

Maximum-likelihood estimates of parameters of the Cobb-Douglas frontier function

Maximum-likelihood estimates of the parameters of the stochastic cost frontier and the inefficiency model are presented in Table 2. The diagnostic statistics for σ^2 and γ were 0.5749 and 0.4632, and all significant at 1 percent level, respectively. The sigma squared σ^2 indicates the goodness of fit and correctness of the distributional form assumed for the composite error term while the gamma γ indicates that the systematic influences that are un-explained by the costs function are the dominant sources of random errors, thus indicating that about 46% of the variation in the total cost of production among the sampled farmers was due to differences in their cost efficiencies. Since inefficiency effects make significant contribution to the cost inefficiencies of sorghum farmers, thus the hypothesis which specifies that the inefficiency effects are absent from the model is strongly rejected. Furthermore, the rejection of this hypothesis was justified by using generalized likelihood ratio test which is defined by chi-square distribution which indicated that the traditional response function (OLS) is not an adequate representation of the data. All parameters estimate exhibit the expected sign with seed costs and fertilizer costs been highly significant at 1%, while labour costs, herbicides costs and output of sorghum are significant at 5%; meaning that these factors were significantly different from zero and thus were important in sorghum production. The annual depreciation cost of capital items was non-significant. The non-significant of this variable may be due to the fact that it is a sunk cost which last beyond a production cycle. The cost elasticities with respect to all input variables use in the production analysis are positive and imply that an increase in the labour cost, seed cost, fertilizer cost, herbicides cost, annual depreciation cost and production (output in kg) increases total production cost. That is ₦1 increase in the labour cost will increase total production cost by approximately 3kobo, ₦1 increase in the cost of seed will increase total production cost by 3kobo, ₦1 increase in the cost of fertilizer will increase total production cost by 2kobo, while 1kg increase in the sorghum output will increase total production cost by approximately 3kobo. However, all costs parameters are positive, implying that the cost function monotonically increases in input prices.

The result of the presence of economies of scale among the sorghum farms computed as inverse coefficient of cost elasticities with respect to the sorghum output in kg as the only output in the analysis shows that economies of scale prevail among the sampled farms, judging by the fact that E*s* computed is greater than one, that is ***Es*** =1.648. The economic implication of this value is that the sampled farms despite being small scale in nature expand their production capacities in order to decrease their cost to the lowest minimum in course of production irrespective of their size of operation which shows that the farms are experiencing decreasing but positive return to scale (stage II of production surface), since return to scale and economies of scale are equivalent measures (Chambers, 1983).This result further confirms Schultz's poor-but-efficient hypothesis that peasant farmers in traditional agricultural setting are efficient in their resource allocation behavior giving their operating circumstances (Schultz, 1964).

The estimated coefficient in the explanatory variables in the model is presented in the lower part of Table 2 for the cost inefficiency effects are of interest and have important implication. The negative coefficient for age and farming experience implies that the aged farmers and the most experienced farmers in the sorghum production are more cost efficient than

Table 2a
Maximum-likelihood estimates of parameters of the Cobb-Douglas stochastic cost frontier function and cost inefficiency in small scale sorghum production in Niger state, Nigeria.

Variable	*Parameters*	*Coefficients*	*Standard error*	*t-ratios*
General model				
Constant	β_0	0.4909***	0.1876	2.617
Cost of labour (₦)	β_1	0.02694**	0.01058	2.546
Cost of seed (₦)	B_2	0.03394***	0.01089	3.117
Cost of fertilizer (₦)	B_3	0.204***	0.0207	9.855
Cost of herbicides (₦)	β_4	0.01047**	0.0471	2.223
Capital Depreciation cost (₦)	β_5	0.01694^{NS}	0.01194	1.418
Sorghum output (kg)	β_6	0.3244**	0.1560	2.079
Inefficiency model				
Constant	δ_0	0.1407^{NS}	0.1089	1.2913
Age (years)	δ_1	-0.5878***	0.0453	-12.9757
Educational level	δ_2	-0.0937***	0.00536	-17.481
Household size	δ_3	0.749*	0.391	1.9156
Farming experience (years)	δ_4	-0.216***	0.0438	-4.9315
Co-operative membership	δ_5	-0.668***	0.1977	-3.37888
Extension contact	$ä_6$	-0.932***	0.234	-3.983
Diagnostic statistic				
Sigma-square $\sigma^2 = \sigma^2v + \sigma^2u$	0.5749***	0.1390	4.136	
Gamma $\gamma = \sigma^2u/\sigma^2v + \sigma^2u$	0.4632***	0.1053	4.399	
Log-likelihood function (llf)	10.34			
LR test	15.23			

Source: Computer print-out of FRONTIER 4.1.
Note: ***, ** Implies significance at 0.01 and 0.05 probability levels respectively.

Table 2b
Generalized likelihood ratio test of hypothesis for parameters of the stochastic cost function for small scale sorghum farmers in Niger State, Nigeria

Null hypothesis Decision	*Log likelihood*	*No. of Restrictions*	*χ^2-statistics*	*Critical value*
$H_0: \gamma = 0$ Rejected	10.34	8	15.23	14.68

Source: Computed from MLE Results.

the younger ones meaning that as the age and farming experience of farmers increases in the study area the cost inefficiency of the farmers decreases. This is in conformity with the assumption that farmers' age affects the cost efficiency since farmers different ages have different levels of experience ability to obtain and process information. This agrees with the findings of Ogundari *et al.*, (2006). The negative coefficient of education indicates that farmers' level of cost efficiency tends to increase with education acquisition. This is in conformity with the assumption that educational level of the farmers will have positive effects on the level of efficiency as they embody skill that can improve their overall efficiency. This finding contradicts previous work by Dia *et al.*, (2010). Co-operative membership had a negative coefficient, implying that farmers' that belong to co-operative societies have the opportunity of interacting with others, thereby exchanging information on improved technology, thus, rendering them more efficient. The negative coefficient of extension contact implies that increases in extension visits lead to reduction in allocative inefficiency level. The household size exhibited positive sign, which means that farmers with large family size tend to be inefficient as a result of large family expenditure been incurred.

Cost efficiencies levels of sorghum farmers in the study Area

Table 3 reveals summary of cost efficiency scores for sorghum farms in the sampled area. Cost efficiency was estimated as C_{EE} = exp (Ui). The mean cost efficiency of the farms was estimated as 1.47. This implies that an average sorghum farmers in the sampled area recorded costs that is 47% above the minimum defined by the frontier. In other words, 47% of their costs are wasted relative to the best practiced farms producing the same output and facing the same technology. The higher the value of C_{EE}, the more inefficient the sorghum farm is. However, the frequencies of occurrence of the predicted cost efficiency between 1.0 and 1.5 representing about 93% of the sampled farmers, implying that majority of the farmers were fairly efficient in producing at a given level of output using cost minimizing input ratios which reflects the farmers' tendency to minimize resource wastage associated with production process from cost perspective. The average farmer needs a cost cut of 47% [(1 – 1.47/1)* 100] to be on the frontier, and cost cut of 36.1% [(1 – 1.47/1.08)*100] to attain the status of the most cost efficient farmer, while the poorly efficient farmer needs a cost cut of 80% [(1 – 1.8/1)* 100] to be on the frontier, and approximately cost cut of 66.7% [(1-1.8/1.08)*100] to attain the status of the most cost efficient farmer. However, the most efficient farmer needs cost cut of 8% [(1 – 1.08/1)*100] to be on the frontier.

Table 3
Deciles frequency distribution of cost efficiencies of sorghum farmers

Efficiency level	*Frequency*	*Relative Efficiency (%)*
1.0-1.1	33	33
1.2-1.3	22	22
1.4-1.5	38	38
1.6-1.7	4	4
≥ 1.8	3	3
Total	100	100
Minimum	1.08	
Maximum	1.82	
Mean	**1.42**	

Source: Computed from MLE Results.

SUMMARY AND CONCLUSION

This empirical study is on neoclassical test of cost efficiency in small scale sorghum production using parametric neoclassical cost function. A Cobb-Douglas functional form was used to impose the assumption that return to scale and economies of scale are equivalent measures if and only if the production function is homothetic. The empirical evidence indicates the existence of relative economies of scale despite the fact that the farmers operate at small scale level. The relative economies of scale in the sense that, the computed overall economies of scale was slightly above one, which means that the farmers were currently expanding their present level of production, which in the long run will enable them to experience decrease in the cost of production per output. Furthermore, the outcome of this analysis reveals that 93% of the farms included in the sample operate close to the frontier level, achieving scores of about 42% or lower in terms of cost difference relative to the best-practiced technology. However, the level of the observed cost efficiency has been shown to be significantly influenced by age, education, farming experiences, co-operation membership, extension contact and household size. In conclusion, the relative closeness of the computed overall economies of scale (***Es***) of 1.648 and an average cost efficiency (C_{EE}) of 1.42 from unity, is an indication that although the farmers were above the frontier and small scale resource poor, they are fairly efficient in the use of their resources and that any expansion in their present level of production will reduce the cost of production per output, given the prevailing economies of scale obtained for the study which is in accordance with results from earlier studies that indicate higher relative efficiency for small farms (Paudel and Matsuoka, 2009; Dia *et al*., 2010; Ohajianya *et al*., 2010).

REFERENCES

Abba M. W., (2012), Technical efficiency of sorghum production in Hong local government area of Adamawa State, Nigeria, *Russian Journal of Agricultural and Socio-Economic Sciences*, **6**(6): 10-15.

Aigner D. I. C., Lovell A. K. and Schmidt P., (1977), Formation and Estimation of Stochastic frontier production function Models, *Journal and Econometrics*, **6**: 21-37.

Amodu M. Y., Owolabi J. O. and Adeola S. S., (2011), Resource use efficiency in part-time food crop production: The stochastic frontier approach, *Nigerian Journal of Basic and Applied Science*, **19**(1): 102-110.

Bagi F. S., (1984), Stochastic frontier productions function and farm-level technical efficiency of full-time and part-time farms in Tennessee North Central. *Journal of Agricultural Economics*, **6**: 48-55.

Battese G. E. and Corra G. S., (1977), Estimation of a production Function Model with Application to the Pictorial Zone of Eastern Australia, *Australian Journal of Agricultural Economics*, **21**: 169-179.

Battese G. E., and Coelli T. J., (1995), A Model for Technical Inefficiency Effects in Stochastic Frontier Production for Panel Data, *Emperical Economics*, **20**: 325-345.

Chambers R. G., (1983), *Applied Production Analysis: A Dual Approach*, Cambridge: Cambridge University Press.

Chavas J. and Aliber M., (1983), An Analysis of Economic Efficiency in Agriculture: A Non-parametric Approach. *Journal of Agricultural and Resource Economics*, **18**:1.

Chavas J. P. and Cox T. L., (1988), A Non-parametric Analysis of Agricultural Technology. *American Journal of Agricultural Economics*, **70**: 303-10.

CGIAR, (2013), A Global Alliance for improving Food Security Nutrition and Economic Growth for the world's most vulnerable poor, *Annual report* 2013, 1-32.

Coelli T. J., (1995), Recent Development in Frontier Modeling and Efficiency Measurement", *Australian Journal of Agricultural Economics*, **39**: 219-245.

Dia Y. Z., Zalkuwi. J. W. and O. Gwandi O., (2010), Economics of scale and cost efficiency in small scale maize production in Mubi North Local Government in Adamawa State, Nigeria. *African Journal of Agricultural Research*, **5**(19): 2617-2623.

Enwerem V. A. and Ohajianya D. O., (2013), Farm size and technical efficiency of rice farmers in Imo State, Nigeria, *Greener Journal of Agricultural Sciences*, **3**(2): 128-136.

Erhabor P. O. and Ahmadu J., (2013), Technical efficiency of small-scale rice farmers in Nigeria, *Journal of Agriculture and Allied Sciences*, **2**(3): 14-22.

Farrell J. M., (1957), The Measurement of Productive Efficiency, *Journal Royal Statistics Society*, **120**: 253-290.

Farrell R., Grabowski R. and Grasskopt S., (1985), Technical efficiency of Philippine Agriculture. *Applied Economics*, **17**: 205-14.

FEPSAN, (2012), Working together to improve Fertilizer Supply in Nigeria, *Newsletter*, **2**(2): 1-4.

FEWSNET, (2014), Monitors trends in staple food prices in countries vulnerable to food insecurity, *Nigeria Price Bulletin*, 1-4.

FMARD, (2012), Agricultural Transformation Agenda: We Will Grow Nigeria's Agricultural Sector, *Draft for Discussion*, 1-90.

GAIN, (2013), Nigeria grain and feeds annual report, *Gain Report*, 1-14.

GAIN, (2014), Nigeria grain and feeds annual report, *Gain Report*, 1-16.

Grain Africa, (2014), Africa grain, pulses and technologies congress and expo, *Africa Union Conference, Addis Ababa, Ethiopia*, (29-31 October, 2014), 1-26.

Ibrahim U. W., (2011), Analysis of Production Efficiency and Profitability of Watermelon in Kaga and Kukawa Local Government Areas of Borno state, Nigeria, *Unpublished M.sc. Thesis* submitted to Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria, Nigeria.

Kalirajan K., (1981), The Economic efficiency of farmers growing high- yielding irrigated rice in India, *American Journal of Agricultural Economics*, **63**: 556.

Meeusen W., and Broeck J. V. D., (1977), Efficiency estimation from Cobb-Douglas production functions with composed error, *International Economics Review*, **18**(2): 435–444.

Ogundari K. and Ojo S. O., (2005), "The Determinants of Technical Efficiency in mixed Crop Food Production in Nigeria: A Stochastic Parametric Approach." *Proceedings of the 1st Annual Conference on Developments in Agriculture and Biological Science,* 21st April, 2005. School of Agriculture and Agricultural Technology, Federal University of Technology, Akure, Nigeria, 159-164.

Ogundari K., Ojo S. O., and Ajibefun I. A., (2006), Economies of Scale and Cost Efficiency in Small Scale Maize Production: Empirical Evidence from Nigeria. *Journal of Social Science*, **13**(2): 131-136.

Ohajianya D. O., Echetama J. A., Offodile P. O., Osuagwu C. O., Henri-ukoha A., Okereke–Ejiogu N. and Anyaoha N. O., (2010), Allocative Efficiency Among Maize Farmers In Imo State, Nigeria, *Report and Opinion*, 2010; **2**(12): 139-147.

Paudel P. and Matsuoka A., (2009), Cost Efficiency Estimates of Maize Production in Nepal: A Case Study of the Chitwan District, *Journal of Agricultural Economics–Czech,* **55**(3): 139-148.

RPCA, (2013), Final Communiqué on Food and Nutritional Situation in the Sahel and West Africa Restricted, *RPCA Meeting,* (Paris, 14-16 April, 2014).

Sadiq M. S. and Yakasai M. T., (2012), Estimation of Efficiency constraints in small scale upland Rice production in Bida Agricultural Zone, Niger State, Nigeria, *Techno Science Africana Journal,* **7**(63): 11-16.

Sadiq M. S., Mohammed Abubakar and Yusuf T. L., (2013), Economies of Scale and Cost Efficiency in Small- scale Egusi melon production in Bida Local Government Area of Niger State, Nigeria, *Journal of Agriculture and Veterinary Science,* **2**(6): 92-97.

Sadiq M. S., (2014), Profitability of small-scale maize production in Niger state of Nigeria, *Indian Journal of Economics and Development*, **10**(3): 205-210.

Schultz T. W., (1964), *Transforming Traditional Agriculture*, New Haven: Yale University Press.

Zalkuwi J. W., Adebayo E. F., Moses, J. D. and Gwandi O., (2014), Economics of Sorghum Production In Guyuk Local Government of Adamawa State, Nigeria, *International Journal of Commerce, Business and Management,* **3**(5): 687-696.