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Measurement of Allocative Efficiency and Its Determinants Among Soyabean Farmers In Central Agricultural Zone, Nigeria.

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Abstract
Allocative efficiency of Nigerian farmers deserves special attention given the various intervention programmes by the government to improve productivity of farmers through better input allocation decisions in production. Data were collected, using structured questionnaire, from 485 soyabean farmers sampled through a multistage procedure. The Cobb-Douglas stochastic frontier production function was used to analyse the data. Results show that allocative efficiency ranged from 10% to 98% with a mean of 95% (95%). The wide variation in allocative efficiency implies that there are ample potentials for the farmers to improve their resource allocation. There is scope for enhancing soyabean production by 5 percent through better allocation of resources. Education, farming experience, farm size, extension contact and improved soyabean variety were found to positively influence allocative efficiency while age decreased it. The study recommends policies that will encourage youths, educated and experienced farmers to cultivate larger farm sizes and plant improved soyabean varieties for increased allocative efficiency.
Keywords: *Cobb-Douglas stochastic frontier production function, economic and allocative efficiencies, soyabean farmers, Central Agricultural Zone of Nigeria.*

INTRODUCTION

Before Nigeria's independence and post-independence in the early 1960s, agriculture was the mainstay of the economy and accounted for over 50 percent of the total GDP. By mid-1970, the contribution of agriculture to the nation's GDP had declined remarkably to about 25 percent and the food deficit gap had widened significantly. By late 1970s, there were signs of problems existing in the agricultural sector, shortages in food supply and increases in food prices, for example, were noticed. The performance of Nigeria's agricultural contribution to the nation's GDP declined to about 23 percent by the (CBN, 1991). The country witnessed significant decline in agricultural productivity growth. The study on allocative efficiency of Nigerian farmers is crucial in the context of various intervention programmes implemented by the Nigerian government to transform the country's agriculture and increase productivity. Soyabean, 'the miracle seed', a versatile crop from which so many products like soyabean oil, soyabean milk, soyabean "fufu", soyabean "dadawa," livestock feed, soyasauce and baby foods such as "golden morn", "babeena", "nutrend" and "cerelac" are derived, is one of the crops that significantly contributes to the nation's GDP. It is the world's most important oilseed legume with respect to total production and international trade (Salunkhe*et al*., 1992) and Nigeria is the largest producer of soyabean in West and Central Africa (Singh *et al*., 1987).
Available efficiency studies on agriculture in Nigeria have mostly focused on technical efficiency. In comparison to the literature on technical efficiency, studies relating to the measurement of the level and determinants of allocative efficiency are relatively scanty. Some attempts that have been made to estimate allocative efficiency in Nigerian agriculture include: Okoye *et al.* (2007), and Nwachukwu and Onyenweaku (2009). Okoye *et al.* (2007) estimated allocative efficiency of cocoyam farmers in Anambra State and found a mean allocative

efficiency of 65 percent while Nwachukwu and Onyenweaku (2009) found a mean of 62 percent in the estimation of allocative efficiency among FADAMA fluted pumpkin farmers in Imo State.

This study therefore attempted the measurement of the level of allocative efficiency and its determinants in Central Agricultural Zone of Nigeria among soyabean farmers, using Cobb-Douglas stochastic frontier cost and production functions. Allocative efficiency is the ratio between total cost of producing one unit of output using actual factor proportions and total cost of producing one unit using optimal factor proportions in a technically efficient manner (Ohajianya and Onyenweaku, 2001). A production process may be allocatively inefficient in the sense that the marginal revenue product of input might not be equal to the marginal cost of input. Allocative inefficiency results in utilization of inputs in the wrong proportions given input prices (Okoye *et al.,* 2007). The result is expected to guide the initiators and implementers of agricultural programmes on the type of policies that best fit the farmers' allocative conditions.

METHODOLOGY

The study was undertaken in Central Agricultural Zone of Nigeria. The Zone covers: Benue, Kogi, Kwara, Niger, Nassarawa, Taraba and Plateau States, as well as the Federal Capital Territory, Abuja.The broad objective was to measure the allocative efficiency level of soyabean farmers and the socio-economic characteristics that influence it. The Central Agricultural Zone was chosen as the study area based on its predominance of soyabean production in the country. Shaib *et al.* (1997) recorded that the Zone is the largest soyabean producer in the country, producing well over 64 percent of national production. Data were collected through the use of a questionnaire administered to 485 soyabean farmers, sampled through a multistage sampling technique. First, three States, namely: Benue, Niger and Plateau, were purposively selected because of their lead in soyabean production in the Zone. Second, Local Government Areas (LGAs) within the sampled States were selected, from the sampled States based on their high level of soyabean production. Third, 0.2 percent of soyabean farmers were randomly selected from the sampled LGAs/States soyabean farming population. The data collected solicited information on socio-economic characteristics of the farmers and their production activities in terms of inputs, output, and their prices for the year 2010 using the cost-route approach.

The Cobb-Douglas stochastic frontier production function (SFPF) was used to analyze allocative efficiency of the soyabean farmers and its determinants.

(a) The theoretical model of the stochastic frontier cost function is defined as:

$C = f(W_i, Y_i; \alpha)\ exp e_i i = 1, 2 \ldots\ldots n$ …………………………………… (1)

Where;

C - Represents the minimum cost of production

W - vector of input prices

Y - soyabean output

α - vector of parameters

e_i - composite error term $(v_i - u_i)$

using Sheppard's Lemma we obtain;

$\partial C = X_i\ (W, Y; a)$…………………………………………………………(2)

Where ∂P_i: Is the system of minimum cost input demand equations (Bravo-Ureta and Pinheiro, 1997).

Substituting a farm's input prices and quantity of output in equation 2 yields the economically efficient input vector X_c. With observed levels of output given, the corresponding technically and economically efficient costs of production will be equal to X_{ii} P and $X_{ie,}$ respectively, while the actual operating input combination of the farm is X_i P. The three cost measures can then be used to compute the economic efficiency indices as follows;

$TE = (X_{ie}\ P)/(X_i.\ P)$……………………….…………………………………(3)

$EE = (X_{ii}.P)/(X_i.P)$…………………………………………….……….….(4)

The combination of equations (3) and (4) is used to obtain the allocative efficiency (AE) index following Farrell (1957).

$AE = EE/TE = (X_{ie}.\ P)/(X_{ii}.P)$……………………………………..………(5)

The efficient production is represented by an index value of 1.0 while the lower values indicate a lower degree of efficiency. Using the method by Bravo-Ureta and Pinheiro (1997), which was based on the work of Jondrow*et al.* (1982), technical efficiency can then be measured using the adjusted output as shown in equation (6)

$Y^* = f\ (x_{i;}\beta) - u$ ………………………….…………………………………….(6)

Where u can be estimated as :

$$E\ (u_i/\ e_i) = \frac{\sigma\lambda}{I+\lambda^2}\ \frac{f^*(\varepsilon_i\lambda/\sigma)-\Sigma_i\lambda}{1-F^*(\varepsilon_i\lambda)} \quad \text{………………………….………… (7)}$$

Where;

$f^*(\varepsilon_i\lambda/\sigma)$ and $F^*(\varepsilon_i\sigma)$ are normal density and cumulative distribution functions, respectively.

$\lambda = \sigma_u/\sigma_v$

$\varepsilon_i = V_i - U_i$ and

When y* is the observed output adjusted for statistical noise ε_i, σ and λ estimates are replaced in equations (5) and (6), it will provide estimates for U and V. The term V is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer e.g weather, disease outbreaks, measurements errors, etc. The term U is a non negative random variables representing inefficiency in production relative to the stochastic frontier, e.g age of the farmer, educational level, farming experience, etc. The random error V_i is assumed to be independently and identically distributed as $N(o,\sigma^2)$ random variables independent of the U_{is} which are assumed to be non-negative truncation of the $N(o,\sigma_u^2)$ distribution (i.e. half-normal distribution) or have exponential distribution.

(b) Empirically, the economic efficiency was measured using stochastic Cobb-Douglas frontier cost function for soyabean production. The function is specified as:

$L_n C_i = b_{0+}b_1LnP_1+b_2LnP_2+b_3LnP_3+b_4LnP_4+b_5LnY+V_i - U_i$ ……………………(8)

Where:

$L_n C_i$ – total cost of soyabean production of the i-th farm

P_1 – average daily wage rate per manday

P_2 – price of fertilizer per kilogram

P_3 – price of seed in naira per kilogram

P_4 – price of agrochemicals per litre

Y– output of soyabean in kilogram

$b_0 - b_5$ – regression parameters to be estimated

$V_i - U_i$ – as defined earlier

Technical efficiency was measured using a stochastic Cobb-Douglas production function specified as follows:

$LnY_i = \beta_o + \beta_1LnX_{1i} + \beta_2LnX_{2i} + \beta_3LnX_{3i} + \beta_4LnX_{4i} + \beta_5LnX_{5i} + V_i - U_i$------(9)

where:

Ln – denotes natural logarithm to base e

Y_i – the total soyabean output of the farmer in kilograms

X_{1i} – farm size in hectares

X_{2i} – labour in mandays

X_{3i} – quantity of seeds planted in kilograms

X_{4i} – the total amount of fertilizer applied in kilograms.

X_{5i} – agro-chemicals in litres

β_o - β_1 – parameters to be estimated
V_i –U_i are as defined earlier

The maximum likelihood estimates of the parameters in the Cobb-Douglas stochastic frontier production model defined in equations 8 and 9, respectively, given the specification for technical efficiency effects defined by equation 10 were obtained by using a computer programme, Frontier 4.1 developed by Coelli (1994).
Allocative efficiency was measured as follows:
AE = EE/TE
Where: AE - Allocative efficiency
EE - Economic efficiency
TE - Technical efficiency
Determinants of allocative efficiency were estimated from allocative efficiency scores from equations 3 and 4 regressed against the set of farm specific factors to obtain the determinants for allocative efficiency, following Kalirajan (1991).
$Exp.(Ui)=ao+a_1Z_1+a_2Z_2+a_3Z_3+a_4Z_4+a_5Z_5+a_6Z_6+a_7Z_7+a_8Z_8+a_9Z_9$................................(10)
Where:
Exp ($-U_i$) - allocative efficiency of the ith-farmer
Z_1 – farmer's age in years
Z_2 – farmer's educational level in years
Z_3 - number of extension contact in a year
Z_4 - household size, in numbers
Z_5 - farm size in hectares
Z_6 - farmer's farming experience in years
Z_7 - fertilizer use (dummy variable, fertilizer use = 1, 0 otherwise)
Z_8 - access to credit (dummy variable access = 1, no access = 0)
Z_9 - membership of farmers cooperatives (member = 1, non member = 0)

RESULTS AND DISCUSSION

Stochastic Frontier Cost and Production Functions

The maximum likelihood estimates of the Cobb-Douglas stochastic frontier cost and production parameters for soyabean are presented in Tables 1 and 2, respectively. For the cost function, the sigma squared (σ^2=0.78) is quite high and highly significant at 1 percent level of probability while the gamma γ=0.32 is significant at 5 percent. The high and significant value of the sigma squared indicate the goodness of fit and correctness of the specified assumption of the composite error terms distribution (Idiong, 2005). The gamma shows that 32 percent of the variability of the output of soyabean farmers that are unexplained by the function is due to economic inefficiency. For the production function, the sigma squared (σ^2=0.23) is statistically significant at 1 percent indicating goodness of fit and correctness of the specified distributional assumptions of the composite error term. Gamma is estimated at 0.99 and is statistically significant at 1 percent indicating that 99 percent of the total variation in soyabean output is due to technical inefficiency.

Table 1: Maximum Likelihood Estimates of the Parameters in the Cobb-Douglas Frontier Cost Function Model for Soyabean Farmers in Central Agricultural Zone of Nigeria.

t-values	Coefficients	Parameters	Variables
6.64***	6.58	β_0	Constant
4.46***	0.64	β_1	Ln wage rate
2.44**	0.15	β_2	Ln price of fert
5.13***	0.78	β_3	Ln price of seed
4.73***	-0.04	β_4	Ln price of agroch
2.12**	0.11	β_5	Ln output
11.88***	0.78	(σ^2)	Sigma squared
2.64**	0.32	(γ)	Gamma
	-602.86		Log likelihood function
	44.10		LR test

Source: Field Survey (2010)

Values in parenthesis are t-values. ***, ** and * t-test significant at 1, 5 and 10 percent, respectively.

Table 2: Maximum Likelihood Estimates of the Parameters in Cobb-Douglas Stochastic Frontier Model of Soyabean Farmers in Central Agricultural Zone, Nigeria.

t-values	Coefficients	Parameters	Variables
37.57***	6.76	β_0	Constant
5.69***	0.22	β_1	Ln farm size
6.57***	0.31	β_2	Ln labour
4.27***	0.16	β_3	Ln seed rate
3.79***	0.09	β_4	Ln qty of fert
0.36	0.04	β_5	Ln qty of agroch
14.85***	0.23	(σ^2)	Sigma squared
66.17***	0.99	(γ)	Gamma
	-334.09		Log likelihood function
	223.85		LR test

Source: Field Survey (2010)

Values in parenthesis are t-ratios ***** and *=t- ratio significant at 1, 5 and 10 percent, respectively.

Measurement of Allocative Efficiency

The frequency distribution of allocative efficiency estimates are shown in Table 3. The results indicate that allocative efficiency range from 0.10 to 0.98 with a mean of 0.95. The result implies that the average soyabean farmer in the Zone would experience a cost saving of about 3.06 (1-0.95/0.98) percent if he or she attains the level of the most allocatively efficient farmer among the respondents. The most allocatively inefficient farmer will have an efficiency gain of 89.87 (1-0.10/0.98) percent in soyabean production if he or she attains the efficiency level of the most allocatively efficient farmer in the Zone. Furthermore, the wide variation in allocative efficiency shows that there are potentials to improve allocative efficiency among the farmers for enhanced profitability. Results further shows that majority (57.73%) of soyabean farmers in the study area were in the highest allocative efficiency range of 0.91 to 1.00, indicating that the average farmer in the Zone was a little inefficient in allocating resources as classified by Laha and Kuri (2011).

Table 3: Distribution of Allocative Efficiency estimate of Soyabean Production

10.10	49	≤0.30
03.09	15	0.31-0.60
29.07	141	61-0.90
57.73	280	0.91-1.00
100.00	485	Total
-	0.95	Mean
-	0.10	Minimum
-	0.98	Maximum

Source: Field Survey (2010)

Determinants of Allocative Efficiency

The result of the factors influencing allocative efficiency are presented in Table 4

The coefficient for age (-0.22) was negatively signed and statistically significant at 5 percent. This implies that increase in age will result in allocative inefficiency as the aged would tend to misallocate their resources. This was also reported by Okoye *et al.* (2007), Idiong (2005) and Hussain *et al.* (1984).

The coefficient of education (0.34) was positive and statistically significant at 1 percent level of probability. This is in agreement with the findings of Amaza and Olayemi (2000) that increasing years of formal education increases a farmer's level of allocative efficiency. Also, Battese and Coelli (1995) stressed that the more educated the farmers are the more receptive to improved farming techniques and amenable to risk taking. The result also agrees with that Bravo-Ureta and Pinheiro (1997) but goes against the assertion of Okoye *et al.* (2007) that education is not costless but requires investment and lack of it might not be regarded as a factor causing inefficiency and would contribute to improvement in farmer's efficiency only if it is costless.

The coefficient of farming experience was positive (0.29) and statistically significant at 1 percent level of probability indicating its importance in soyabean production. This agrees with the findings of Okoye *et al*. (2007), Laha and Kuri (2011) and Ukwuaba and Inoni, (2012). Farmers with more years of experience achieved highest levels of profit efficiency suggesting that they are aware of current farm techniques in broiler production and/or are better at managing their limited resources at that point in time (Offiong and Onyenweaku, 2006). The positive and significant coefficients of education and farming experience of farmers justify the argument that schooling and experience influence positively the level of allocative efficiency in agriculture (Laha and Kuri, 2011).

The coefficient of extension contact was positive (0.21) and statistically significant at the 5 percent probability level. This shows that soyabean farmers who had more extension visits and teachings were more allocatively efficient in soyabean production in the Zone. This result agrees with that of Bravo-Ureta and Pinheiro (1997). Interactions through extension contacts give the farmers opportunities to learn improved technologies and to acquire and use needed inputs and services.

The coefficient of farm size was estimated to be positive (6.47) and significant at 1 percent. This indicates that larger farm holdings are more allocatively efficient. This is in consonance with Laha and Kuri (2011) that larger farmers tend to be more efficient in allocating inputs than small farmers but is in contrast with Okoye *et al.* (2007) that commercial farms would become significantly more efficient if they become smaller. Farmers in the study area have average farm holdings of 1.57 hectares.

The coefficient of fertilizer use was positive (0.21) and significant at 1 percent. The coefficient

of credit access was positive (0.43) and significant at 5 percent level of probability. Credit availability shifts the cash constraint outwards and enables farmers to make timely purchases of those inputs which they cannot provide from their own resources Okoye *et al.* (2007). The positive influence of fertilizer use as an input corroborates to credit. If a farmer fails to buy fertilizer for his crop output loss may be irretrievable. This agrees with Laha and Kuri (2011) that credit has a catalytic role in improving allocative efficiency of farmers.
The coefficient of household size and membership of farmers cooperatives were positive but not significant, probably, because prevailing market prices of inputs remain the same to both members and non-members of cooperatives and irrespective of sizes household farmers

Table 4: Maximum likelihood Estimates of the Determinants of Allocative Efficiency of Soyabean Production in Central Zone of Nigeria.

Coefficients	t-values	Variables
2.98	4.22***	Constant
-0.22	2.85**	Age
0.34	5.45***	Education
0.21	2.60**	Ext contact
0.07	0.62	Household size
0.47	3.22***	Farm size
0.29	6.32***	Farming exp
0.21	5.17***	Fertilizer use
0.43	2.84**	Access to credit
0.16	1.28	Membership of cooperatives

Source: Field survey (2010)
***, ** and * t-test significant at 1, 5 and 10 percent, respectively.

CONCLUSION AND RECOMMENDATIONS

The study has indicated that soyabean farmers in Central Agricultural Zone of Nigeria are not fully allocative. Individual level of allocatively efficient. Individual levels of allocative efficiency range between 0.10(10%) and 0.98(98%) with a mean of 0.95(95%). This result shows that there is scope for improving allocative efficiency of soyabean farmers in the Zone by 5 percent. On the average, soyabean farmers would reduce cost by 3.06 percent if they attain the efficiency level of the best practiced soyabean farmers in the Zone.
Significant factors found to exert positive influence on allocative efficiency are age, farming experience, education, extension contact, farm size, fertilizer use and credit access while age had a negative influence. This calls for policies that will encourage new entrants, especially young farmers, to produce soyabean and experienced farmers who are educated to remain in soyabean production as well as policies to improve soyabean farmers' access to extension services, fertilizer, credit and cultivation of larger farm sizes for enhanced soyabean productivity.

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