AAB BIOFLUX

Advances in Agriculture & Botanics-
International Journal of the Bioflux Society

Determinants of technical efficiency in arable crops production and policy implications in Imo state, Nigeria

[1]Chima I. Ezeh, [1]Clinton E. Akpa, and [2]Patrick O. Okudu

[1]Department of Agricultural Economics and Extension Abia State University, Umuahia Campus, Umuahia, Abia State, Nigeria, [2]Farm Management Centre, Michael Okpara University of Agriculture Umudike, Umuahia Abia State, Nigeria.
Corresponding author: C. I. Ezeh, chimaezeh@yahoo.com

Abstract. This study utilized the stochastic frontier production function to determine technical efficiency in arable crops production in Imo state, Nigeria. A multi-stage random sampling technique was used to select 120 arable crops farmers from which input/output data were collected. Relevant data was collected with the aid of a structured and pre-tested questionnaire. The estimated farm level technical efficiency ranged between 0.15 and 0.98 with a mean of 0.67. Critical determinants of technical efficiency of arable crop farmers were: household size, farming experience, membership of cooperative societies and frequency of extension agents contact. Higher yield and technical efficiency could be attained by efficient allocation of the employed resources, which is vital to the sustainability of agriculture in Nigeria.

Key Words: technical efficiency, stochastic frontier, arable crops, policy implication.

Introduction. Agriculture, the dominant occupation of the rural dwellers is predominantly small-scale (average operational holding of 2 ha per farm family), mainly rain fed and characterized by low land and labour productivity due to a combination of problems including poor macroeconomic and sector policies. However, this sector employs over two third of the population and accounts for a third of the gross domestic product (GPD) (NPC 2005; Ingawa 2001).

Nigeria has a potential comparative advantage in the production of fresh and processed high value agricultural products, given its favourable agro-ecological conditions and relatively low labour cost. The major problems of arable crops production in Nigeria are those of low productivity and inefficiency in resource utilization. Specifically, there is the problem of deciding on how much of the available factor productivity or resources to be devoted for future growth as well as how much to satisfy current consumption needs (Johnson 1982). The problems of resource availability, resource scarcity in relation to human wants, with the difficulty of tapping the resources or controlling them in the production process, including the accessibility of the resources; are obstacles to efficient resource utilization (Awoke & Okorji 2003). It has become obvious that efforts to increase arable crops production may have to concentrate on increasing their productivity rather than on extensification of production areas. The analysis of productivity should help to identify the possibilities for increasing output while the resources are conserved (Mbanasor & Obioha 2003). The role of increased technical efficiency was examined as a viable complement to any set of policies to stimulate arable crops production and/or to promote resource conservation.

This study would resolve the above problems through the following specific objectives namely:

i. determine the technical efficiency of arable crops farmers in Imo State, Nigeria;

ii. determine the socio-economic variables that influence technical efficiency of the arable crops farmers;

iii. estimate production elasticity and returns to scale of the farmers;
iv. make policy recommendation based on research findings.

To guide this study in achieving meaningful inference, the following null hypothesis was tested: Ho_1: Arable crops farmers in Imo state are fully technically efficient.

Material and Method. The study area was Imo state. The state was purposively chosen because of the preponderance of arable crops farmers. The state lies between latitude 5^o 10′ and 6^o 35′ north of the Equator as well as between longitude 6^o 35′ and 7^o 35′ east of the Greenwich meridian (National Agricultural Extension and Research Liaison Service (NAERLS), 1995). All the three agricultural zones (Orlu, Okigwe and Owerri) were involved in the study.

Multi-stage random sampling technique was used in the selection of samples. First, one local government area (LGA) was selected at random from each agricultural zone. The selected LGAs included Onuimo (Okigwe zone); Aboh-Mbaise (Owerri zone) and Oguta (Orlu zone). Second, 4 practising arable crops production communities were selected from each LGA thus giving a total of 12 communities. Third, 10 arable crops farmers were randomly selected from each community thus giving a total sample size of 120 respondents. The arable crops involved in the study are maize, rice, yam and cassava. The sample frame for this research was obtained from the extension agents of the Imo state ADP in-charge of various circles covered by the study.

The data for this study were collected with cost route technique; which is simply described as the collecting of data at the time the farmer is performing each operation and with the aid of detailed, pre-tested and structured questionnaire administered on the selected arable crops farmers in the area.

Data for objectives 1, II and III were analyzed using the stochastic frontier production analytical model.

Theoretical Framework. The theoretical framework of the stochastic frontier production function is specified as follows:

$Yi = F(Xi\ \beta)\ \exp\ (Vi - Ui),\ 1 = 1, 2\ ....n$……………….(1)

Where:

Yi = Output of the i-th farm, Xi = the vector of input quantities used by the i-th farm, β is a vector of unknown parameters to be estimated, $F(Xi\ \beta)$ represents an appropriate function (e.g. Cobb Douglas, translog etc.). The term Vi 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, measurement errors, while the term μi is a non negative random variable representing inefficiency in production relative to the stochastic frontier. The random error Vi is assumed to be independently and identically distributed as N (O, 6^2) random variables independent of the μ_{is} which are assumed to be non-negative truncation of the N (O, 6^2) distribution (i.e. half-normal distribution) or have exponential distribution.

The stochastic frontier was independently proposed by Aigner et al (1997) and Meeusen & Van der Broeck (1977). The technical efficiency of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology (Onyenweaku & Effiong 2006).

Technical efficiency (TE) = Y/Yi*

$Yi = [(Xi\ \beta)\ \exp\ (Vi - \mu i)/(Xi, \beta)\ \exp\ (Vi)] = \exp\ (- Ui)$ ……(2)

Where: Yi = Observed output and Yi* = the frontier output. The parameters of the stochastic frontier production function are estimated using the Maximum Likelihood method.

The Empirical Model. For this study, the production technology of the arable crops farmers in Imo State Nigeria is assumed to be specified by the Cobb Douglas frontier production defined as follows:

$In\ Q = \beta O + \beta_1\ In\ X_1 + \beta_2\ In\ X_2 + \beta_3\ In\ X_3 + \beta_4\ In\ X_4 + \beta_5\ In\ X_5 +$
$V_i = \mu_1$……………..(3)

Where,

Q = arable crops output -; X_i = planting material (kg); X_2 = fertilizer use (kg); X_3 = labour input (mandays); X_4 = farm size (ha); X_5 = depreciation (#); Vi = random error and μ_I = technical efficiency. In addition, μ_I is assumed in this study to follow a half normal distribution as is done in most applied frontier production literature. The value of the technical efficiency lies between zero and one. The most efficient farmer will have value of one, while a farmer having a value lying between zero and one is described as inefficient (Okoye 2006).

Determinants of Technical Efficiency. In order to determine factors contributing to the observed technical efficiency, the following model was formulated and estimated jointly with the stochastic frontier model in a single stage Maximum Likelihood Estimation procedure using the computer soft ware Frontier Version 4.1 (Coelli 1996).

$TE = a_0 + a_1 Z_1 + a_2 Z_2 + a_3 Z_3 + a_4 Z_4 + a_5 Z_5 + a_6 Z_6 + a_7 Z_7$........(4)

Where,

TE = Technical Efficiency of the i-th arable crops farmers

Z_1 = age of farmer (years);

Z_2 = educational level (years);

Z_3 = household size;

Z_4 = farmer experience (years);

Z_5 = membership of cooperative society (Dummy);

Z_6 = credit access (#);

Z_7 = frequency of contact with extension agents, while, a_1……a_{ij} are parameters to be estimated.

Results and Discussion. The mean statistics of arable crops farmers in Imo state, Nigeria, are displayed in Table 1. On the average, a typical arable crops farmer in Imo state is 45.05 years old, with approximately 5 years of education, 11 years of farming experience and farm size of 0.84 ha. The mean household size was 6 persons with an average annual farm income of #34,333.84 and output of 5,550.17 kg per annum.

Estimated Production Function. The results of the Maximum Likelihood Estimates (MLE) of the stochastic frontier production parameters of arable crops farmers are presented in Table 2. Planting materials and anorganic fertilizer use coefficients were positive and negative respectively. These variables out of the five were significant at 1.0% probability level and thus had influence on the output of the arable crops farmers.

The estimated coefficient of farm size was negative. The coefficient (-0.0104) implies that a one percent increase in farm size would lead to 0.0104 percent decrease in the arable crops output. This result is in consonance with Effiong (2005). Estimated coefficient of labour is positive but not statistically significant at given levels of probability while the estimated coefficient for depreciation on capital tools was 0.0077 and is positively signed in accordance with a priori expectation. The sign of the coefficient is consistent with the finding of Ajibefun & Daramola (2004) that efficient firms with positive and low coefficient value for depreciation operate on the production frontier. But the result is inconsistent with Okoye (2006) who reported that decreased expenditure in farm tools would result in the increase in technical efficiency. This is based on the fact that reduced expenditure on farm tools is an evidence of reduced maintenance cost and the machines concerned running steadily at full capacity. The model had a variance ratio of 0.9957 and log likelihood function of -45.5747. Therefore, on the basis of econometric and statistical reasons such as number and level of significant production variables, lower magnitude of log likelihood function and variance ratio, the function has effect on the technical efficiency of the farmers (Ayibefun & Daramola 2004).

Determinants of Technical Efficiency of Arable Crops Farmers in Imo State Nigeria. The result of analysis on socio-economic determinants of technical efficiency are presented in Table 2. This revealed that age of farmers, farming experience and credit access; had negative coefficients whereas educational level, household size, membership of cooperative society and frequency of extension contact had positive coefficients.

Table 1

Distribution of respondents according to socio-economic characteristics in Imo state, Nigeria

Categories of ages (years)	Frequency	Percentage
30 – 39	11	9.7
40 – 49	40	33.33
50 – 59	48	40.00
60 and above	21	17.50
Total	120	100.00
Mean	45.05 years	
Categories of education level (i.e. no. of years spent in school)	Frequency	Percentage
No formal education	1	0.83
Primary school education	57	47.50
Secondary school education	26	21.67
Tertiary education	36	30.00
Total	120	100.00
Mean number of years spent in school = 05.05		
Farm experiences (Years)	Frequency	Percentage
1 – 10	55	45.83
11 – 20	41	34.17
21 – 30	24	20.00
Total	120	100.00
Mean farming experience	= 11.0 years	
Farm size (ha)	Frequency	Percentage
0.1 – 1.0	90	75.00
1.1 – 1.5	10	8.33
1.6 – 2.0.	8	6.67
2.1 – 2.5	5	4.17
2.6 – 3.0	1	0.83
3.1 and above	6	5.00
Total	120	100.00
X or mean = 0.84 ha		
Household size	Frequency	Percentage
1 – 5	54	45.0
11 – 15	63	52
Total	120	100.00
X or mean = 06.00		
Farm income (#)	Frequency	Percentage
1.00 – 40,000.00	26	21.67
2,501.00 – 4,000.00	4	3.33
4,00 - 5,500.00	30	25.00
7,000 – 8,500.00	60	50.00
Total	120	100.00
Mean X = # 550.17		

Source: Field survey data, 2007

Age of the farmers had negative coefficient (-0.4363). This is in consonance with the findings of Ajibefun & Daramola (2004), Onyenweaku & Nwaru (2005), and Onu et al (2000) but contrary to Kalirajan & Flinn (1981), Kalirajan and Shand (1985), Belbase & Grabowski (1983), Bravo-Ureta & Pinheiro (1997), whose results showed age to be positively and significantly related to technical efficiency.

Educational level made a positive contribution to technical efficiency but is not statistically significant at given levels. This result is consistent with Onyenweaku & Nwaru (2005), Onyenweaku et al (2004), Onu et al (2000), Nwachukwu & Onyenweaku (2007), Amaza & Olayemi (2000), Belbase & Grabowski (1983), but is contrary to those of

Kalirajan (1984), Bravo-Ureta & Pinheiro (1993 and 1997), Kalirajan & Shand (1985) and Bravo-Ureta et al (1994), whose results showed no significant relationship of educational level with technical efficiency.

Table 2

Maximum Likelihood Estimation of the Cobb Douglas Stochastic Production Function for arable crops farmers in Imo state, Nigeria

Production factor	Parameter	Coefficient	Standard error	
Constant term	β_0	13.0693	0.2639	49.5215***
Planting material	β_1	0.2878	0.0225	12.7491***
Fertilizer use	β_2	-0.0087	0.0022	-2.9226
Labour input	β_3	0.0061	0.0061	0.9938
Farm size	β_4	-0.0104	0.0200	-0.5218
Depreciation on farm tools	β_5	0.0077	0.0389	0.1991
Efficiency factor				
Constant	a_0	-7.7446	3.3939	-2.2819**
Age	a_1	-0.4363	0.5246	-0.8317
Educational level	a_2	2.70622	0.7431	2.7749**
Farming experience	a_3	-5.9505	2.1140	-2.8148**
Membership of Cooperatives	a_4	2.7288	1.4504	1.8814*
Credit access	a_5	-0.8646	0.5922	-1.4428
Frequency of extension Contact	a_6	2.7261	1.1735	2.32229**
Household size	a_7	-0.9585	0.3653	-2.6267**
Diagnostics statistics				
Total variance	σ^2	2.111	0.6636	3.1802***
Variance ratio	χ	0.9957	0.0028	346.49997***
Likelihood ratio test	120.253			
Log likelihood function	-45.5747			

Source: Computed from survey data, 2007

Note *** indicate variable significant at 1.0% level

** indicate variable significant at 5.0% level

* indicate variable significant at 10.0% level

Household size is positively and significantly ($P < 0.05$) related to technical efficiency. This result disagrees with those of Onyenweaku & Nwaru (2005) and Bravo-Ureta & Pinheiro (1997) which showed household size and technical efficiency to be negatively and significantly related.

Farming experience is negatively and significantly related to technical efficiency. This result is inconsistent with those of Onyenweaku and Nwaru (2005), Onyenweaku et al (2004) and Kalirajan (1981). However, this result is in consonance with that of Onu et al (2000), whose results showed a negative relationship between farming experience and technical efficiency.

Membership of farmers' association/cooperative societies is positively and significantly ($P<0.05$) related to technical efficiency. Members of farmers' association have access to agricultural information, credit and other production inputs as well as enhanced ability to adopt innovations. This result is consistent with that of Effiong (2005).

Credit access is negatively and not significant related to technical efficiency. This is contrary to a priori expectation. This result is a confirmation of the fact that the rural areas are still under-banked and the few available ones are reluctant to lend to resource-poor farmers.

Frequency of extension contact is positively and significantly related to technical efficiency in accordance with the a priori expectations that extension contact leads to more efficient transmission of information to farmers as well as enhancing the adoption of innovation. This result agrees with those of Effiong (2005), Onyenweaku et al (2004), Amaza & Olayemi (2000) and Kalirajan (1981). The variance of the farm effects is found to be a highly significant proportion of the total variability of the value of arable crops production. Gamma (χ) is estimated at 0.9957 which implies that 99.57% of the total variation in arable crops production in Imo state is due mainly to technical inefficiency.

Distribution of Technical Efficiency Estimates of Arable Crops Farmers in Imo State, Nigeria. The frequency distribution of technical efficiency of arable crops farmers is presented in Table 3. Individual technical efficiency indices ranged between 15% and 98% with the mean of 69%. Its implication is that an average arable crop farmer is able to obtain 69% of potential output from a given production input mix. However, there is a scope for increasing arable crops production by 41%, by adopting the techniques and technologies employed by the best practice farmers.

An average arable crops farmer requires 30.61 i.e. (1 – 0.68/98) / 100 percent cost savings to attain the status of the most efficient arable crops farmer among the sampled best 10 category farmers, while the least performing farmer would need 65.31% i.e. (1 – 0.34/0.998) / 100 cost savings to become the most efficient arable crops farmer among the worst 10 sample farmers.

Table 3

Frequency distribution of technical efficiency indices of arable crops farmers in Imo state, Nigeria

Technical efficiency index	Frequency	Percentage
0.00 – 0.20	2	1.67
0.21 – 0.40	6	5.00
0.41 – 0.60	20	16.67
0.61 – 0.80	36	30.00
0.81 – 1.100	56	46.66
Total	120	100.00
Maximum technical efficiency		0.98
Minimum technical efficiency		0.15
Mean technical efficiency		0.69
Mean best 10 farmers		0.95
Mean of worst 10 farmers		0.34

Source: Computed from field survey, 2007

Elasticity of Production and Returns to Scale of Arable Crops Farmers in Imo State, Nigeria. The production elasticities of arable crops farmers in Imo State are presented in Table 4. The production elasticities have a function coefficient of 0.2825. This means that the arable crops farmers are in stage III of production function phase (i.e. irrational stage of production) which is a decreasing return to scale. This was necessitated by the low and negative value of the coefficient of fertilizer and farm size. Therefore, it implies that arable crops farmers in Imo State are subsistent farmers and do not allocate and utilize their inorganic fertilizer optimally.

Table 4

Elasticity and returns to scale for arable crops production in Imo state, Nigeria

Inputs	Elasticity
Planting materials	0.2878
Inorganic fertilizers	-0.0087
Labour input	0.0061
Farm size	-0.0104
Depreciation on farm tools	0.0077
Sum of Elasticities	0.2825

Source: Computed from Table 2.

Conclusions and Recommendations. The results of the study showed that technical efficiency of arable crops farmers in Imo state, Nigeria is relatively high. Individual levels of technical efficiency ranged between 0.15 and 0.98 with a mean of 0.69 suggesting that opportunities still exist for increasing productivity and hence income of arable crops farmers in the study area. This can be achieved by increasing the efficiency of resource use at the farm level up to 31% (0.31) by adopting the techniques employed by the best practice arable crops farmer.

Based on the findings of this study, the following recommendations will suffice in improving the technical efficiency of arable crops farmers in Imo state.

1. Policy that encourages the formation of Cooperative societies and the resuscitation of moribund ones should be encouraged. This is due to the importance of cooperatives in capacity building, acquisition of credits and production inputs at low costs.
2. Since planting materials made a positive influence on technical efficiency, it is important that deliberate policies should be put in place to ensure the availability and affordability of these inputs and at the most appropriate time.
3. Evidence had shown that age made negative contribution to technical efficiency of the farmers. Policies and programmes that discourage rural – urban migration by youths should be put in place. These may include the putting in place of such facilities as all season rural roads, efficient communication system and uninterrupted and reliable electric power supply system.

References

Aigner D., Lovell C. A. K., Schmidt P., 1997 Formation and estimation of stochastic frontier production models. Journal of Econometrics **1997**:612–637.

Ajibefun I. A., Daramola A. G., 2004 Efficiency of micro-enterprises in the Nigerian Economy. AERC Resource Paper **134**. African Economic Research Consortium, Nairobi.

Amaza P. S., Olayemi J. K., 2000 The influence of education and extension contact on food crop production in Gombe state, Nigeria. Journal of Agri-business and Rural Development **1**(1):80–92.

Awoke M. U., Okorji E. C., 2003 Analysis of constraints in resource use of efficiency in multiple cropping system by smallholder farmers in Ebonyi state of Nigeria. Global Journal of Agricultural Sciences **2**(2):10-17.

Belbase K., Grabowski R., 1983 Technical efficiency in Nepalese agriculture. Journal of Development Studies **19**(4):511–524.

Bravo-Ureta B. E., Pinheiro E., 1997 Technical and Allocative Efficiency in Peasant Farming: Evidence from the Dominical Republic. The Development Economic, Tokyo, 48–67.

Bravo-Ureta B. E., Evanson R. E., 1994 Efficiency in agricultural production: the case of peasant farmers in eastern Paraguay. Agricultural Economics **10**(1):27-37.

Coelli T. J., 1996 Recent development in frontier modeling and efficiency measurement. Australian Journal of Agricultural Economics **39**(3):219–245.

Effiong E. O., 2005 Efficiency of production in selected livestock enterprise in Akwa-Ibom state, Nigeria. PhD Thesis, Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike.

Ingawa S. A., 2001 An economic analysis of yield variability in paddy production. Canadian Journal of Agricultural Economics **2**(2):167–180.

Kalirajan K., 1981 Measurement of farm specific technical efficiency. Pakistan Journal of Applied Economics **2**:167–180.

Kalirajan K., Shand R. T., 1985 Estimating location-specific and firm specific technical efficiency: An analysis of Malaysian agriculture. Journal of Economic Development **11**(2):147–160.

Johnson D. T., 1982 The Business of Farming: A guide to Farm Business Management in the Tropics. Macmillan, 200–204.

Mbanasor J. A., Obioha L. O., 2003 Resource productivity under fadama cropping system in Umuahia North local government area of Abia state, Nigeria”. Tropical and Sub-tropical Agriculture **2**:81–86.

Meeusen N., Van-der Broeck J., 1977 Efficiency estimation from Cobb Douglas production function with composite error. International Economics Review **18**(2):123-134.

National Agricultural Extension and Research Liaison Service (NAERLS) 1995 NAERLS south east zone extension briefs. Ahmadu Bellow University **1**(7).

National Planning Commission (NPC) 2005 www.npc.org Accessed on 03 06 2006.

Nwachukwu I. N., Onyenweaku C. E., 2007 Economic efficiency of Fadama Telfairia Production in Imo state, Nigeria: A translog profit function approach. Journal of Agricultural Research and Policies **2**(4):87–93.

Okoye B. C., 2006 Efficiency evaluation of smallholder cocoyam production in Anambra state. MSc Dissertation, Dept. of Agricultural Economics, Michael Okpara University of Agriculture, Umudike.

Onu J. K., Amaza P. S., Okunmadewa F. Y., 2000 Determinants of cotton production and economic efficiency. African Journal of Business and Economic Research **1**: 234–240.

Onyenweaku C. E., Igwe K. C., Mbanasor J. A., 2004 Application of the stochastic frontier production function to the measurement of technical efficiency in yam production in Nasarawa state, Nigeria. Journal of Sustainable Tropical/Agricultural Research Nigeria **13**:20–25.

Onyenweaku C. E., Nwaru J. C., 2005 Application of stochastic frontier production function to the measurement of technical efficiency in food production in Imo state, Nigeria. Nigeria Agricultural Journal **36**:1-2.

Onyenweaku C. E., Effiong E. O., 2006 Technical efficiency in pig production in Akwa-Ibom state, Nigeria. A paper presented at the 40th Annual Conference of the Agricultural Society of Nigeria (ASN) held at NRCRI Umudike.

Received: 03 June 2010. Accepted: 15 August 2010. Published online: 08 October 2010.
Authors:
Chima Innocent Ezeh, Department of Agricultural Economics and Extension Abia State University, Umuahia Campus, Umuahia, Abia State, Nigeria. E-mail: chimaezeh@yahoo.com
Clinton Eze Akpa, Department of Agricultural Economics and Extension Abia State University, Umuahia Campus, Umuahia, Abia State, Nigeria.
Patrick Onyebuchi Okudu, Farm Management Centre, Michael Okpara University of Agriculture Umudike, Umuahia Abia State, Nigeria.
How to cite this article:
Ezeh C. I., Akpa C. E., Okudu P. O., 2010 Determinants of technical efficiency in arable crops production and policy implications in Imo state, Nigeria. AAB Bioflux **2**(3):239-246.