Journal of Agriculture and Environment Vol. 7 No. 2, Dec. 2011: 117-124
ISSN 1595465X

ESTIMATION OF TECHNICAL EFFICIENCY OF FOOD CROP PRODUCERS IN IMO STATE, NIGERIA

C. E. Onyenweaku, I. N. Nwachukwu and T. C. Opara

Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike, Nigeria

ABSTRACT

The study investigated the technical efficiency of food crop producers in Imo State with specific interest in assessing their level of technical efficiency and the factors influencing them. A panel data set comprising 210 observations drawn over 2001 – 2007 period was used while the translog stochastic frontier production function was employed in the analysis. The results showed that farm size, fertilizer, labour and capital inputs determined output, while farming experience, number of crops in the mix and time variable influenced technical efficiency. In terms of magnitude of the production elasticities, output had the highest responsiveness to farm size, followed by labour and fertilizer. Technical efficiency was found to positively relate to farming experience and increased over time while increasing crop mix reduced efficiency. The development of optimum farm combinations by research was suggested by the study as remedial measure among others.

Keywords: Technical efficiency; Food crop; Stochastic frontier

INTRODUCTION

The role of agriculture in the economic development of Nigeria is highly fundamental. This is predicated on the fact agriculture provides food for the growing population, employment for over 65% of the population, and raw materials and foreign exchange earning for the development of the industry sector (Ajibefun, 2006). In the bid to sustain this noble role, various governments have tried several programmes, approaches and strategies which were heavily biased towards agriculture and rural development. Some of these efforts are still on course, many others have since gone moribund (Nwachukwu and Ezeh, 2007).

Despite all of the efforts to improve agriculture, the food balance sheet of the nation which used to be positive in the 1960s has shifted to negative. This has led to a decline in per capita consumption. The emerging ugly scenario has been traced to the fact that the nation's agriculture has always been dominated by small-holder farmers who account for the bulk of the total population and produce over 90% of Nigeria's food requirements, with the use of obsolete equipment and cum technology (Okuneye, 1989). Although, Idachaba (2000) identified inconsistent policies as the major source of poor performance of Nigerian agriculture, absence of efficiency in production is a central issue to be addressed if the ugly trend is to be reversed.

As a major constituent of agricultural output, improvements in food crop production can be achieved by the adoption of new technologies designed to enhance farm output and income. However, output growth is not only realised through technological innovation, but also through the efficiency in which such technologies are used (Kibaara, 2005).

Efficiency is concerned with relative performance of the processes used in transforming given inputs into output. Invariably, it means attainment of a production goal without waste (Ohajianya and Onyenweaku, 2001; Ajibefun and Daramola, 2004). Efficiency can be grouped into technical efficiency, price or allocative efficiency and economic efficiency. Technical efficiency is the ability of farms to employ the “best practice” in the position process so that not more than the necessary amount of a given set of inputs is used in producing the “best” level of output (Opara, 2008). The crucial role of efficiency in increasing agricultural output has been widely recognised by researchers and policy makers alike. Thiam *et al.* (2001) highlighted the importance of efficiency as a means of fostering production which has led to proliferation of studies in agriculture on technical efficiency around the globe. Improvements in technical efficiency constitute a major component of total factor productivity and are identified in the literature as particularly important in developing countries (Brümmer *et al.,* 2006).

Previous studies (Ajibefun and Daramola, 2004; Onyenweaku and Nwaru, 2005; Okoruwa and Bashaasha, 2006; Udoh and Nsikak, 2007) are in concert with the home truth that Nigeria’s food security objective can only be achieved if scarce resources are used more efficiently. Unlike the previous studies that assessed technical efficiency using cross - sectional data, this study delved into the estimation of stochastic frontiers with panel data. This is because it can avoid several limitations present in cross – sectional studies (Schmidt and Sickles, 1984; Bravo–Ureta *et al.,* 2002). A Meta analysis by Thiam *et al.,* (2001) on 32 frontier studies using farm level data from 15 different developing countries found that cross-sectional data exhibits significantly lower technical efficiency (TE) estimates than studies that use panel data.

MATERIALS AND METHODS

Study Area

The study area was Imo State, Nigeria, which lies between latitudes 5^0 10’ and 6^0 35’ North of the equator and between longitudes 6^0 35’ and 7^0 31’ East of the Greenwich meridian. It is therefore in the tropical rainforest zone and located in the Southeastern zone of Nigeria. Imo State is one of the 36 states in Nigeria with a population of about 3.934 million people, disaggregated into 2.032m males and 1.903m females in 2006 (NPC, 2007). The state is divided into 27 administrative units called Local Government Areas which are grouped into 3 agricultural zones of Owerri, Okigwe and Orlu. Agriculture is the predominant occupation of the people for almost all the farm families either as primary or secondary occupation. The ecological zone favours the growing of tree crops, roots and tubers, cereals, vegetables and nuts. These crops are grown in small holder plots usually in mixtures of at least two simultaneous crops (IADP, 1994).

Data Collection

The data used in the study were farm level data elicited from the Agricultural Development Programme’s (ADP’s) yearly survey for the periods 2001 – 2007, collected with past questionnaire. The ADP annually collects micro – economic data from the sample of agricultural holding in Imo State. The panel data used for the study were elicited from a panel of 70 food crop farmers emanating from each of the three agricultural zones, while 10 farmers were selected from each Local Government Area. By implication, 21 LGAs were involved. The structured questionnaire employed was administered by ADP extension agents in the selected LGAs. Although, the collected data were based on individual responses, State and zonal level aggregates were used to define some variables such as land, labour and capital. The sample comprised 210 observations that constituted the panel data used by the study.

Data Analysis

The performance of a firm or farm has been conventionally assessed through the concept of efficiency. The technique employed in this study to measure technical efficiency was the stochastic frontier method (Meeusen and Van Den Broeck, 1977; Aigner *et al.*, 1997). The stochastic frontier is a parametric approach, and this technique assumes that for a given combination of inputs, the maximum attainable production by a firm is delimited by a parametric function of known inputs involving unknown parameters and a measurement error. A stochastic frontier production function formulated within a panel data context can be expressed as follows:

$$Y_{it} = f(X_{it}, \beta, t)\, e^{Vit - Uit} \quad \ldots\ldots(1)$$

Where Y_{it} is the output of the ith firm in the period t,
$f(X_{it}, \beta, t)$ represents the production technology
X_{it} is a (1 x k) vector of inputs and other factors influencing production associated with the ith firm in the period t.
β is the (k x 1) vector of unknown parameter to be estimated.
V_{it} is a vector of random errors that are assumed to be iid $N(0, \delta_V^2)$ and U_{it} is a vector of independently distributed and non negative random disturbances that are associated with output oriented technical inefficiencies.
Following Battese and Coelli (1995), exogenous influences are incorporated in the model to explain changes in producer performance. In this regard, it is assumed that technical inefficiency effects, the U_{it}'s have mean Ui and δ_u^2. Specifically, the technical inefficiency term responds to the following pattern of behaviour.

$$U_{it} = Ui \exp[-\eta (t - T)] \quad \ldots\ldots(2)$$

Where the distribution of Ui is taken to be non-negative truncation of normal distribution N (μ, σ_u^2) and η is a parameter that represents the rate of change in technical inefficiency over time, the maximum likelihood estimate for the parameter of the stochastic frontier model were obtained using the program FRONTIER 4.1, in which the variance parameters are expressed in terms of $\gamma = \sigma_u^2 / \sigma_s^2$ and $\sigma_s^2 = \sigma_u^2 + \sigma_v^2$ (Coelli, 1994).

Model Specification

In line with previous literature (Fan, 1991; Mazvimavi, 2002; Nwachukwu and Onyenweaku, 2007), the following empirical model was employed in the estimation of technical efficiency and specified in translog form as:

$\text{In } Y_{it} = \beta_0 + \beta_1 \text{ In } X_1 + \beta_2 \text{ In } X_2 + \beta_3 \text{ In } X_3 + \beta_4 \text{ In } X_4 + \beta_5 \text{ In } t + 0.5\, \beta_6 \text{ In } (X_1)^2 + 0.5\, \beta_7 \text{ In } (X_2)^2 + 0.5\, \beta_8 \text{ In } (X_3)^2 + 0.5\, \beta_9 \text{ In } (X_4)^2 + 0.5\, \beta_{10} \text{ In } (t)^2 + \beta_{11} (X_1) \text{ In } (X_2) + \beta_{12} \text{ In } (X_1) \text{ In } (X_3) + \beta_{13} \text{ In } (X_1) \text{ In } (X_4) + \beta_{14} \text{ In } (X_1) \text{ In } (t) + \beta_{15} \text{ In } (X_2) \text{ In } (X_3) + \beta_{16} \text{ In } (X_2) \text{ In } (X_4) + \beta_{17} \text{ In } (X_2) \text{ In } (t) + \beta_{18} \text{ In } (X_3) \text{ In } (X_4) + \beta_{19} \text{ In } (X_3) \text{ In } (t) + \beta_{20} \text{ In } (X_4) (t) + V_i - U_i$ …(3)

Where: In = Natural logarithm

The subscripts i and t represent the ith sample farmer in the period t.

Y_{it} = Total value of output in Naira of the ith farmer in the period t

X_1 = Farm size measured as total land area in hectares

X_2 = Quantity of fertilizer used in kg

X_3 = Labour in man days used in production

X_4 = Capital Inputs (values of farm implements measured in Naira)

t = The period of time in years the study was conducted (t = 1….7)

β_0 = Intercept

$\beta_1 - \beta_{20}$ = Coefficients estimated

V_{it} = Random noise error component

U_{it} = Technical efficiency error component

RESULTS AND DISCUSSION

The estimation of the technical efficiency employed translog stochastic frontier model and the results are presented in Table 1. Farm size had the highest coefficient of 0.525 followed by labour (0.017) and fertilizer (-0.185) with high significance level at 1% level of probability, while capital being the least at -0.614 is significant at 5% risk level. On the basis of input elasticities, output has the highest responsiveness to farm size, followed by labour and fertilizer.

The first–order parameters show both negative and positive coefficients. Farm size and labour had positive coefficients, and this indicates that output is increasing with increase in these inputs, while fertilizer and capital inputs with negative coefficients imply an inverse relationship. Fertilizer decreasing production could be as a result of poor soil management, lack of knowledge of the appropriate type of fertilizer to use, inorganic fertilizer having adverse effect on soil fertility such as killing the micro-organisms that helps in soil resuscitation. Capital decreasing production can also be as a result of low capital investment, which leads to the predominance of primitive techniques of agricultural production and declining soil fertility (Tanko *et al*., 2006; Onyenweaku and Nwaru, 2005). More so, Dolisca and Jolly (2008) found in their study that age, education and experience were major technical efficiency.

Almost all the second-order coefficients are significant at 1% level of probability with varied signs. By implication, any of the second-order coefficients with a negative sign indicates that there is possibility of input substitution while the reverse implies the possibility of the inputs acting as complements.

In terms of the efficiency determinants, farming experience and the time variable were found to influence efficiency positively. This is in line with a priori expectation and consistent with Bravo – Ureta and Pinheiro (1997) and Nwachukwu and Onyenweaku (2009) who also found evidence on impact of farming experience on efficiency. The coefficient of crop mix possesses a negative sign, implying that more crops in the mix reduce technical efficiency. This may be hinged on the fact that more crops could increase competition for soil fertility and as such, influence output negatively.

Table 1: Maximum likelihood estimates of the Stochastic Translog production function

Production Factor	Parameter	Coefficient	Standard Error	t-value
Constant term	β_0	11.090	0.718	15.438***
Farm size	β_1	0.525	0.209	2.504***
Fertilizer	β_2	-0.185	0.065	-2.839***
Labour	β_3	0.017	0.218	7.915***
Capital	β_5	-0.614	0.255	-2.410**
Time	β_5	0.697	0.495	1.409
Farm size^2	β_6	-0.282	0.037	-7.530***
Fertilizer^2	β_7	-0.022	0.017	-1.288
Labour ^{2}	β_8	0.035	0.006	5.710***
Capital^2	β_9	0.058	0.022	2.678***
Time^2	β_{10}	-0.999	0.262	-3.815***
Farm size x fertilizer	β_{11}	0.030	0.021	1.437
Farm size x Labour	β_{12}	0.044	0.032	1.381
Farm size x Capital	β_{13}	-0.105	0.026	-4.063***
Farm size x Time	β_{14}	0.119	0.082	1.460
Fertilizer x Labour	β_{15}	-0.077	0.024	-3.233***
Fertilizer x Capital	β_{16}	0.032	0.055	2.075**
Fertilizer x Time	β_{17}	0.236	0.307	7.682***
Labour x Capital	β_{18}	-0.069	0.179	-3.883***
Labour x Time	β_{19}	-0.511	0.122	-4.197***
Capital x Time	β_{20}	0.235	0.033	7.100***
Technical Efficiency				
Constant	α_0	1.192	0.717	1.663*
Educational Level	α_1	-0.137	0.112	-1.218
Farming Experience	α_2	0.003	0.001	3.881***
No of crop in mix	α_3	-0.010	0.179	-5.601***
Time	α_4	0.439	0.072	6.117***
Diagnostic Statistics				
Log– Likelihood function		-223.041		
Total Variance (σ^2)		2.945	0.169	17.592***
Variance Ratio (γ)		0.999	0.000	1126637.900***
LR Test		89.001		

Source: Computed from Frontier 4.1 MLE/ Survey data; Note: ***, **, * indicates statistically significant at 1.0, 5.0 and 10.0 percent probability respectively.

The variance ratio is statistically significant and close to one (0.999) which confirms the relevance of technical efficiency in explaining the output behaviour for sampled farms. The mean annual efficiency scores within the period ranged from 0.24 to 0.68 and the result presented in Table 2.

The predicted technical efficiencies took an average value of 47% throughout the period under study. Majority of the farmers have efficiency score of less than 30 (38.57%).

This indicates that inefficiency is very high in resource utilization and suggests that opportunities exist for increasing the efficiency of the farmers in the State, despite the great fluctuations in the scores that seem to characterise the efficiency trend.

Table 2: Mean technical efficiency by year and farms

Range	2001	2002	2003	2004	2005	2006	2007	Total
0 – 29	12	13	4	5	4	22	21	81
30 – 49	0	14	2	1	4	2	3	26
50 – 69	4	3	9	8	6	3	1	34
70 – 89	6	0	6	12	8	2	3	17
90 – 99	8	0	9	4	8	1	2	32
Mean	0.55	0.30	0.68	0.65	0.63	0.24	0.28	0.47

Source: Computed from Field Survey Data

CONCLUSION

The need to develop optimum farm plan by researchers based on the best crop combinations becomes imperative. This is necessary to deal with the decreasing efficiency effect as the number of crops in the mix increases as justified by the findings. Also, extension service delivery should be refocused and intensified to complement the accruing benefits derivable from the experienced farmers and those of them who are technically efficient in the state.

REFERNCES

Aigner, D, C.A.K. Lovell and P. Schmidt (1977). Formulation and Estimation of Stochastic Frontier Production Function Models. *Journal of Econometrics,* 6:21-37.

Ajibefun, I.A. (2006). Linking socio-economic and policy variables to technical efficiency of traditional agricultural production: Empirical evidence from Nigeria. *A Poster Paper Prepared for Presentation at the International Association of Agricultural Economists Conference*, Gold Coast, Australia, Aug, 12th -18th.

Ajibefun, I.A. and A.G. Daramola (2004). Determinants of technical efficiency and policy implication in traditional agricultural production: Empirical study of Nigeria food crop farmers. *Final Report Presentation at Bi-annual Research Workshop of African Economic Research Consortium*, Nairobi, Kenya.

Battese, G.E. and T. Coelli (1995). A Model of Technical Inefficiency Effects in a Stochastic Frontier Production function for Panel Data. *Journal of Empirical Economics*, 7: 185 – 208.

Bravo-Ureta, B.E. and E. Pinheiro (1997). Technical and allocative efficiency in peasant farming: Evidence from the Dominican Republic. *The Development Economics*, 48 - 67

Bravo-Ureta, B.E., T.E. Rivas and A. Thiam (2002). A Meta- Analysis of technical efficiency in farming: A Multi-country perspective. *A Paper Presented at the 13th*

International Farm Management Congress, Wageningen, The Netherlands on 7th – 12th July.

Brümmer, B., T.H. Glauben and W. Lu (2006). Policy reform and productivity change in Chinese agriculture: A Distance Function Approach. *Journal of Development Economics*, 81: 61 – 79.

Coelli, L.J (1994) *A Guide to Frontier 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation*. Department of Econometrics, University of New England, Armidale.

Dolisca, F. and C.M. Jolly (2008). Technical efficiency of traditional and non- traditional crop production: A case study from Haiti. *World Journal of Agricultural Sciences*, 4(4): 416 – 426.

Fan, S. (1991). "Effects of technological changes and institutional reform on production growth in Chinese agriculture. *American Journal of Agricultural Economics*, 73(May): 266 – 275.

Idachaba, F.S. (2000). Desirable and workable agricultural policies for Nigeria in the First Decade of the 21st Century. *Tropical Issues in Nigerian Agriculture Series,* University of Ibadan, Nigeria.

Imo State Agricultural Development Project (IADP) (1994). *Crop Area and Yield Survey* (CAYS).Summary Report Owerri, Nigeria

Kibaara, B.W. (2005). Technical efficiency in Kenya's maize production; An application of the Stochastic Frontier Approach. An M.Sc Thesis, Department of Agricultural and Resource Economics, Colorado State University, USA.

Mazvimavi, K. (2002). Socioeconomic analysis of efficiency and productivity growth in the resettlement areas of Zimbabwe. A PhD Dissertation Proposal, Department of Development Economics, University of Wisconsin Madison.

Meeusen, W. and J. Van Den Broeck (1977). Efficiency Estimation from Cobb-Douglas Production Function with Composed Error. *International Economic Review,* 18: 435- 444.

National Population Commission (NPC) (2007). Details of the Breakdown of the National and State Provincial Population Totals 2006 Census. *Federal Republic of Nigeria Official Gazette*, 94(24): 1 – 26.

Nwachukwu, I.N. and C.E. Onyenweaku (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.

Nwachukwu, I.N. and C.E. Onyenweaku (2009). Allocative efficiency among fadama fluted pumpkin farmers in Imo State, Nigeria. *International Journal of Agriculture and Rural Development*, 11(2): 129 – 136.

Nwachukwu, I.N. and C.I. Ezeh (2007). Impact of selected rural development programmes on poverty alleviation in Ikwuano LGA, Abia State, Nigeria. *African Journal of Food, Agriculture, Nutrition and Development*, 7(5): 1 – 17.

Ohajianya, D.O. and C.E. Onyenweaku (2000). Gender and relative efficiency in rice production systems in Ebonyi State, Nigeria: A Profit Function Analysis. *Journal of Agriculture and Sustainable Environment*, 3(2): 384 – 392.

Okoruwa, V.O. and B. Bashaasha (2006). Technical efficiency of upland and lowland rice production systems in Niger State, Nigeria. *Moor Journal of Agricultural Research*, 7(2): 93- 99.

Okuneye, P.A. (1989). Shift in agricultural production and effects on health by ear 2000. *Rural Development in Nigeria*, 3(2): 12 – 18.

Onyenweaku, C.E. and J.C. Nwaru (2005). Application of Stochastic Frontier Production Function to the measurement of technical efficiency in food crop production in Imo State, Nigeria. *The Nigerian Agricultural Journal*, 36: 1 – 2.

Opara, T.C. (2008). Efficiency and productivity growth in food crop production in Imo State, Nigeria. An M.Sc Thesis Submitted to the Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

Schmidt, P. and R.C. Sickles (1984). Production Frontiers and Panel Data. *Journal of Business Economics and Statistics*, 2: 367 – 374.

Tanko, L., C.E. Onyenweaku and A.C. Nwosu (2006). Optimum crop combination under limited resource condition: A microlLevel study in Yauri, Kebbi State, Nigeria. *The Nigerian Agricultural Journal,* 37: 1 – 10.

Thiam, A., B.E. Bravo-Ureta and T. Rivas (2001). Technical efficiency in developing country agriculture: A Meta-Analysis. *Agricultural Economics*, 25: 235 – 243.

Udoh, E.J. and A.E. Nsikak (2007). Cocoyam farms in Akwa – Ibom State, Nigeria: A Stochastic Production Frontier Approach. *Journal of Sustainable Development and Environment,* 2(1): 1 – 8.