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Investigation of the factors responsible for contamination of oil and specialized effectiveness of food crop farmers in the Niger Delta locale

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Abstract

A study was carried out to investigate into factors responsible for technical inefficiency of food crop farmers in the oil polluted and non-polluted areas of Niger Delta. Data were collected from 270 (140 for oil polluted and 130 in unpolluted area) farmers selected through a multistage random sampling technique. A stochastic frontier function that incorporated inefficiency effect was estimated using the Maximum Likelihood Estimation (MLE) technique. The MLE of the stochastic production function revealed mean technical, efficiency of 78% in polluted area while the corresponding values in unpolluted area were 88%. The most efficient farmer had the technical efficiency (TE) of 0.93 and least efficient farmer of 4.48. Farmers with efficiency index between 4.48 and 0.65 constituted 31% while 68.2% of the farmers had efficiency index between 0.70 and 0.95. The predicted technical efficiency varied widely across farms between 28 and 86% for farmers in polluted area while between 38 and 96% for the farmers in unpolluted area. The results show that farmers generally in the study area are not technically efficient, although the farmers in the unpolluted area are relatively more efficient than farmers in the polluted area. The implications are that the policies that would reduce oil pollution and encourage farmers to utilize their resources optimally should be put in place. Hence, in order to halt the continual degradation of the Niger Delta environment there is need for the enactment and enforcement of stringent environmental laws to protect the area.

Keywords: Nigeria, Niger Delta, stochastic function, oil pollution, technical efficiency, food crops farmers.

INTRODUCTION

Food remains a major requirement for man’s survival and the need to produce enough food to feed the teeming population continues to be a major focus in the developing countries. Efforts to produce enough food in countries like Nigeria are however being frustrated by a number of natural, human and economic factors. Food production in the Niger Delta zone which incidentally is the oil producing area of the country is hampered by a number of environmental problems and prominent among them is oil pollution occasioned by the oil exploration involving several million barrels of crude oil have been going on in that area. Hundreds of cases of oil spills reported (Eronmosele, 1998; Egwaikhide and Aregbeyan, 1999). It is also reported that an on average about 86% of the total gas production from 1970 to 1996 was flared. The effects of oil spillage and gas flaring have been a source of major concern. Indeed, gas flaring has been identified as the major cause of respiratory infection among the Niger Delta people including the farmers as well as the cause of reduced growth potentials of farm crops. Oil pollution has been identified among the factors causing land degradation which results in the reduction of the soil's ability to contribute to crop production and a change to the land that makes it less useful for human beings.

Chindah and Braide (2000) in a study on the effects of oil spill on crop production in the Niger Delta reported that oil spill caused great damage to the plant community due to high retention time of oil occasioned by limited flow. They observed that oil pollution affects the physiochemical properties of the soil such as temperature, structure, nutrient status and pH which results to wilting and die back of some plants. Benson and Odinwa (2010) found that cassava planted in oil polluted soil recorded low yield. Land degradation also reduces productivity thereby contributing to the low efficiency of the farmers. Inoni et al. (2006) observed that oil spill reduced crop yield, land productivity and greatly depressed farm income. They found out that a 10% increase in oil spill reduced crop yield by 1.3% while farm income declined by 5%. Orubu et al. (2004) discovered that oil pollution contributes to the depletion of the active labour force as well as the farm size which affect the efficiency and productivity of the farmers. Efficiency is a very important factor of productivity growth, especially in developing agricultural economies where resources are meager and opportunities for developing and adopting better technologies are dwindling (Ali and Chaudhry, 1990). In such economies inefficiency studies help to indicate the potential possibility to raise productivity by improving efficiency without necessarily developing new technologies or increasing the resource base (Bifarin et al., 2010). The concept of efficiency is concerned with the relative performance of the processes used in transforming given inputs into outputs. Economic theory identifies at least three types of efficiency. These are technical, allocative and economic efficiencies.

Allocative efficiency refers to the choice of an optimum combination of inputs consistent with the relative factor prices. Technical efficiency shows the ability of firms to employ the 'best practice' in an industry, so that no more than the necessary amount of a given sets of inputs is used in producing the best level of output. Economic efficiency is the product of technical and allocative efficiencies. Efficiency is a very important factor of productivity growth, especially in developing agricultural economies where resources are meager and opportunities for developing and adopting better technologies are dwindling (Ali and Chaudhry, 1990). It is often assumed that factors affecting farm households' technical efficiency (TE henceforth) are due to demographic and socio-economic characteristics. However, Pascual (2001) noted that input quality (and not just quantity) is important when deriving TE measures. Coelli (1995) recognized that environmental factors such as soil quality may also influence technical efficiency measures. This study is concerned with the assessment of the effect of oil pollution on farmers' efficiency. The outcome of the analysis is relevant for policy making in the Niger Delta. It will help to assess the role of environmental (soil) quality and relevant demographic and socio-economic factors affecting the agricultural performance of food crops farmers in the region.

METHODOLOGY

Data

Data used for this study were collected from 270 food crops farmers (140 from oil polluted area and 130 farmers from non- oil polluted area) in 31 villages in Rivers and Delta States of the Niger Delta Region of Nigeria through multi-stage sampling procedures. The data covered socio-demographic characteristics of the farmers, types of crop grown, labour used, membership of association, sources of fund for farming, land ownership status, incidence of oil pollution, prices of output and wages.

Theoretical framework

Several techniques have been developed for the measurement of efficiency of production. These techniques can be broadly categorized into two approaches: parametric and non parametric. Under the parametric technique we have deterministic parametric frontier (Afriat, 1972) and stochastic parametric frontier (Aigner et al., 1977). The parametric stochastic frontier production approach (Aigner et al., 1977); Meeusen and van den Broeck (1977) deals with stochastic noise and permits statistical test of hypotheses pertaining to production structure and the degree of inefficiency. As in Bravo-Ureta and Evenson (1994) and Bravo–Ureta and Rieger (1991), the parametric technique cost decomposition procedure is used to estimate technical, allocative and economic efficiencies. Following Sharma et al. (1999), the firm's technology is represented by a stochastic production frontier as follows:

$$Yi = f(Xi; \beta) + \varepsilon i \quad (1)$$

Where Yi denotes output of the ith firm, Xi is a vector of functions of actual input quantities used by the ith firm; β is in vector of parameters to be estimated and εi is the composite error term (Aigner et al., 1977; Meeusen and Van den Broeck, 1977) defined as:

$$ei = vi - ui \quad (2)$$

Where vis are assumed to be independently and identically distributed N (0.02) random errors, independent of the uis; and the uis are non-negative random variables, associated with technical inefficiency in production which are assumed to be independently and identically distributed and truncation (at zero) of the normal distribution with mean μ and variance σ_u^2 $|N(\mu u;\sigma_v^2)|$

The maximum likelihood estimation (MLE) of Equation 2 provides estimation for β and variance parameter $\sigma^2 = \sigma_u^2 + \sigma_v^2$, and $v = \sigma_u^2 / \sigma_v^2$. Subtracting vi from both sides of Equation 1 yield:

$$\Psi i = Yi - vi = f(Xi\beta) - ui \quad (3)$$

Where Ỹi is the observed output of the ith firm adjusted for the stochastic noise captured by vi.

Empirical model specification

Theoretically, a production frontier defines the maximum output attainable for a given level of inputs. Therefore, in order to estimate an efficient frontier, farm level data on input and output quantities are required. However, it is often the case that input quantity data are not available. Data are often available, however on farm output revenue and input expenditures. Therefore, a common approach is to use revenue and expenditure data as proxies for input and output quantities for example, Aly et al. (1987), Grabrowski et al. (1990) and Neff et al. (1991). In traditional agriculture, multiple outputs and inputs are common features and for the purpose of efficiency, analysis output is aggregated into one category and inputs are aggregated into seven categories namely: farm size, fertilizer, labour, capital, land that is, rental value of land, other variable inputs. The stochastic frontier production function used in this study is a linearized version of Cobb-Douglas production function. The stochastic frontier production function in Equation 4 and the inefficiency model in Equation 5 were simultaneously estimated as proposed by Battese et al. (1996).

Specification of technical efficiency model

$$\ln Y = \beta o + \beta_1 \ln X_{1}ij + \beta_2 \ln X_{2}ij + \beta_3 \ln X_{3}ij + \beta_4 \ln X_{4}ij + \beta_5 \ln X_{5}ij + \varepsilon i \quad (4)$$

Where subscripts ij refer to the ith observation on the j^{th} farmer; In = denotes logarithm to base e; Y = represents the farm output in grain equivalent (Kg); X_1 = total farm size under cultivation (in hectares); X_2 = family labour used in production (mandays); X_3 = is hired labour used in production (in man-days); X_4 = is material inputs of seeds and other planting stocks (in kgs and cuttings); X_5 = quantity of fertilizer used (in kgs); εi = error term (vi - ui).

It is assumed that the technical efficiency effects are independently distributed and varies and uij arises by truncation (at zero) of the normal distribution with mean μ and variance σ^2; where uij is defined by equation.

Inefficiency model

$$Uij = \alpha o + \alpha_1 \ln Z_{1}ij + \alpha_2 \ln Z_{2}ij + \alpha_3 \ln Z_{3}ij + \alpha_4 \ln Z_{4}ij + \alpha_1 \ln D_{1}1ij + \alpha_2 \ln D_{2}1ij + \alpha_3 \ln D_{3}1ij + \alpha_4 \ln D_{4}1ij \quad (5)$$

Where uij represents the technical inefficiency of the ith farmer; Z1 denotes age; Z2 represents sex;

Z3 represents family size; Z5 represents years of schooling; D1 denotes dummy variable for membership of association; where one denotes membership of association and zero is otherwise. D3 denotes dummy variable for ownership of farmland; where one denotes who own their farmland zero is otherwise. D4 denotes dummy variable for source of fund for farming; where one represents those who depend on personal saving for their farming activities and zero is otherwise. D5 denotes dummy variable for pollution; where one denotes farmland where there is oil pollution and zero is otherwise.

The β and α coefficient are unknown parameters to be estimated together with the variance parameters. The parameters of the stochastic production function are estimated by the method of maximum likelihood, using FRONTIER 4.1* program (Coelli, 1994). The maximum likelihood estimation (MLE) procedure is used because it is asymptotically efficient; consistent and asymptotically normally distributed.

Description of variables

Farm output

Output is the total quantity of crop mix in each farm converted to their grain equivalent in kilograms.

Farm size (XI)

This is expressed in hectares. On the expected sign of the coefficient, there seems to be no consensus of opinion (Oredipe, 1998). Hence, the sign of the coefficient of the variable cannot be predicted a-priori.

Farmily labour (X2)

Because family labour is not paid for in the study area, large family labour may not reflect considerable increasing output nor be matched with increase in resource pool. Inefficiency may set in if there is excess labour on the farm. The coefficient of this variable is therefore expected to be negative.

Hired labour (X3)

Labour intensive technologies will require additional or specialized skill, which can be secured through hired labour. Hired labour constitutes a major constraint to attainment of optimal productivity level and is expected to be positively related to technical efficiency level.

Planting stock (X4)

The quantity and quality of planting stocks use in farming have considerable influence on the ultimate yield from the farm. Thus, it is expected that good quality planting stock will positively affect farm output.

Fertilizer (X5)

It is generally believed that fertilizer application improves the fertility of the soil and secures greater yield from the farm. This however depends on several factor like the quantity applied and the timing of application. The coefficient of the variable is expected to be positive to output.

RESULTS AND DISCUSSION

The socio-economic characteristics of the respondents are presented in Tables 1 and 2. They seem to exhibit similar pattern. This is quite understandable as they are people with the same cultural, historic and geographical background. The average age of the farmers is 43.3 years. The highest percentage of farmers (71.9%) is within the age bracket of 31 and 50 years. This shows that most farmers from the study areas are still young. On the gender aspect, male farmers are more than female farmers. The percentage of female farmers is 30.7%. This indicates that women involvement in farming in the study area is low. The average family size is 5.18. This large family size implies availability of family labour to the farmers. The literacy level of most farmers is relatively moderate with about 23% having no formal education while 18.1% had primary education. Over 53% of the

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Table 1. Socio-economic characteristics of respondents in the study areas.

Demographic variables	Characteristics	Polluted		Unpolluted	
		Frequency	Percentage	Frequency	Percentage
Gender	Male	84	61.8	65	48.5
	Female	52	38.2	69	51.5
Age	21-30	19	14.0	12	9.0
	31-40	34	25.0	36	26.8
	41-50	41	30.1	45	33.6
	51-60	25	18.4	29	21.6
	61 and above	17	12.5	12	9.0
Marital status	Single	19	14	14	10.4
	Married	99	72.8	103	76.9
	Divorced	01	0.7	02	1.5
	Widow/widower	17	12.5	15	11.2
Household size	1-5	74	54.4	83	61.9
	6-10	62	45.6	51	38.1
Educational qualification	No formal education	26	19.1	31	23.1
	Primary education	18	13.2	25	18.7
	Secondary	29	21.3	30	22.4
	Tertiary	57	41.9	34	25.4
	Vocational	6	4.4	14	10.4
Years of farming	0-5	13	9.6	17	12.7
	6-10	30	22.1	23	17.2
	11-15	31	22.7	27	20.1
	16-20	15	11.0	19	14.2
	21-25	13	9.6	15	11.2
	26 and above	34	25	33	24.6
Land tenure	Family land	44	32.4	61	45.5
	Communal land	15	11.0	12	9.0
	Rented land	53	39.0	45	33.6
	Purchased land	24	17.6	16	11.9
Farming system	Mixed cropping	107	78.7	103	76.9
	Agroforestry	29	21.3	31	23.1
Farm size	0-2.0	102	75.0	103	76.9
	2.1-3.0	23	16.9	24	17.9
	3.1-4.0	2	1.5	2	1.5
	4.1 and above	9	6.6	5	3.7

Source: 2002.

farmers have post- primary education. The marital status of farmers shows that 13.7% of the farmers are singles while over 80% are married. Membership of co-operative societies is not very common among the farmers. Among the respondents only 22.6% belong to co-operative societies. This shows that majority of the farmers are not exploring the benefits accruable from co-operatives societies. The farming experience of farmers shows that most of the farmers have been in the farming business for an average of 16 years. Resulting from the vagaries of farming operation due to unfavourable environmental condition in the study area, 57% of the farmers engage in other jobs like fishing, trading etc, to supplement income from farming activities. The farmland ownership structure shows that most respondents (64.1%) farm on communal and leased lands.

Table 2. Summary statistics of socio- economic characteristics of respondents.

Variables	Oil polluted soil environment				Un- polluted soil environment			
	Sample mean	Minimum value	Maximum value	Standard deviation	Sample mean	Minimum value	Maximum value	Standard deviation
Age	42.4	20	59	10.7	42.95	20	45	11.3
Family size	5.06	1	9	2.13	5.34	1	9	1.9
Years in schooling	9.9	0	19	7.07	11.66	0	19	6.6
Years in farming	16.6	2	32	8.5	15.99	5	27	8.5
Farm size	1.5	0.2	6.07	0.87	1.59	.2	5.89	1.03
Family labour (man days)	82.8	10	215	44.5	83.82	11	200	42.3
Hired labour (man days)	2.95	0	15	2.7	3.55	0	15	3.37
Quantity of fertiliser used (kg)/ha	66.5	0	600	111.57	53.5	0	666.7	113.86
Total output (kg)/farmer	836.5				1546.7			
Average gross revenue (n)	28,834	5,000	300000	33,066	33361.51	5,000	200000	30290.0
Total cost (n)	7516	1200	28200	5064.4	8022.38	1600	24600	6511

Source: Field data (2002).

All the farmers in the area practice mixed cropping with over 50% planting between 4 to 7 different crops on the same plot. About 51.8% of the farmers attested to the pollution of their farm with petro-chemical products while 48.2% reported that there was presence of oil pollution in their farmlands. In summary, the socioeconomic characteristics of the farming households in the study areas seemed to exhibit similar pattern. This is quite understandable as they are people with the same socio-cultural background and within the same geographical setting. For example, while the average farm size in polluted area is 1.5 ha, that of the unpolluted area is 1.59 ha. Also, the average number of mandays used by households in polluted area is 82.8 and those in unpolluted area are 83.8. Meanwhile, farmers in the polluted area appeared to use more of inorganic fertilizer (66.5 kg/ha) than those in unpolluted area (53.5 kg/ha). There is however a marked difference in the average output between farmers in the unpolluted area (1546.7 kg/farmer) and the polluted area (836.5 kg/farmer). A plausible reason is most likely the effects of pollution.

Estimates of the parameters of the inefficiency factors

The estimated parameters and the related statistical tests results obtained from the analysis are presented in the Table 3. All the coefficients in the model have the expected signs and many are statistically significant at 10% or less.

Determinants of technical inefficiency

The coefficient of farm size was significant in the 5% that is, in polluted and non-polluted areas. Family labour was significant at the 10% in both polluted and non-polluted areas. Hired labour was not significant as it was observed that majority of the farmers did not engaged hired labourprobably due to high cost. The coefficient of planting materials, which include seeds, was not significant. Fertilizer was significant at 10% level in both cases. The coefficients of family size years schooling, crop diversification and membership of Farmers Association had negative sign in both polluted and unpolluted areas while family size was significant in both situations; years of schooling was significant in unpolluted area. The significance of these coefficients combined with their negative signs implies that these variables help to reduce inefficiency in the farmers. In other words, crop diversification for example, reduces farmers technical inefficiency (Amaza, 2000) while

Table 3. Maximum likelihood estimates of the parameters of the stochastic frontier production function (technical efficiency model).

Variables	Polluted area		Unpolluted area	
	Coefficient	**Standard error**	**Coefficient**	**Standard error**
Production factor constant	2.8845	0.3239***	2.9395	0.03656***
Farm size (X1)	0.2596	0.0095**	0.2853	0.1257**
Family labour (X2)	0.6544	0.0719***	0.7312	0.0779***
Hired labour (X3)	-0.0624	0.0712	-0.0586	0.0759
Fertilizer (X4)	0.0442	0.0260*	0.0417	0.0263
Planting stocks (X5)	0.0336	0.1384	0.0191	0.1532
Inefficiency factor				
Constant	0.5793	0.9477	0.8368	0.0102***
Sex (Z1)	0.8838	0.6188	1.040	0.5926*
Year of farming (Z2)	-1.500	0.4238**	-1.9574	0.8874**
Family size (Z3)	-0.7574	0.5244	-0.8728	0.7165
Year in schooling (Z4)	-0.2787	0.1367**	-0.3248	0.1492
Crop diversification (Z5)	-7.0753	0.3028**	-1.312	0.4525**
Membership of association (D1)	-0.3749	0.1705**	-0.3913	0.2064*
ownership of land (D2)	0.7839	0.3932**	0.9054	0.5519
Source of fund (D3)	0.8086	0.3559**	0.9591	0.5329*
Pollution (D4)	0.2205	0.0166**	-	-
Diagnostics statistics				
Livelihood ratio	41.73		39.92	
Sigma square (σ^2)	0.1209	0.0331***	0.1593	0.0552**
Gamma (γ)	0.6807	0.0856***	0.7707	0.0784***

Source: Computed from field data, ***1% level of significance, **5% level of significance, *10% level of significance.

membership of Farmers Association affords the farmers the opportunity to share information on new farming practices by interacting with other farmers thereby reducing their inefficiency. These findings are consistent with earlier findings by Bravo-Ureta and Evenson (1994), Ajibefun and Aderinola (2004) and Nwaru (2004). The coefficient of pollution (0.2205) had positive sign to technical inefficiency. In other words, it contributes to technical inefficiency among the farmers. This finding is however contrary to that of Hadri and Whittaker (1999) who assessed the effect of soil pollution on crop technical efficiency and found a positive relationship between technical efficiency and use of contaminants in a sample of farms in South West England.

Pascual (2001) also found out that soil quality affects technical efficiency in Mexico and attributed this to household response to ecological constraints who try to substitute lower soil quality for higher managerial ability. In this study, the effects of pollution on food production can be seen in the output of farmers. Whereas, the total output per farmer in the polluted area was 836.7 kg; that of the unpolluted area was 1546.7 kg per hectare for cassava. The coefficient of source of fund had positive and significant at the 5% level. The significance of this coefficient indicates that where the farmers source for fund for farming affects their efficiency. A situation where farmers depend largely on their personal saving as is the case with majority of the farmers in the area will adversely affect their efficiency.

The diagnostic statistics of the technical efficiency factors

The estimated sigma-squared (σ^2) in Table 3 for both polluted and unpolluted areas are large (0.12 and 0.15) and significantly different from zero at the 5% level. This indicates a good fit and the correctness of the specified distributional assumption of the composite error-term. In addition, the magnitude of the variance ratio defined as $\gamma = \delta u^2/(\delta u^2 + \delta v^2)$ is estimated to be as high as 68% for polluted area and 77% suggesting that systematic influences that are unexplained by the production functions are the dominant sources of errors. It also confirms the presence of one-sided error component in the model, thus rendering the use of the ordinary least squares (OLS) estimating technique inadequate in representing the data. This means that over 65% of the

Table 4. Frequency of technical efficiency in the study area.

Efficiency (%)	Technical efficiency	
	Oil polluted	Unpolluted
10-50	6	3
50-55	0	2
55-60	3	1
60-65	3	0
65-70	9	3
70-75	20	4
75-80	24	10
80-85	65	16
85-90	10	24
90-95	0	67
95-100	0	0
	140	**130**
Minimum value	28	38
Maximum value	86	96
Mean value	77.6	88

variations in output among the farms in both polluted and unpolluted areas are due to difference in technical efficiency. In other word the inefficiency effects indicated by the variance parameter are significant in determining the level and variability of output of farmers in the study area. The livelihood functions are estimated to be 41.73 and 39.92 for polluted and unpolluted areas, respectively. These values represent the values that maximize the joint densities in the estimated model.

Distribution of technical efficiency

The technical indices of farmers are derived from the analysis of the stochastic production frontier function in Equation 4. The technical efficiency of the sampled farmers in both polluted and unpolluted areas is less than 100 indicating that all the farmers are producing below the maximum efficiency frontier as shown in Table 4. A range of technical efficiency is observed across the sampled farmers. The best farmer in the polluted areas has a technical efficiency of 86% while the least efficient farmer has 28% whereas in the unpolluted area the most efficient has a technical efficiency of 96% and least efficient farmers has 38%. The mean technical efficiency is 77.6% for the polluted area and 88.5% for the unpolluted area. This implies that on the average the respondents were able to obtain a little over 77.6% of optimal output in the polluted area and 88.5% in the unpolluted area. Testing for significance difference reveals that the computed z- statistics is statistically significant at 1% level showing that farmers in the unpolluted area are more efficient than those in the polluted area. The hypothesis that states that there is no difference in the technical efficiency of farmers in the two areas is thereby rejected. A plausible reason for this could be the effects of oil pollution given the fact that farmers in the area operate under the same technical condition.

The distribution of technical efficiency group reveals that the highest proportion (46.4%) of the farmers in the polluted area falls between the efficiency ranges of 0.80 to 0.85 while the highest proportion (23.7%) falls between the efficiency ranges of 0.85 to 0.90 in the unpolluted area. The distribution of the technical efficiency shows efficiency at 77.6 and 88.5% for farmers in polluted and unpolluted area respectively implying that in the short-run there is scope for increasing technical efficiency in food crop production in the study area especially those in the polluted area. That is, if the problem of oil pollution is taken care of and if farmers would adopt the technology and production techniques currently used by the most efficient farmers.

Conclusion

Expanding population and economic development have generated a growing demand for various land based products leading to unnecessary pressure on soil, water resources and plants with the attendant consequences of deteriorating land resources, declining productivity and reduced income. This study has been able to quantitatively establish the fact that oil pollution in the area is having negative impacts on the food crop farmers resulting in reduced income from farm activities. In considering the results obtained from the analysis of technical efficiency effects of stochastic frontier production function, it is important to note that the production frontier involved are determined by models and within the sample values. This implies that there may be techniques of production practiced by some of the farmers in the sample, which yielded much higher output for the same level of inputs. Governments at both the Federal and State levels should ensure increase fund allocation to agriculture in the region as well as the provision of and distribution of farm inputs like fertilizers, chemical, capital, etc. so as to boost food production in that area. Government should also ensure that stringent environmental laws to protect the area are enacted and enforced.

REFERENCES

Aigner D, Lovell CAK, Schmidl P (1977). Formulation and Estimation of Stochastic Frontier Production Function Model. J. Econ. 6:21-27.

Ajibefun IA, Aderinola EA (2004). Determinants of Technical Efficiency and Policy implication of Traditional Agricultural Production: Empirical Study of Nigerian Food Crops Farmers. Final Report Presentation at Biannual Research Workshop on African Economic Research Consortium, Nairobi, Kenya. pp. 2-20.

Ali M, Chaudhry MA (1990). Interregional Farm Efficiency in Pakistan's Punjabi. A frontier production function study. J. Agric. Econ. 41:62-73.

Aly HY, Belbase K, Grabrowski R, Kraft S (1987). The Technical Efficiency of Illinois Grain Farms: An Application of a Ray-Homothetic Production Function. Southern J. Agric. Econ. 19:69-78.

Amaza PS (2000). Resource Use Efficiency in Food Crops Production in Gombe State Of Nigeria. Unpublished Ph.D Thesis. Department of Agricultural Economics. University of Ibadan.

Battese GE, Malik SJ, Gill MA (1996). An Investigation of Technical Inefficiencies of Production of Wheat Farmers in Four Districts of Pakistan. J. Agric. Econ. 47(1)37-49.

Benson DN, Odinwa AB (2010). Impact of crude oil exploration and production on the yield and Income of Cassava(Manihot spp) in Khana Local Government Area, Rivers State, Nigeria. Africa J. Agric. Res. Dev. 3(3):59-64.

Bifarin JO, Alimi T, Baruwa OI, Ajewole OC (2010). Determinant of technical, allocative and Economic efficiencies in the plantain (Musa spp.) production industry, Ondo State, Nigeria. In (Eds) Dubois T , Staver C, Coyne D, Hauser S *Proc. IC on Banana & Plantain in Africa* Kenya.

Bravo-Ureta BE, Evenson RE (1994) Efficiency in agricultural production: the case of peasant farmers in Eastern Paraguay. Agric. Econ. 10:27-37.

Bravo-Ureta BE, Rieger C (1991) Diary farm efficiency measurement using Stochastic frontier and neo-classical duality. Am. J. Agric. Econ. 73:421-428.

Chindah AC, Braide SA (2000) The impact of oil spils on the Ecology and Economy of the Niger Delta. In Proceedings of the workshop on Sustainable Remediation Development Technology held at the Institute of Pollution Studies, Rivers State University of Science and Technology, Port Harcourt.

Coelli TJ (1994) A Guide to Frontier 4-1: A Computer Programme for Stochastic Frontier Production Function and Cost Function Estimation" Unpublished Paper Department of Econometrics. University of New England Armdale P. 32.

Coelli TJ (1995) Recent developments in frontier modeling and efficiency measurement. Aus. J. Agric. Econ. 39(3):219-245

Egwaikhide FO, Aregbeyan O (1999). Oil Production and Externalities in the Niger Delta. Is Fiscal Solution feasible?. Proceeding of the 1999 Annual Conference of the Nigerian Econmic Society. 101-115.

Grabrowski R, Kraft S, Pasurka C, Aly HY (1990). A Ray- Homothetic Frontier and Efficiency: Grain Farms in Southern Illinois. Eur. Rev. Agric. Econ. 17:435-448.

Hadri K, Whittaker J (1999). Efficiency, environmental contaminants and farm size: Testing for links using stochastics production frontiers. J. App. Econ. 2(2):337-356.

Inoni OE, Omotor DG, Adun FN (2006). Effect of Oil Spillage on Crop Yield and Farm Income in Delta State, Nigeria. J. Central Eur. Agric. 7(1):41-48.

Meeusen W, van den Broeck J (1977). Efficiency Estimation from Cobb - Douglas Production Function with composed Error. Int. Econ. Rev. 18:435-444.

Neff DC, Grarcia P, Hornbaker RH (1991). Efficiency Measures Using the Ray- Homothetic function: A Multiperiod Analysis. Southern J. Agric. Econ. 23:113-121.

Nwaru JC (2004). Rural Credit Markets and Arable Crop Production In Imo State of Nigeria. Ph.D Dissertation. Michael Okpara University of Agriculture, Umudike, Nigeria.

Oredipe AA (1998). "An Analysis of Efficiency and Production Crops Among Farmers Adopting Improved Maize Technology in Ogun State, Nigeria. Unpublished Ph.D Thesis.University of Ibadan.

Orubu CO, Odusola A, Ehugreime W (2004). The Nigeria Oil Industry: Environment Strategies and Need for Community Involvement. J. Hum. Ecol. 3:204-224.

Pascual U (2001). Soil Degradation and Technical Efficiency in Shifting cultivation: The Case of Yucatan(Mexico). Discussion Paper Series No 16 University of Manchester. October 29th, P. 25.

Sharma KR, Leung P, Zaleski HM (1999). Technical, allocative, and economic efficiencies in swine production in Hawaii: A comparison of parametric and non-parametric approaches. Agric. Econ. Elservier 20:23-35.