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SHORT NOTE [NOTA CORTA]

TECHNICAL EFFICIENCY OF FARMERS UNDER DIFFERENT MULTI-CROPPING SYSTEMS IN NIGERIA

[EFICIENCIA TÉCNICA DE AGRICULTORES EN NIGERIA CON DIVERSOS SISTEMAS DE POLI-CULTIVO]

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SUMMARY

The study examined technical efficiencies of farmers under different multiple-cropping systems in Nigeria. A total of 200 farmers were sampled. The farmers were group on the basis of numbers of crops on their farms. The results showed that farmers with 5 crops relatively perform better than those with less number of crops on their farms in terms of the resource-use efficiency indicators examined such as the estimated input elasticities as well as the returns to scale and average technical efficiency (TE) from the analysis. Further results show that; marginal analysis of the farmer's years of education recorded highest simulated technical efficiency across the farms followed by extension, and credit. The study suggests implementation of policies that will strengthen present institutional framework on human capital development via education, credit delivery, and extension systems in the country.

Key words: Subsistence farmers, technical efficiency, socio- variables, marginal effects.

RESUMEN

El estudio revisó las eficiencias técnicas de agricultores de Nigeria con diversos sistemas de policultivo. Se encuestaron 200 agricultores y se agruparon con base al número de cultivos en sus fincas. Los resultados mostraron que aquellos productores con 5 cultivos tienen un mejor desempeño en términos de los indicadores de eficiencia de uso de recurso empleados. Se encontró que los años de educación seguida de la extensión y el crédito tienen el mayor impacto en la eficiencia técnica. El trabajo sugiere la implementación de políticas que fortalezcan la estructura institucional presente en relación a desarrollo de recursos humanos a través de la educación, el acceso a crédito y los sistemas nacionales de extensión.

Palabras clave: Campesinos de subsistencias, eficiencia técnica, variables socio económicas, efectos marginales.

INTRODUCTION

Vertical integration is defined as the degree at which firms participate in more than one successive stages of production of goods and services (Nor Ghani Md *et al.* 2006). Subsistence farmers move along vertical chain of production process (i.e., increasing or decreasing the number of crops on their farm) because of their decision to meet the family food security, assessing the security of their farm enterprises and risk minimization through crop diversification (Abdulkadri and Ajibefun 1998). As such, multiple cropping strategies are often employed by these farmers to address the uncertainty that characterized their production process. Against this background, the study examines technical efficiency and marginal effects of farmer´s socio-economic variables on their estimated technical efficiency under different multiple-cropping systems in Nigeria.

MATERIAL AND METHODS

The study was carried out in Ondo State Nigeria in 2005. Ondo State climatically falls within the rainforest belt of the country with vast agricultural potentials. The people are predominantly peasant farmers, cultivating mainly food crops. The data were collected with the aid of a well-structured questionnaire distributed to 200 randomly selected farmers across the state and administered by trained enumerators.

The data were analyzed using a stochastic frontier production model. Following the specification of Battese and Coelli, (1988), the model used for the analysis can be defined as:

$Y_i = f(X_{i;}\ \beta_i) \exp(V_i - U_i)$.

Where:
Y_i is the output;
f is the functional form (we assume Cobb-Douglas for this study);
X_i is input used;
β_i is unknown parameters to be estimated;
v_i are random errors as $v_i \sim$ iid $N(0,\sigma^2)$, while
u_i are non-negative random error associated with technical inefficiency as $u_i \sim$ iid $N(\mu_i,\sigma^2)$.

Technical efficiency (TE) is defined as the maximum output obtained from a given level of inputs. That is:

$TE_i = [Y / f(X_{i;}\ \beta_i) \exp(V_i)] = \exp(-U_i)$.

Distribution of mean inefficiency (μ_i,) is related to the farmers' demographic variables by allowing heterogeneity in the mean inefficiency term to investigate sources of differences in technical efficiencies of the farmers. A vector of farmer's demographic variables (Z_{ij}) that determines his/her technical inefficiency (μ_i) is specified as:

$\mu_i = \delta_0 + \delta_j Z_{ij}$.

The sampled farmers (200) were group on the basis of numbers of crops on their farms. As such for each set of the groups, we assumed a Cobb-Douglas production function. The functional form is, therefore, specify as follows:

$$\ell n y_i = \beta_0 + \sum_{j=1}^{5} \beta_j \ell n x_{ji} + v_i - u_i$$

Where:
ln represents the natural logarithm; the subscript i-th sample farmer from each group;
y_i represents the total revenue of all food crops produced in naira (₦) equivalent for farmer *i* ;
x_j represents: farm size, cost of planting materials, labour, pesticides and fertilizers;
β_j represents the input coefficients while $\mathbf{v_i}$, and $\mathbf{u_i}$ as earlier defined.

The inefficiency model earlier defined is explicitly specified for this study as:

$$\mu_i = \varphi_0 + \sum_{k}^{4} \delta_k Z_{ki} + e_i$$

Where:
z_{1i} is farmer's age;
z_{2i} is years of schooling;
z_{3i} is amount of credit access, and
z_{4i} is the number of contacts with extension agents.
A negative δ_k implies decrease in inefficiency while a positive implies increase in inefficiency.

In a related development, quantification of the marginal effects of the estimated technical efficiency as used in Wilson *et al.* (2001) and adopted in this study is describe as follows. Marginal effects measure the change in the individual observed technical efficiency (TE) estimates to the change in the z_k variables. This, however, is possible by partial differentiation of the technical efficiency predictor w. r. t. z_k – variables in the inefficiency function. A positive sign indicate an increase in TE and *vice versa*. Nevertheless, quantification of marginal effects takes the form:

$$\frac{\partial TE_i}{\partial Z_k} = \left(\frac{\exp[\{(\gamma-1)Z_k\delta + \gamma e_i\} + 0.5\,\gamma(1-\gamma)\sigma_s^2]\,[(1-\gamma)\{\gamma\,\sigma_s^2 - Z_k\delta\} + \gamma e_i]\,[(1-\gamma)\delta_k]}{[(1-\gamma)\,Z_k\delta - \gamma e_i]} \right)$$

Where:
γ, σ_s^2, and δ_k represent gamma, sigma-square, coefficient of the z_k variables in equation.
The inefficiency variables (z_k) are evaluated at their mean values and

the residuals ***e***i are calculated at the mean value from the estimated equation.

RESULTS AND DISCUSSIONS

From the survey, we observed 2 to 5 different multi-cropping systems among the respondents as none practiced mono-cropping system. This observation, however, is in line with the suggestion in the work of Abdulkadri and Ajibefun (1998) that food crop farmers in Nigeria grow more than one type of crop annually on their farm lands. Based on this, about 13% of the respondents were found to have planted -cassava and maize (called Group A for easy identification). 15% planted -cassava, cocoyam and maize (Group B); about 30% planted- cassava, cocoyam, maize and yam (Group C) while 42% planted- cassava, cocoyam, maize, potato and yam (Group D). Hence, presented in the table 1 is the summary statistics of variables employed in the regression.

However, the results of the estimated elasticities from the specified regressions for each of the groups shows that Group D farmers with 5 crops on their farms have the highest elasticities of production with respect to land, labour and fertilizer. The returns to scale computed from the summation of the input elasticities shows that an average farm in Group A (0.893), Group B (0.861) and Group C (0.923) exhibits decreasing return to scale while such in Group D (1.112) exhibit increasing return to scale.

Presented in Figure 1 are the distributions of the TE across the groups. Group D recorded the highest TE of 0.868, followed by Group C with 0.813, Group B with 0.682 and Group A with 0.523. This suggests that, 13.2%, 18.7%, 31.8 and 47.7% of yields of the farms in Groups D, C, B, and A respectively compare to the yields of the most efficient farms across their respective groups are forgone due to inefficiency.

Table 1: Summary statistics of the variables in the regression (means).

Variables*	Group A (n=26)	Group B (n=30)	Group C (n=60)	Group D (n=84)
Total Revenue as output / ₦	21,158.55	33,026.86	48,172.97	61,345.12
Farm size /ha	0.79	0.63	0.81	1.16
Cost of planting materials / ₦	4,072.01	5,188.12	9,216.54	12,823.05
Labour /man-days	82.18	113.74	148.63	161.57
Pesticides / litre	2.06	3.68	5.27	6.04
Fertilizers / kg	36.01	41.79	47.24	59.81
Age / years	51.43	44.21	48.56	39.04
Education / years	9.35	11.92	10.81	13.90
Credit / ₦	21,263.13	16,897.26	16,151.01	18,201.60
Extension / counts	6.14	8.53	6.79	7.26

*1$= ₦126 (exchange rate as the time of the study)

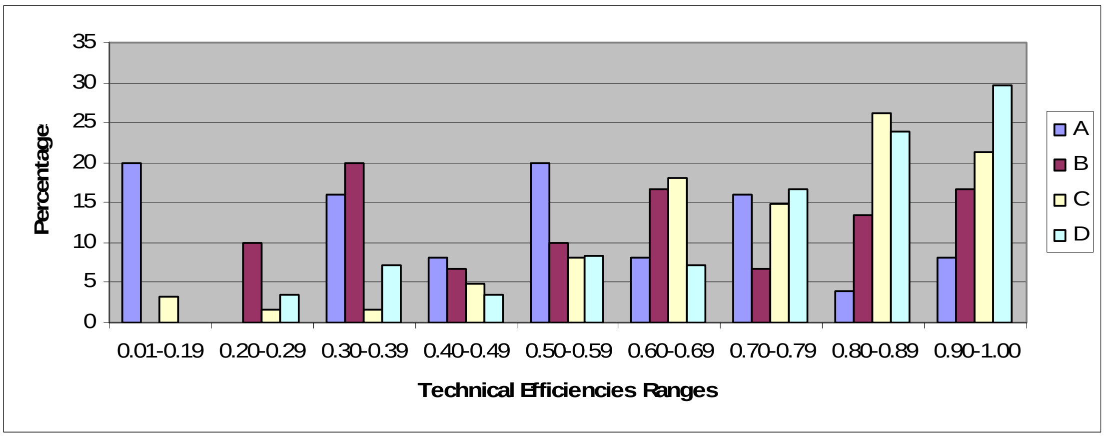

Figure 1: Distribution of the predicted Technical efficiencies across the groups

The examination of the effect of farmer`s demographic variables on the technical inefficiency shows that TE of the farmers increased significantly with years of education, extension, and credit for Group A while it increased with age, education, extension, and credit for the Groups B, C and D (for brevity the table is not presented).

However, result of the marginal analysis of change in the estimated technical efficiency w. r. t change in the selected demographic variables is presented in the table 2. The results show that, marginal gain in technical efficiency for an increase in the variables for Group A farmers is -4% for age; 0.9% for education; 11.7% for extension; and 17.3% for credit. For Group B farmers: 31% for age, 1.6% for education, 45.8% for extension, and 1.3% for credit. For Group C farmers: 1.2% for age, 1.1% for education, 32.3% for extension, and 3.9% for credit. For Group D farmers: 21% for age, 48.2% for education, 20.1% for extension, and 6.5% for credit. In all, marginal analysis of years of education recorded the highest simulated technical efficiency across the groups followed by extension and credit.

Table 2: Marginal effects of inefficiency Variables*.

$\partial TE_i / \partial Z_k$	Group A	Group B	Group C	Group D
Age/years	-0.040	0.310	0.012	0.210
Education/years	0.009	0.016	0.011	0.482
Credit/₦	0.173	0.013	0.039	0.065
Extension/counts	0.117	0.458	0.323	0.201

* Multiplication of each coefficient by 100 yields the results presented under the discussion

The findings suggest that the more a farm is vertically integrated (i.e. increase in the number of crops on the farm) the higher the technical efficiencies and the higher is the output obtained from given level of inputs. This implied that subsistence farmers in Nigeria perform efficiently, as numbers of crops on their farms increases. The performance of the farms with multiple crops is a further confirmation of Schultz's hypothesis that farmers in developing agriculture are poor but efficient in resource use (Schultz, 1964). However, these findings have a number of policy implications in particular the results of the years of education, extension contacts as well as credit with highest simulated TE across the farms.

CONCLUSIONS

The study, therefore, suggests introduction of policies that will strengthen the present institutional framework on credit delivery, human capita development (education) and extension delivery systems in the country as productivity effects of these policy variables are expected to enhance food production in Nigeria in the future.

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