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Full Length Research Paper

Comparative analysis of aggregate agricultural productivity between low and high external input technology farms in Nigeria

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The study compared the aggregate agricultural productivity between the Low External Input Technology (LEIT) and High External Input Technology (HEIT) Farms in Imo State of Nigeria. The state is divided into three agricultural zones, out of which two were randomly selected for the study. Using a multistage sampling technique, 80 LEIT farmers and another 80 HEIT farmers were randomly selected, giving a total sample size of 160 farmers. The result of Chow F- test showed that the LEIT farmers who used animal manure had a higher aggregate agricultural productivity than the HEIT farmers who used inorganic fertilizer. It is therefore recommended that policies geared toward more production and utilization of animal manure be put in place by the government.

Key words: Aggregate agricultural productivity, low and high external input technology farms.

INTRODUCTION

Although Nigeria is indeed a country endowed with abundant natural and human resources, the country is still grappling with the problems of low agricultural output and productivity. Olayide (1990) attributed this to the low output and productivity characteristic of Nigeria's smallholder farmers. Given the fact that 90% of the food consumed in poor countries including Nigeria is produced locally, the economic and physical well-being of these countries therefore will depend on increasing and stabilizing agricultural productivity through more effective practices and technologies (NEPAD, 2002). Productivity performance in the agricultural sector is therefore critical to improvement in overall economic wellbeing of Nigerians in particular and Sub-Saharan Africa in general, since two-thirds of the labour force is accounted for by agriculture and 40% of the earnings come from this sector (Fulginiti et al., 2003). Agriculture is the largest non oil export earner and largest employer of labour accounting for 88% of the non oil foreign exchange earnings and 70% of the active labour force of the population (FGN, 2001).

Productivity growth therefore is the main determinant of income growth and poverty reduction. More so, governments view increasing and sustaining agricultural productivity as a means of over all growth, poverty reduction and promotion of food security. In particular it has been shown that agricultural productivity growth is more poverty alleviating than non agricultural productivity led growth (Nomaan, 2004).

Nigerian agricultural development policy over the years has been informed by the belief that the development of agriculture is a *sine qua non* for the over all growth and development of the economy. This understanding constituted the basis of all efforts made in the planning and design of programmes and projects to ensure growth in the sector (CBN, 2003).

However, over the years the growth rate of agricultural production has either stagnated or failed to keep pace with the country's rapid population growth rate of about 3.2% resulting in perennial food shortages, soaring food prices and massive importation of food by governments. While food production increases at the rate of 2.5 per cent, food demand increases at a rate of more than 3.5 per cent (FOS, 1996).

The main thrust of Nigeria's agricultural development efforts, therefore has been to enhance and sustain the

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capacity of the sector to produce enough food commodities, especially those in which the country has comparative advantage. It also involve developing the capability to increase the production of agricultural raw materials to meet the growing needs of an expanding industrial sector, as well as the production and processing of exportable cash crops to boost the nation's non oil foreign exchange earning capacity. This process of transformation from a predominantly subsistence agriculture to a highly mechanized farming to enhance agricultural production as well as ensure its sustainability has been undermined by the disincentives induced by the macroeconomic environment on the use of imported agricultural inputs (CBN, 2003). The realignment of the naira exchange rate, which resulted in the depreciation of the naira, has increased the prices of imported agricultural inputs such as inorganic fertilizers, agro-chemicals, tractors and vaccines among others. In 1997 subsidies on fertilizers were removed completely but re-introduced in 1999 (CBN, 2003). The potential of these high external input technologies (HEIT) in improving agricultural productivity in Imo state in particular and Nigeria in general is not in doubt. However, the current harsh macroeconomic environment that has made these inputs scarce and beyond the reach of the average farmer necessitates a search for alternatives that are cost effective.

Problem statement

The small-holder farmer in Imo state appears to be in dilemma on the need to increase agricultural productivity in a harsh macroeconomic environment.

On the one hand Graves et al. (2004) observed that the significant reduction in the total number of the undernourished in the world in the past was as a result of the use of high external input agricultural technologies (HEIT), that is, high yielding cereal varieties, together with high levels of inputs, such as water from irrigation system, fertilizer to provide the nutrients needed by the crop varieties and pesticides to control any associated weeds, pests and diseases. These technologies according to him generally need a relatively high capital investment and a well functioning economic and physical infrastructure for effective implementation.

On the other hand, some scholars (Pretty, 1995; Snapp et al., 1998), argue that in order to increase farm level productivity, the labour intensive low external input technology (LEIT) holds the key, while others argue that food security cannot be achieved without widespread adoption of HEIT. Proponents of LEIT often claim that the reliance on local sources of inputs is more sustainable, but the analysis of De Jager et al. (2001) suggests there is little difference between HEIT and LEIT in this respect. However the disincentives induced by the macroeconomic environment on HEIT utilization such as removal of subsidy on fertilizer and re-alignment of the naira exchange rate and consequent increase in the prices of imported Agricultural inputs (such as fertilizer, agro-chemicals, tractor etc) have narrowed down their use.

In the face of the apparent scarcity and expensiveness of the high external input agricultural technologies, it becomes compelling to re-examine the low external input agricultural technologies (LEIT), with a view to determining which of the two (LEIT or HEIT) offers the farmer higher productivities and why. Thus this paper attempts a comparative analysis of aggregate agricultural productivities and their determinants in the LEIT and HEIT in Imo state of Nigeria.

METHODOLOGY

Sampling procedure

The study was carried out in Imo state. Imo state is located in the South Eastern part of Nigeria. According to the National Population Commission (2006), Imo state has a population of 3,934,899 people, with an annual growth rate of 3.2 per cent. The state lies between longitude 6° 4' East and latitude 4° 4' and 8° 15' north.

Imo state is divided into three agricultural zones, namely Owerri, Okigwe and Orlu. A multi-stage sampling technique was adopted in order to capture a significant portion of the resource characteristics of the farmers at different stages and to ensure a good spread of the data. Two agricultural zones were randomly selected. From these two agricultural zones, two local government areas (LGA) were randomly selected from the list of LGAs in each zone making a total of 4 LGAs. From each of these LGAs two communities were randomly selected from the list of communities in the LGAs collected from the LGA headquarters. The list of farmers that use high external input technology (HEIT) and low external input technology (LEIT) in the communities were compiled with the assistance of the extension agents. This list formed the sampling frame. From this sampling frame, 10 farmers that used the HEIT and another 10 farmers that used the LEIT were randomly selected from each of the 8 communities making a sample size of 160 farmers (made up of 80 HEIT and 80 LEIT) users.

Data collection

Both questionnaire and practical field measurement of plot sizes with the aid of global positioning system (GPS) were used in the data generation exercise. Questions relating to the socio- economic characteristics of the farmers were asked, such as age, years of farming experience, years spent in school. Data also were collected on farm size, expenditure on fertilizer and organic manure, expenditure on agro- chemicals, seeds, labour input (including contract sum in case of farm operations contracted out) wage rate. Data were generated on non farm income, number of crop species (in a mixture) planted per plot per year, household size. In addition data were generated on capital inputs used. Data was also elicited on the estimated value of produce (in Naira) consumed, stored and sold.

Apart from the primary data other sources of information were journal articles, books, periodicals etc.

Agricultural productivity

Farm or agricultural productivity measures can be defined with one to all crops in the numerator. When there is more than one input,

input quantities are aggregated using prices as weights (e.g. with a divisia index). When all crops of the farm are in the numerator and all inputs in the denominator, one has an index of total factor productivity (TFP). When a single input is used (with one or more output) one has partial factor productivity. TFP calculations in many areas are constrained by missing input prices (from missing markets) especially for land and manure and to a lesser extent labour (Kelly et al., 1995).

To compare input productivities across goods or to aggregate over goods, productivities are commonly valued at the output price. For example the marginal product of land, multiplied by the price of the good produced is the "marginal value product of land" or land MVP.

In theory if the producer is economically rational and there is no constraint on the use of or access to inputs the MVP of the input should equal the pecuniary factor price (which is termed "allocative efficiency"). If however the farmers' access to the labour market is constrained or the farmers lack complementary inputs, the MVP of labour can be below the wage indicating excess use of labour. Labour may be "bottled up" on the farm. Or if the MVP of seed is above its price (because of constraints in access to seed), that means that farmers could efficiently use more seed. If the constraint were removed, farmers would use more seed and the MVP of seed would decline until it equaled the seed price.

Aggregate agricultural productivity in this study is measured by the index of the ratio of the total value of farm output (measured in naira values), to the value of total inputs (measured in naira values) used in farm production. This approach is consistent with Olayide and Heady (1982), Obasi (2000) and Anyanwu (2009). In its implicit form, the function to be estimated in this study is specified as:

$$Q = f(X_1, X_2 \ldots X_{12}, e) \ldots \quad (1)$$

$$Q = \sum Yp / \sum Xr = \text{Aggregate Agricultural productivity} \ldots \quad (2)$$

$\sum Yp$ = total value of output (Naira)
$\sum Xr$ = total value of input (Naira)

$$Q_L = f(X_1, X_2 \ldots X_{12}, e) \ldots \quad (3)$$

$$Q_H = f(X_1, X_2 \ldots X_{12}, e) \ldots \quad (4)$$

Where Q = aggregate agricultural productivity (ratio of total value of farm output to total value of farm input), QL = for low external input technology and Q_H = high external input technology. X_1 = farm size (ha), X_2 = labour input (man days), X_3 = expenditure on planting materials (Naira), X_4 = non farm income (naira), X_5 = capital input (depreciation and interest charges) (naira), X_6 = expenditure on fertilizer for HEIT or manure for LEIT farms (naira), X_7 = number of crops in a mixture (number), X_8 = distance to the nearest market (km), X_9 = years in schooling of the farmer (years), X_{10} = age of the farmer (years), X_{11} = household size (number), X_{12} = years of farming experience (years), and e = random error.

In order to achieve this objective a structural stability test was carried out on the two relations specified in equation (3) and (4) for LEIT and HEIT. That is

$Q_L = f(X_1, X_2 \ldots X_{12}, e)$ and

$Q_H = f(X_1, X_2 \ldots X_{12}, e)$

In the structural stability test the Chow (1960) F – test was used to establish the existence or absence of structural changes in the two functions. In this test the two samples were pooled together ($n_1 + n_2$) to compute a pooled function and the unexplained (residual) variations $\sum e^2_p = (\sum Q^2_p - \sum Q^{\wedge 2}_p)$ estimated (with $n_L + n_H - k$) degrees of freedom.

Regression analysis also were performed on each of the samples and their respective unexplained variations $\sum e^2 = \sum Q^2 - \sum Q^{\wedge 2}$ with n – k degrees of freedom computed. The unexplained variations of these two samples were added together ($\sum e^2_L + \sum e^2_H$) with ($n_L + n_H - 2k$) degrees of freedom and then subtracted from the pooled residual variance thus; $\sum e^2 p - (\sum e^2_L + \sum e^2_H)$ with ($n_L + n_H - k$) - ($n_L + n_H$ - 2k) degrees of freedom.

$$F^* = \frac{\sum e^2 p - (\sum e^2 L + \sum e^2 H) / k}{(\sum e^2 L + \sum e^2 H) / (nL + nH - 2k)} \ldots \quad (5)$$

Where p = pooled, k = total number of b's, L = LEIT, H = HEIT, others are as previously defined.

Ho: bo = Bo

We compare the observed F* ratio with the theoretical value at 1 or 5% (level of significance) with V_1 = K and $V_2 = (n_L + n_H - 2K)$ degrees of freedom.

Decision rule: we reject Ho, if F* > F0.05 and accept that the HEIT and LEIT farms differ significantly in their productivities.

However structural changes in the parameters of a function can arise due to changes in either bo or $b_1 \ldots$, bn or both (Koutsoyiannis, 2001). Thus to establish the identity or otherwise of the two constant intercept terms (denoting equality or otherwise in aggregate productivity a dummy variable separator was introduced in the combined data explicitly specified thus:

$$LnQp = Lna0 + boD + b_1LnX_1 + b_2LnX_2 + b_3LnX_3 + b_4LnX_4 + b_5LnX_5 + b_6LnX_6 + b_7LnX_7 + b_8LnX_8 + b_9LnX_9 + b_{10}LnX_{10} + b_{11}LnX_{11} + b_{12}LnX_{12} + e. \ldots \quad (6)$$

Where Ln = the natural logarithm, Q_p = pooled aggregate agricultural productivity, Ao = intercept term, D = dummy variable which takes the value of unity for HEIT (Farmers who used fertilizers or agro- chemicals etc) and zero for LEIT (farmers who used animal manure), Bo = coefficient of the intercept shift dummy. b1…b12 = slope coefficients. Others are as earlier defined in equations (1) (3) and (4).

Hence for HEIT farmers equation (6) will now be given by

$$LnQ_H = Ln\,Ao + bo + \sum biLnXi + e \ldots \quad (7)$$

While for LEIT farmers equation (6) will now be given by

$$LnQ_L = LnAo + \sum biLnXi + e \ldots \quad (8)$$

Using the ordinary least squares (OLS) technique the dummy variable is introduced in the combined data essentially to test (using t- test) the statistical significance of the coefficient of the dummy variable and to measure the direction of the intercept shift using the sign of the estimated coefficient. If it is significant and positive it shows a higher level of aggregate agricultural productivity for HEIT, the reverse can also be the case if otherwise.

RESULTS AND DISCUSSION

Structural stability test

The estimated multiple regression results for the two farm types as well as the pooled data are presented in Table 1, figures in parenthesis are t-ratios. The unexplained variations are computed as 0.8874, 0.9602 and 1.4894 for LEIT, HEIT and pooled data respectively. Using the Chow (1960) F- test, the F- cal = 1.998 > F0.05,13,134 =

Table 1. Estimated Multiple Regression Results on the Determinants of Aggregate Agricultural Productivity for LEIT, HEIT and Pooled Data in Imo State Nigeria.

Explanatory variables	LEIT Farms	HEIT Farms	Pooled Data
Constant term	-818 (-1.09)	-1.458 (-1.44)	0.845 (0.947)
Farm size (X1)	0.657 (3.64)***	1.10 (6.39)***	1.10 (6.09)***
Labour input (X2)	0.00022 (0.38)	-0.003 (-4.19)***	-0.0021 (-3.01)***
Expenditure on planting materials (X3)	0.000005 (-3.36)	-0.000007 (-5.72)***	-0.000006 (-4.08)***
Non farm income (X4)	-0.0000002 (-0.49)	-0.0000024 (-3.23)***	-0.0000013 (-2.21)**
Capital input (X5)	1.16 (4.97)***	0.00039 (5.63)***	1.36 (4.85)***
Expenditure on fertilizer / manure (X6)	0.000026 (4.42)***	0.0000004 (0.276)	9.52 (0.571)
Crop mixture (No.) (X7)	0.67 (5.27)***	0.47 (3.34)***	0.117 (1.03)
Distance to nearest Market (X8)	-0.029 (-0.44)	0.19 (3.38)***	0.0181 (0.274)
Level of education (X9)	0.0546 (1.95)**	0.0630 (2.19)**	0.0592 (2.08)**
Age (X10)	-0.0031 (-0.28)	-0.029 (-1.31)	-0.023 (-1.45)
Household size (X11)	-0.047 (-1.44)	-0.012 (-0.325)	-0.032 (-0.89)
Farming experience (X12)	2.74 (2.27)**	0.0446 (2.03)**	0.0428 (2.72)***
R2	89.6	77.2	59.1
F-ratio	48.12	18.858	17.68
S.E (e2)	0.8874	0.9602	1.4894

Source: Computed from survey data 2008.
** = Significant at 5%; *** = Significant at 1%
Figures in parenthesis are t-ratios.

Table 2. Estimated multiple regression results with pooled data and a dummy variable.

Explanatory Variables	Coefficients
Constant term	0.593 (0.807)
Dummy variable (D)	-2.103 (-8.45)***
Farm size	1.041 (7.00)***
Labour input	-0.002 (-3.62)***
Expenditure on planting materials	-0.0000057 (-4.74)***
Non farm Income	-0.000001 (-2.76)***
Capital input	1.04 (4.44)***
Expenditure on fertilizer / manure	0.0000003 (2.31)**
Crop Mixture	0.601 (5.49)***
Distance to nearest market	0.0379 (0.697)
Level of Education	0.0684 (2.91)***
Age	-0.023 (-1.82) *
Household size	-3.2 (-1.08)
Farming Experience	0.0322 (2.48)**
R^2	72.5
F – ratio	7.506

Source: Computed from survey data 2008.
** = Significant at 5%; *** = Significant at 1%
Figures in parenthesis are t-ratios.

1.75, we thus reject the null hypothesis and accept the alternative that there is a significant difference in the aggregate agricultural productivity of LEIT and HEIT farms in Imo state.

However structural changes in the parameters of a function can arise due to changes in bo or b1,….b12. according to Koutsoyiannis (2001). Thus to isolate the source of the structural changes a dummy variable separator was used. The data from the two farm types (LEIT and HEIT) were pooled together and a dummy variable introduced with the purpose of testing (using t- test) the statistical significance of the coefficient of the dummy variable and to measure the direction of the intercept shift using the sign of the estimated coefficient of the dummy variable. The estimated regression results with pooled data and dummy variable are presented in Table 2. The coefficient of the dummy variable is highly statistically significant at 1 percent level of probability and is also negative.

This further confirms that there is a significant difference between the aggregate agricultural productivity of LEIT and HEIT farm types. The negative sign of the coefficient of the dummy variable indicates that the HEIT farm type has a lower aggregate agricultural productivity relative to the LEIT farm type. An examination of the constant terms of LEIT (-0.818) and HEIT (-1.458) will reveal indeed that the LEIT farm type has a higher intercept term than the HEIT farm type. Thus one can conclude that probably the low external input technology farms in Imo state of Nigeria achieved higher aggregate agricultural productivity than their high external input technology counterpart.

Conclusion

A comparative analysis of aggregate agricultural productivity between LEIT and HEIT shows that LEIT achieved higher aggregate agricultural productivity than HEIT thus factors that accounted for these significant difference should be “the issues that need to be addressed in scaling up production” according to Tripp (2006a) and Graves et al. (2004). Explanatory variables such as farm size, planting materials, capital input, organic manure, number of crops planted in a mixture, level of education and farming experience are statistically significant at 1 and 5 percent levels of probability. The implication is that they significantly accounted for the high aggregate agricultural productivity observed in the LEIT farm types.

REFERENCES

Central Bank of Nigeria (CBN) (2003). Contemporary Economic Policy Issues in Nigeria. In Nnanna OJ, Alade SO, Odoko FO (eds). Kas Arts Services, Nigeria.

Chow GC (1960). Tests of Equality Between Sets of Coefficients in Two Linear Regressions. Econometrica. Vol. 28: pp. 591-605.

De Jager A, Onduyra D, Wijk V, Viaming MS, Abad J, Gachin GN, (2001). Assessing Sustainability of Low External Input Farm Management Systems with the Nutrient Monitoring Approach: a Case Study in Kenya. Agric. Syst. 69: 99-118

Federal Government of Nigeria (FGN) (2001). New Agricultural Policy, Ministry of Agriculture, Natural Resources and Rural Development Lagos.

Federal Office of Statistics (FOS) (1996). Annual Abstracts of Statistics 1996.

Fulginiti LE, Perrin RK, Yu B (2003). Institutions and Agricultural Africa Paper Presented at the 25th Annual Conference of Association of Agricultural Economists, August 16th-23rd, 2003, Durban, South Africa.

Graves A, Matthews R, Waldie K (2004). Low External Input Technologies for Livelihood Improvement in Subsistence Agriculture. Institute of Water and Environment, Cranfield University Sisloe Bedfordshire United Kingdom.

Koutsoyiannis A (2001). Theory of Econometrics 2nd Edition Palgrave New York 10010.

National Population Commission (2006) Population Census of Nigeria, Government Press, Abuja, Nigeria.

New Partnership for African Development (NEPAD) (2002). An Informational Assessment of the Role of Technology in Reducing Hunger and Improving Rural Livelihoods. Issues Paper on Agricultural Science and Technology.

Nomaan M (2004). Reaching Millennium Goals: How Does Agricultural Productivity Growth Reduce? Employment Strategy Papers. Employment Analysis Unit, Centre for Efficiency and Policy Analysis, School of Economics, University of Queen Land.

Obasi PC (2000). The Determinants of Food Consumption and Agricultural Productivity in Imo State, Nigeria. Unpublished Ph.D Thesis Federal University of Technology Owerri, Nigeria.

Olayide SO, Heady EO (1982). Introduction to Agricultural Production Economics, Ibadan, University Press, Ibadan, Nigeria. pp. 9-247

Olayide SO (1990). A Quantitative Analysis of Food Requirements, Supplies and Demand in Nigeria ibadan University Press, Ibadan Nigeria.

Pretty J (1995). Regenerating Agriculture Polices and Practices for Sustainability and Self-Reliance.pp 336. Earthscan London.

Snapp SS, Matongoya PL, Washington S (1998). Organic Matter Technologies for the Integrated Nutrient Management in Small Holder Cropping Systems of Southern Africa. Agric. Ecosyst. Environ. 71: 185-200.

Tripp R (2006a). Is Low External Input Technology Contributing to Sustainable Agricultural Development? Natural Resource perspective 102. ODI (Oversea Development Institute), UK pp. 1-4.