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Agricultural Extension and Efficiency Differentials among Upland Rice Farmers in Southwest Nigeria: A Profit Function Analysis

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Abstract: The study examined the differences in resource use efficiency of Participatory Technology Development (PTD) farmers and non-PTD farmers in upland rice production system in Ogun State, Nigeria. The data obtained from 190 farmers (40 PTD and 150 non-PTD) are analysed using normalised profit function approach. The results indicated that PTD rice farmers are relatively more economic efficient (technical and allocative) than their non-PTD counterparts. This suggests that exposure to technology through farmers' participation has positive effect on their production activities. Also, there is evidence of decreasing returns to scale for the underlying technology. In sum, PTD is an important and very reliable means of transforming farmers' efficiency level. Given that technology is time variant and efficiency increases with frequent practice of the adopted technology, it becomes imperative to sustain PTD activities among rice farmers in Ogun State, Nigeria.

Key words: Resource-use efficiency, participatory technology development, profit function, Nigeria

INTRODUCTION

Over the past years, traditional approach characterised by a top-down flow of information has been employed for the generation of technologies. In recent years, participatory techniques for farmer-centred research are now widely practised. These technologies are characterised by a bottom-up flow of information. There have been rapid developments in field methodologies within participatory approaches to agricultural and rural development such as Rapid Rural Appraisal, Participatory Technology Development and Farming systems Research and Extension (Jiggins and Roling, 1994). Participatory Technology Development (PTD) refers to collaboration between farmers, scientists and development workers in generating improved farming technologies, particularly in resource-poor areas. It implies that outsiders participate in an on-going process of research and communication by farmers. In this process, farmers analyse their problems and opportunities; they plan, implement and evaluate their own experiments with innovation and they inform each other about the results (Waters-Bayer and Farrington 1993). In PTD, development services seek to strengthen smallholders' capacity to innovate, help them establish closer links with agencies, which can supply relevant information and other inputs. It also help them exert pressure on external agencies to conduct the type of research and provide the type of inputs which smallholders require (Waters-Bayer and Farrington, 1993).

Rice is the most important staple food for about half of the human race (Hawksworth, 1985; Oteng and Sant'Anna, 1999). It ranks third after wheat and maize in terms of indigenous production. Wudiri and Fatoba (1992) and Ladebo (1999) establish that rice contribute about 12-14% of the food requirement of the population. They further opine that production capacity of the Nigeria's peasants is well below the national requirement. In order to satisfy the deficit between local production and demand, the nation for over two decades now, relies on importation.

Given the importance of rice in the country (Nigeria is the largest producer in West Africa) and the introduction of PTD by WARDA-The Africa Rice Center, it becomes imperative to examine the resource use efficiency of farmers in Ogun State with a view to comparing PTD farmers with non-PTD farmers. The

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farmers involved in PTD are expected to be more efficient because they receive more technical attention and training than their counterparts. If the farmers are efficient in the allocation of inputs, this will lead to minimization of cost. As a result, they maximize profit and are encouraged to produce more thus leading to food security, import substitution and competitiveness in rice production. An underlying factor behind this research is that if farmers are not making efficient use of existing technology; then efforts designed to improve efficiency would be more cost-effective than introducing new technologies as a means of increasing agricultural output (Shapiro, 1983). It is because of these that the study sets to examine the efficiency differentials between PTD and non-PTD farmers in upland rice production system in Ogun State.

MATERIALS AND METHODS

Sampling procedure and sample size: Six Local Government Areas (LGAs) (Abeokuta North, Ewekoro, Ifo, Ikenne, Obafemi-Owode and Yewa North) were selected from the 10 rice producing LGAs taken into consideration the intensity of rice production (low, medium and high). List of the rice growing villages in each LGA was obtained from Ogun State Agricultural Development Programme (OGADEP). A proportionate random sampling method was used to select 30 villages from the list of rice growing villages. The proportionality factor used is stated as follows: V = n/N * 30. Where, V is the number of villages to be sampled from each LGA, n is the number of the rice producing villages in the LGA, N is the summation of the rice producing villages in the 6 LGAs, and 30 is the desired number of villages for the survey. In each village, rice farmers were identified with the assistance of OGADEP Village Extension Agents (VEAs). From these, 5 farmers were randomly selected in each village. In all, 190 farmers were sampled including 150 farmers in the non-PTD group and 40 farmers in the PTD group. Due to the low population of PTD farmers, a total enumeration was carried out. The data used were collected during the 2002 planting season.

MODEL SPECIFICATION

Normalised restricted profit function: Normalised restricted profit function was used to determine the resource use efficiency of rice farmers taking into consideration their participation in PTD or not. The function was also used to estimate the indirect production elasticity.

Using the output price as the numeraire, the normalised restricted profit function ($\pi^*(q, Z)$) can be written in a generalised form as:

$$\pi^*(q, Z) = F\left[X_1^*(q,Z)......, X_n^*(q,Z)\right] - \sum_{j=1}^{m} q_j X_j^*(q,Z) \quad (1)$$

Where q_j represents the normalised factor prices, F is a well-behaved production function, X is the vector of variable inputs and Z is the vector of fixed inputs used in the production process. Starting with any well-specified normalised restricted profit function, direct application of Hottelings-Shepherd's Lemmas to the function yields the corresponding factor demand and output supply equations.

$$\partial\pi^*(q, Z)/\partial q_j = -X_j^* \; j = 1, ..., m \quad (2)$$

Multiplying both sides by q_j/π^* gives a series of m factor share equations.

$$[\partial\pi^*(q, Z)/\partial q_j] = -X_j^* q_l/\pi^* = a_j^* \; j = 1,.....,m \quad (3)$$

Equation 1 and 3 form the theoretical basis for the specifications of the model.

Following previous studies (Saleem, 1988; Duraisamy, 1990; Adesina and Djato, 1997) the specification of the systems of equations of the normalised restricted profit function and the factor share equation is given as

$$\ln\pi^* = \ln A^* + \delta^* D + \sum_{i=1}^{2}\theta_i^* \ln w_i \sum_{i=1}^{2}\beta_i^* \ln Z_i \psi_i \quad (4)$$

$$\frac{-w_i X_i}{\pi_i^*} = \alpha_{1i}^{*p} D_p + \alpha_{2j}^{*N} D_N + \xi i = 1, 2 \quad (5)$$

Where, π^* is the normalised profit defined as revenue less variable costs normalised by the price of paddy (P) in Naira. A* is the intercept.

X_1 is the number of hours of labour used including family and hired labour. Family and hired labour are lumped together because most of the labour input came from family labour. It is only on rare specific operations such as virgin land clearing that hired or exchange labour is used. This is why the used of hours of labour is favoured in this study.

X_2 : The quantity of seeds in kg.
W_1 : The wage rate normalised by the price of paddy.
W_2 : The price of seed normalised by the price of paddy.
Z_1 : The capital inputs and is the sum of the costs of various implements used in rice production.

The implements used in rice production include cutlass, hoes, baskets, knife, sacks etc. the implement are usually replaced after each planting season, hence their actual values were used without depreciation.

Z_2 is the land input, which is the net area sown to rice in hectares.

D	:	The dummy variable taking the value of unity for PTD farmers and zero otherwise.
^PD_p	:	A dummy variable taking on the value of unity for farmers in PTD.
^ND_N	:	A dummy variable taking on the value of unity for farmers in NPTD.
α_i, θ_i and β_i	:	Parameters to be estimated.
Ψ_i and ς_i	:	Error terms.

The a priori expectations of the variables used in the normalised profit function are presented in Table 1.

Assumptions:

- It is assumed that the errors of the system of equations are additive with zero mean and finite variance.
- For the same farm, the co-variance of the error terms in these equations are non zero; while the co-variance of error terms of any of the equation for different farms are assumed to be zero.

Following previous studies, Zellners' Seemingly Unrelated Regression method (SUR) was used to estimate the system of equations in order to obtain asymptotically efficient parameter estimates.

Indirect production elasticity: To determine the effects of individual production factors on paddy output for the sampled farmers, identities that link the self-dual profit function with the primal production function was used (Sidhu, 1974; Duraisamy, 1990). It has been shown (Yotopoulus and Lau, 1973) that the indirect production elasticities for the variable inputs can be derived from the self-dual profit function used above as $\alpha_j = -\alpha_j^* (1-\mu^*)^{-1}$ where α_j^* corresponds to the estimated parameters of the factor prices of these variables in the dual profit function, and $\mu^* = \sum \alpha_j^*$. The elasticities of the fixed factors are computed as $\beta_j = \beta_j^* (1-\mu^*)^{-1}$ where β_j^* is the indirect elasticity of production with respect to the fixed factor. These indirect production elasticity estimates have been shown to have statistical consistency (Sidhu, 1974).

Table 1: Expected signs for variables

variable	Expected sign
Number of hours of labour	-
Quantity of seeds	-
Wage rate	-
Seed price	-
Capital input	+
Land output	+

In the normalised restricted profit function, four models were specified. The first model is unrestricted, the second model is one restriction, third model two restrictions and the last model four restrictions. One restriction was imposed to test for equal relative economic efficiency. Two restrictions were imposed to allocative efficiency and four restrictions were imposed to test for constant returns to scale.

RESULTS AND DISCUSSION

Efficiency of rice production: A normalised restricted profit function approach: The results of the estimated normalised restricted profit function are presented in Table 2. The coefficients of rice area and capital aresignificant at 10% levels of significance in all the four models. This is consistent with the findings of Adesina and Djato (1997). As expected, the coefficient of labour price (wage rate) and seed price are negatively signed. On the other hand, capital has a contrary sing from expectation. The negative sign of the coefficient of capital can be attributed to a misspecification of this variable (Yotopoulos and Lau, 1973). Earlier, Yotopoulos and Nuggent (1976) showed that the measurement of capital leads to biased coefficients. However, in Adesina and Djato (1997) the coefficient of capital has the expected positive sign. The coefficient of wage rate is significant at ten percent level in model 1, 2 and 3 but not significant in model four (four restrictions). On the contrary, the coefficient of seed price is not significant in models 1, 2 and 3 but significant at 1% in model four.

The behaviour of the coefficients in the share equations is also of interest. The imposition of the within equation constraints (model 3) is essentially equivalent to pooling two samples to obtain an estimate of the mean. Therefore, it is not surprising that the significance of the coefficient is increased. For example, the coefficient of seed in the (PTD) factor share equation is not significant in model one and two but highly significant in model three. This is also applicable to the coefficient of labour in the (PTD) factor share equation.

The imposition of the cross-equation (model 4) provides a more critical test. The imposition of the constraints could improve or reduce the significance of the share equation coefficient (Quiggin and Bui-Lau, 1984). In this study, results show that the imposition of the constraints simply transfers significance from the share equation to the profit function. The coefficient of labour in the factor share equation is reduced while the coefficient of seed price in the profit function is increased.

Table 2: Estimate Simultaneous Regression (SUR) of system of normalised restricted profit function and factor sahe equation for PTD and NPTD rice farmers in Ogun state

Normalised profit function	Model 1 Unrestricted	Model 2 1 Restic.	Model 3 2 Restic.	Model 4 4 Restic
Constant	14.546	13.458	14.587	15.122
	(4.796)***	(4.533)***	(4.804)***	(4.983)***
Group (1=PTD; 0=NPTD) δ^*	0.615	-	0.428	0.434
	(1.735)*	-	(1.366)	(1.385)
Wage rate (w_1)	-2.111	-2.111	-2.111	-1.830
	(-1.653)*	(-1.653)*	(-1.653)*	(-1.434)
Seed price (w_2)	0.067	0.0706	0.067	-1.141
	(0.174)	(0.183)	(0.174)	(-3.929)***
Capital (z_1)	-0.541	-0.392	-0.541	-0.574
	(-2.253)**	(-1.748)*	(-2.243)**	(-2.395)**
Rice area (z_2)	2.253	2.242	2.253	2.150
	(13.533)***	(13.50)***	(13.553)***	(13.043)***
Factor share equation				
Labour				
Factor share parameter PTD	-300.154	-921.024	-1017.003	-1.083
	(-0.208)	(-0.659)	(-2.024)**	(-1.434)
Factor share parameter NPTD	-1115.879	-1030.24	-1017.003	-1.830
	(-2.081)**	(-1.930)**	(-2.024)**	(-1.434)
Seed				
Factor share parameter PT	-2.445	-5.132	-5.832	-1.141
	(-0.533)	(-1.189)	(-3.653)***	(-3.929)***
Factor share parameter NPTD	-6.299	-5.928	-5.832	-1.141
	(-3.698)***	(-3.508)***	(-3.653)***	(-3.920)***

Results from data analysis 2002 *Significant at 10 %**Significant at 5%***Significant at 1% PTD= farmers with participatory technology development knowledge;NPTD = farmers without. The numbers in parenthesis are t-values

One restriction	Two restriction	Four restrictions		
$\delta^* = 0$	$\alpha^*_{1L} = \alpha^*_{2L}$	$\alpha^*_{1L} = \alpha^*_{2L}$	$\alpha^*_{1L} = \theta^*_1$	
		$\alpha^*_{1S} = \alpha^*_{2S}$	$\alpha^*_{1S} = \alpha^*_{2S}$	$\alpha^*_{1S} = \theta^*2$

Table 3: Statistical tests of hypotheses on relative efficiency differences between PTD and NPTD rice framers, Ogun State 2002

Hypotheses		Computed F	Critical		
Maintained	Tested	F (5,159)	F (0.01)	F (0.05)	F(0.01)
Hypothesis 1	$\delta^* = 0$	38.67	3.11	2.26	1.88
	$\alpha^*_{1L} = \alpha^*_{2L}$				
Hypothesis 2	$\alpha^*_{1S} = \alpha^*_{2S}$	40.34	3.11	2.26	1.88
Hypothesis 3	$\beta^*_1 = \beta^*_2 = 1$	35.81	3.11	2.26	1.88
$\alpha^*_{1L} = \alpha^*_{2L}$					
$\alpha^*_{1S} = \alpha^*_{2S}$					
$\alpha^*_{1L} = \theta^*_1$					
$\alpha^*_{1S} = \theta^*_2$					

Results from data analysis 2002

Statistical hypotheses tested: Three statistical hypotheses were tested successively on the data.

The hypotheses stated in the null form are as follows: Equal relative economic efficiency of PTD and non-PTD farmers. Equal relative price efficiency of PTD and non-PTD farmers constant returns to scale for factors of production. The results of these tests are reported in Table 3. A test of equal relative economic efficiency was conducted (hypothesis 1). This hypothesis is rejected at 1%. Hence, it is concluded that PTD rice farmers are relatively more economic efficient than non-PTD rice farmers. The second hypothesis states that the relative price efficiency of PTD and non-PTD farmers is equal, i.e. they equate the value of marginal product of labour to wage rate and the value of marginal product of seed to seed price to the same degree. This hypothesis is also rejected at 1% level. It is concluded that PTD and non-PTD farmers do have different price efficiency parameters i.e., they have different degree in maximising profits. Non-PTD rice farmers are relatively more profit maximisers than PTD rice farmers. Finally, the hypothesis of constant returns to scale under the maintained hypothesis of absolute price efficiency for PTD and non-PTD farmers was tested (hypothesis 3). This hypothesis is also rejected at one percent level. There is evidence of decreasing returns to scale for the underlying technology as the elasticity of the profit function with respect to the fixed factor of production (land) is less than one.

Indirect production elasticity: From the estimated parameters, the indirect estimates of the production elasticities of labour, seed, capital and land were computed. These are presented in Table 4. The estimates in Table 4 show that the elasticity of paddy output is highest with respect to land followed by labour. In the unrestricted model, an increase of labour by 10% will increase paddy output by 5.9%. Similarly, a 10% increase in land is expected to lead to 6.3% increase in paddy

Table 4: Indirect estimates of the input elasticities of the production function

Production factor	Indirect elasticity estimate Unresticted	1 Restiction	2 Restriction	4 Restriction
Labour	0.59	0.59	0.59	0.40
Seed	-0.02	-0.02	-0.02	0.25
Capital	-0.15	-0.11	-0.15	-0.16
Land	0.63	0.65	0.63	0.47

Computed from results of data analysis (2002)

output. But a 10% increase in seed will reduce paddy output by 0.2%. These results also show that paddy output is inelastic in response to a unit change in any of the factors of production.

CONCLUSION AND RECOMMENDATIONS

The study shows an empirical application of the profit function method to test for efficiency differences between rice farmers with and without PTD knowledge in Ogun State. The study concludes that PTD rice farmers are relatively more economic efficient while non-PTD farmers are more price efficient than PTD rice farmers. Also, there is evidence of decreasing returns to scale for the underlying technology as the elasticity of the profit function with respect to the fixed factor of production (land) is less than one. Thus, PTD farmers given their exposure to new technology have improved technical efficiency than the non-PTD farmers.

From the estimated parameters of the normalised restricted profit function, the indirect estimates of the production elasticities of labour, seed, capital and land were computed. These results also show that a unit change in land area to rice will have the highest impact on output when compared with similar change in the level of other inputs. As a result, expansion of area cultivated to rice is likely to achieve significant positive effects on rice production. Expansion could be achieved through mechanisation of rice farming in the state. This could be difficult considering the cost implications and the resource base of the farmers. Incentives to encourage farmers cultivate more land area should be advanced. Cultivation of small land area has constituted a constraint to rice production. However, while land expansion will increase rice output, there is the need for the introduction of improved means of bird scaring to encourage farmers embark expansion. This is necessary because most farmers limit the area sown to rice because of bird's problem.

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