Resource-use efficiency of small holders root and tuber expansion programme(RTEP) In Plateau state, Nigeria: An application of stochastic frontier production function

Folorunso Solomon T. and Abia Eno. E.

Department of Agricultural Extension and Management, Federal College of Forestry, Jos,. Plateau State, Nigeria
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ABSTRACT

Using a cross sectional data obtained through a multistage sampling technique, this study estimated the technical efficiency of small holders RTEP participants and non-participants in Plateau State, Nigeria and further examined the factors that determined the differential in efficiency index. A total of 160 RTEP participants and non-participants in the study area were randomly selected for the study. The stochastic frontier production model was used in the analysis to determine the relationship between output and the level of input used in the study area. The empirical results revealed that farm size was significant at 5% for RTEP participants only. Planting materials, fertilizers and hired labour were statistically significant at 5% level. The estimated gamma parameters (γ) of 0.89 for RTEP participants and 0.94 for non-participants indicated that 89% and 94% of the total variation in total output was due to technical inefficiencies of the respondents. The mean technical efficiencies (χ) level was 0.91 for RTEP participants and 0.56 for non-participants. It was therefore concluded that there was scope for increasing root and tuber crops production by 0.91% for RTEP participants and 54% for non-participants with the present technology. Therefore the study confirmed that increased land, planting material, fertilizer and hired labour can be used in the area for both RTEP participants and non participants.

Key words: Technical efficiency, RTEP, Plateau State, stochastic production frontier.
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INTRODUCTION

Nigeria is predominantly rural in character with more than 80% of the population residing in rural areas [1](Agbara, 1985). It is characterized by a dualistic economy made up of a market economy and a subsistence economy. While the market economy is in and near the towns, the subsistence economy is in the rural areas. The market economy is more developed than the subsistence economy[1]. This dualism is also characterized by the existence of an advanced industrial system and an indigenous backward agricultural system. The industrial sector uses capital intensive techniques and produces variety of capital goods and durable consumer goods. The rural sector uses labour intensive mode of producing agricultural commodities with traditional techniques[2].

The Nigerian economy is basically agrarian with majority of the people living under poor conditions. A proportion of the farmers practice subsistence farming with small farm size-holdings, cropping about 1–2 hectares under a traditional system characterized by low technology. Agriculture is crucial to the social and economic development of Nigeria[3]. It contributes to the Gross Domestic Product (GDP), employment, foreign exchange earnings and provision of food for local consumption and agro-allied industries[4]. Agriculture is second only to petroleum as the most important contributor to the Gross Domestic Product, accounting for an estimated 51% in 1999/2000[5] and

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33.4% in 2008/2009 farming season[6] (World facts book Nigeria, 2009). However, the Nigerian agriculture has been on the decline compared with other sectors of the economy.

In most developing countries, farmers very well know the need to allocate given resources and the technologies at their disposal so as to maximize profit and achieve the greatest economic efficiency. Yet the food production has continued to dwindle and food demand as well as high population growth continues to skyrocket. The annual rate of population has been as high as 2.9% [7]. Persistently, the gap between food production rate and food demand has continued to widen [8] irrespective of the various programmes by government to increase food production and at the same time reduce hunger and poverty. Consequently, Nigeria is being enlisted as one of the most food insecure countries [9].

Root and tuber crops are some of the agricultural crops produced by the Nigerian farmers. In Africa, about 40% of all root and tuber crops are produced in Nigeria; followed by Congo DRC (10%), Ghana (8%); Tanzania (6%); Uganda (5%); Mozambique (3%); Angola (3%) [10]. This makes Nigeria the largest producer of roots and tubers in Africa. A major policy thrust is to boost the production of cassava for export, which has been estimated to earn up to $5 Billion foreign exchange for Nigeria[11]. [11] further asserted that, immense value of root crops as raw materials for numerous and diverse industries provide adequate impetus for their increased production. Some of these industries include textile industries, livestock feeds, flour mills, food industries, ethanol production, and bakeries among others.

Since agriculture remains the mainstay of employment in the country employing about 70% of the working population, it became imperative that appropriate policy measures, aimed at alleviating poverty, must take agriculture and rural development into consideration,[12] (Soludo, 1996). [13], in their analyses of the poverty trend in Nigeria, noted that poor families are in high proportion in farming household who are mainly in the rural areas. Within the last three decades, serious efforts have been made to make the Nigerian economy self-sufficient in food production, and ultimately improve the standard of living of the farmers in particular and the Nigerian people in general. One of these efforts was the establishment of the Agricultural Development Programmes (ADPs) in 1974 with the overall objective of increasing food production and farm family incomes of the rural population [14].

An attempt to increase and sustain food production and resource use efficiency resulted in the establishment of Root and Tuber Expansion Programme (RTEP) by the Federal Government in collaboration with International Fund for Agricultural Development (IFAD). In spite of the billions of naira spent on this programme, reports on socioeconomic analysis of poverty level among rural dwellers in Kwara state in Nigeria still shows that there is widespread poverty generally in the country and particularly among the rural farm families[15] . [16] in his study on quantitative analysis of food requirement affirmed that although Nigeria is endowed with abundant natural and human resources, the country is still grappling with the problem of low agricultural output and productivity. The purpose of the study was to analyze empirically, the technical efficiency of resource use by RTEP participants and non participants in the study area.

The analysis of the impact of root and tuber expansion programme on productivity will bring to the fore the need to give support to this programme as well as replicate such in other parts of the country owing to the fact that there has been little study carried out on the effect of the programme on poverty alleviation and productivity of farmers in the study area. The study will improve the data base of RTEP and provide necessary information on both participating and non-participating farmers with the view of improving and modifying programme design, planning and implementation of strategies, thus accelerating the achievement of the set objectives of the programme. The result of this study will provide the necessary data required by policy makers that will positively impact the livelihood of the people, increase food production and provide raw materials to boost and increase the establishment of agro allied and cottage industries.

MATERIALS AND METHODS

The study area
The study was conducted in Plateau state of Nigeria. This state lies between latitudes 8^0N and 10^oE and longitudes 7^oE and 11^oE of the prime meridian[17] . The Plateau highland stands at an average height of 1200 meters above mean sea level [17]. The mean temperature in the Southern part of the state varies from 31^oC to about 14^oC on the Plateau while the annual rainfall varies from 131.75 mm in the Southern part to 146.00 mm on the Jos plateau[17].

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Though situated in the tropical zone, the climate on Jos Plateau and its environs simulates that of the temperate region while the Southern part is much more tropical. With adequate fertilizer supplement and the use of improved varieties, crop varieties like maize, Irish potato, cocoyam, upland rice, sorghum and vegetables are being produced [17]. Livestock types found in the state are cattle, sheep, goats, pigs and poultry.

Sources of data and sampling procedure
Data for this study was obtained from both primary and secondary sources. The primary data were collected on the production activities of the RTEP participating and non participating farmers using structured questionnaires. A total of one hundred and sixty (160) respondents comprising 80 RTEP participating and non-participating farmers each were randomly selected from sixteen villages comprising Ganawuri, Riyom, Tom Gengere, Wereng Rim, Manish, Langai, Panyam, Ntam, Ampang West, Zamko, Shishin, Langtang, Shendam, Kalong, Longvel and Yelwa. The sample frame was divided into two consisting of participants and non-participants. For the participating and non participating farmers, 80 farmers were also randomly selected making a total of 160 respondents.

Analytical Model
The stochastic production function model was adopted for the study and is specified as follows:

$Y_i = f(X_i, \beta) + \varepsilon_i$ …………………………………………………………………………(i)
$\varepsilon_i = (V_i - U_i)$

Where Y_i is output, X_i is input, β is a vector of parameter to be estimated. The disturbance term ε_i consist of two components V_i and U_i where $V_i = N(0, \sigma^{v2})$ and U_i is a one sided error term. The two errors V_i and U_i are assumed to be independently distributed. The term V_i is the symmetrical component and permits random variation of production across farms; while it also captures factors outside the control of the farmer. A one-sided component ($U_i \geq 0$) reflects technical efficiency relative to the stochastic frontier. If $U_i = 0$, production lies on the frontier. If $U_i > 0$, production lies below the frontier and is inefficient. Following[18]), the Technical Efficiency (TE) of the individual farmer is calculated as the expected values of V_i conditional on $\varepsilon_i = V_i - U_i$. Technical efficiency is then calculated as:

$TE = \exp(-\varepsilon/U_i)$; …………………………………………….…………………………..(2)

So that $0 \leq TE \leq 1$.

The empirical model of the stochastic production frontier is specified as;

$LnQ_i = Ln\beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + \beta_6 LnX_6 + V_i - U_i$………….(3)

Where;
Q_i = Total value of farm output (in Naira) from i-th farm.
X_1 = Farm size in hectares (Ha)
X_2 = Seed/planting materials (Kg).
X_3 = Quantity of Fertilizers used in kilograms (Kg)
X_4 = Quantity of chemicals used (Kg)
X_5 = Family labour (Mandays)
X_6 = Hired Labour (Ha)
β_0 = intercept
β_{ij} = vector of production function parameters to be estimated i=1, 2, 3,…,n farms;
j=1, 2, 3… m inputs.
v_i = random variability in the production that cannot be influenced by the farmer.
μ_i = the deviation from maximum potential output attributable to technical inefficiency.

The variance of the random error $\boldsymbol{\delta}v^2$ and that of the technical inefficiency effect δu^2 and the overall variance of the model are related as follows:-
$\delta^2 = \delta v^2 + \delta u^2$…………………………………………………………………………..……(4)
$\gamma = \delta u^2/\delta^2$ …………………………………...…………………………………………….(5)

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Equation (5) measures the total variation of production (output) from the frontier which can be attributed to technical or allocative inefficiency[19].The δ^2 and γ, coefficients are the diagnostic statistics that indicate the relevance of the use of the stochastic frontier function and the correctness of the assumptions made on the distribution form of the error term.

RESULTS AND DISCUSSION

Technical efficiency and associated inefficiency factors

Table i: Maximum Likelihood Estimates of Cobb-Douglas Stochastic frontier production function.

Variable	RTEP Coefficient	NON_RTEP Coefficient
Constant	0.64(0.43)NS	0.43(5.34)***
Farm size	0.17(2.35)**	0.12 (1.13)NS
Planting material	0.43(2.22)**	0.41(2.01)**
Fertilizer	0.30(8.38)***	0.27(6.40)***
Agro-chemical	0.21((1.63)NS	0.20(1.60)NS
Family labour	-0.26(-0.89)NS	-0.26(0.82)NS
Inefficiency model		
Constant	0.34(2.34)**	0.16(2.33)**
Age	0.17(9.36)***	0.91(2.76)***
Education	0.75(3.97)**	0.16(1.10)NS
Farm size	-0.31(-2.37)**	-0.12(-2.18)**
Farming Experience	0.31(2.84)**	0.23(2.68)***
Household size	-0.10(-2.74)**	-0.03(-2.86)***
Membership of farmers' group	0.91(4.33)***	0.03(3.85)***
Extension contact	-0.68(-3.48)***	0.53(3.30)***
Credit access	-0.14(-2.84)**	-0.28(-2.14)**
Gender	0.98(3.02)***	0.81(2.82)***
Variances	0.21(1.13)NS	0.23((1.11)NS
Sigma squared	1.47(5.65)***	1.27(5.14)***
Gamma	0.89(2.44)**	0.94(2.12)**

Figures in parenthesis are t-values. *indicates values are significant at 5% level and below.
+ A negative sign on a socio-economic parameter indicates a positive impact on efficiency.

Maximum Likelihood Estimates of the stochastic frontier production function for RTEP participants and non-participants in the study areas are presented in Table i. The variance parameter estimate σ^2 and γ for RTEP participants and non-participants are 1.47 and 1.27; 0.89 and 0.94 respectively. They are all significant at 5% level of significance. The sigma squared σ^2 indicates the goodness of fit and correctness of the distributional form assumed for the composite error term while the gamma γ indicates the systematic influences that are unexplained by the production function and the dominant sources of random error. This means that the inefficiency effects make significant contribution to the technical efficiencies of both RTEP and non-RTEP participants. The estimated gamma γ parameter of 0.89 for RTEP participants and 0.94 for non-RTEP participants indicates that about 89 % and 94 % of the variation in the value of farm output of RTEP and non-RTEP participants was due to differences in their technical efficiencies. Thus, the hypothesis that the coefficient of $\gamma = 0$ is rejected. The result shows that inefficiency effects were present and significant.

The estimated coefficients of all the parameters of production function are positive for both RTEP and Non-RTEP farmers except the coefficient for family labour which is negative for both groups.

Farm size (α_1): The coefficient of farm size was positive and significant at 5% level for participating farmers but not significant for non-participating farmers. The result could mean that it is possible to expand tuber crop production activity in the study area. Thus, if farm size is increased by 10 %, total value of farm output level will improve by less than proportionate margin of 1.7% for RTEP farmers and 1.2% for non-participating farmers.

Planting materials (α_2): The coefficient of planting materials was positive and significant at 5 percent level for both RTEP farmers and non-participating farmers. If planting materials are increased by 10%, value of farm output will increase by 4.30% for RTEP farmers and by 4.1% for non-participating farmers. As such, farm output can be significantly increased by increasing the use of planting materials. This may be due to the presence of improved seedlings from the RTEP programme.

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Fertilizer (α_3): The production elasticity with respect to fertilizer is 0.30 and 0.27 for RTEP farmers and non-participating farmers respectively and significant at 5% level. By increasing the quantity of fertilizer by 10%, the value of farm output will increase by 3.0% and 2.7 percent respectively for both groups of farmers. This finding is in conformity with that of [20. In his study of urban farming, he found the coefficient of fertilizer to be highly significant at 1% level.

Hired Labour (α_4): The coefficient of hired labour was significant and had a positive sign for both groups of farmers. This is in line with [20] and [21] who showed the importance of labour in farming, particularly in developing countries where mechanization is rare on small scale farms. The coefficient for agrochemicals and family labour were not significant and was not of any statistical relevance.

(ii) Technical Inefficiency Model
 The variables of the inefficiency model as shown in Table 1 indicates years of schooling, years of experience with RTEP, membership of farmers' group, extension contact and access to credit, have the expected negative signs and significant at 5% for both groups of farmers. This implies that the technical efficiency of RTEP participating and non-participating farmers will increase with increase in the above variables. Education enhances the acquisition and utilization of new technologies by farmers[22] ; [23]; [24];[25] . Membership of farmers' groups enables the farmers to interact and share information with each other on production methods and input sourcing. Access to credit enhances farmers' capacity to acquire production inputs on time to enhance productivity. This finding is consistent with the findings of[26] , [27], and[23].

Coefficients of age, farm size, household size and gender were positive for both groups of farmers. However, only the coefficients of farm size and household size were significant for both groups of farmers, while the coefficients of age was significant only for RTEP farmers and gender was not significant for both groups of farmers. The significance of these coefficients implies that RTEP farmers and non-RTEP farmers with large family size, farm size and relatively older in age have lower technical efficiency. It has been reported the use of large family labour on small farms result in over-utilization and hence inefficiency[21]. Older farmers are often not amenable to changes and are neither likely to adopt improved technologies nor have the physical strength to do manual work as the younger ones [8];[23]. This gives credence to why there exist a positive relationship between age and technical inefficiency. The finding of this study on age is in agreement with[28] who in their study of small scale farmers in Nigeria found age to be positively related to inefficiency.

Farm Level Technical Efficiency for RTEP participants and non-participants

Table iv: Frequency distribution of technical efficiency of RTEP Participants and Non-Participants

Efficiency level (%)	RTEP (%)	Non-RTEP
0.00-0.40	2.25	0
0.41-0.60	7.25	10
0.61-0.80	16	20
0.81-1.00	74.5	70
Minimum (%)	43	34
Maximum(%)	95	97
Mean(%)	91	56

The frequency distribution of predictive individual farm level technical efficiencies are shown in Tables ii. Over 70% of the RTEP farmers in the study area have technical efficiency scores of over 80 percent with an average score 91%. Similarly, Table 2 shows that for the non-RTEP participants, about 91% of the farmers had technical efficiency scores of over 61% with mean score of 56 percent. In comparism however, the mean values of technical efficiency scores of RTEP participants were higher than those of the non-participants. This means that the RTEP participant were more efficient in resource-use than the non-participants. This is in conformity with the work of [29]Helena (2005). This result also shows the importance of examining technical efficiency with the aim of examining critically the role higher efficiency levels play in output in agriculture. Z- Test score shows that there is a significant difference between the efficiency of RTEP participants and Non-participants in the study area at 5% level.

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CONCLUSION

The results of the study show that RTEP participants were technically efficiency in the use of inputs than non-participants. The problems encountered by RTEP farmers in the study area were lack of credit, high cost of input, Lateness in the supply of these inputs and inadequate of markets. The problems encountered by the RTEP management are attitude of the farmers to change, inadequate financial commitment, inadequate knowledge of marketing and record keeping.

The following recommendations were made:
1. The result of the study showed that about 72 percent of the respondents are young men, educated and are predominantly small scale farmers, implying that they are young, active, energetic who are more likely to be more productive and innovative. Therefore, the jobless graduates should be motivated by putting in place graduate farming scheme, with the provision of technology driven inputs to embark on commercial root and tubers crops farming as a means of income.
2. The high technical efficiency of the farmers in the study area which contributed more to economic efficiency should be sustained by adopting improved varieties of planting materials and other inputs that will further increase input/output ratio while RTEP management should put in place appropriate measures that will address the low levels of allocative efficiency.
 3. Proper and effective logistics such as provision of input delivery vans should be put in place by the farmers, P.A.D.P and RTEP management that will reduce time at which these inputs gets to the farmers, since input availability and timeliness of same is crucial to production.
4. A public-Private partnership agreement can be entered by the government both at State and Federal levels with input companies to open outlets in the rural communities so as to ease the problems associated with input supply delay.

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