ESTIMATION OF FARM LEVEL TECHNICAL EFFICIENCY AND ITS DETERMINANTS AMONG MALE AND FEMALE SWEET POTATO FARMERS IN IMO STATE, NIGERIA[1]

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Abstract

With the difficulties encountered by the farmers in adopting improved technologies, increasing resource use efficiency has become a very significant factor in increasing productivity. Therefore, this study was designed to estimate the farm level technical efficiency and its determinants among male and female sweet potato farmers. Primary data collected from a random sample of 120 sweet potato farmers (64 females and 56 males) were subjected to production function analysis. The result showed that fertilizer and farm size positively affected output for both farmer groups. Labour and capital positively affected output for the females while quantity of sweet potato vine affected the output of the male farmers positively. The mean technical efficiency for the female farmers was higher (92%) than that of their male (85%) counterparts. Farming experience and access to credit were positive and significantly related to technical efficiency for both farmer groups, while no significant relationship was found between technical efficiency and level of education, co-operative membership and age for both farmer groups. Therefore, policies for improving farmers' access to credit, land and extension contact would enhance efficiency and productivity.

Keywords: *male and female farmers, sweet potato, technical efficiency*.

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[1] The final version of this article was submitted in August 2012.

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1. Introduction

Sweet potato originated from Central America and spread rapidly to Asia and Africa during the 17th and 18th centuries respectively and has become an important crop in many areas of the world (van An, 2004). It ranks among the five most important food crops in the tropical areas where a high population of the world's poorest people live (Woolfe, 1992). Sweet potato is the only member of the genus Ipomoea whose roots are edible and which has a positive per capita annual rate of increase in production in Sub-Saharan Africa (Tewe *et al.,* 2003). It has a high yield potential that may be realized within a relatively short growing season (Tewe *et al.,* 2003) and is adaptable to a wide range of ecological conditions. As a crop that requires low inputs of land, labour and capital and less management in its production; it does well on marginal soils, giving reasonable yield than most other crops (Islam *et al.*, 2002; Attaliru and Ilangantileke, 2007) and has become one of the world's most important food crops due to its high yield and nutritive value (Data and Eronico, 1987).

Sweet potato is treated as a minor crop in Nigeria (Tewe *et al.,* 2003); ranking behind the other root crops. Therefore, aggressive research efforts are needed to harness the potentials of the crop. Ndukwu (2010) noted that there is a dearth of information on the economics of the production of the crop. Moreover, various researches conducted on the contribution of women to agricultural development in the Nigeria (Dixon, 1982; Auta, *et al.*, 2000; Nwaru, 2004; Iheke, 2006; Damisa, *et al.*, 2007) place the contribution of women as high as between 70 to 85 percent of both family and hired labour for farm activities and this includes sweet potato production (Babatunde *et al.,* 2007). Empirically investigating the dominant and important roles women play in agricultural production with respect to sweet potato production would be contributory to efforts at creating a vibrant paradigm for resource employment and increased food production in Nigeria.

Therefore, the objective of this study was to measure the level of technical efficiency and its determinants in sweet potato production in Imo State of Nigeria among men and women farmers. Technical efficiency here refers to the ability of the farmer to produce the highest level of output with a given bundle of inputs. It indicates all the gains obtainable by simply gingering up the optimal management of production

resources (Farrel, 1957; Iheke, 2006). It is believed that the productivity of farmers could be enhanced through enhancing their technical and allocative efficiencies in response to better information and education (Idiong, 2006). Moreover, with the difficulties encountered by farmers in developing countries for developing and adopting improved technologies due to resource poverty, improving efficiency has become a very significant factor in increasing productivity (Ali and Chandry, 1990). The drive is for the farmers to allocate their resources to those productive ventures that earn higher returns for each unit of resource spent (Iheke, 2006). There might be re-allocation of available resources if they expect to benefit more from such economic actions (Nwaru and Iheke, 2010).

2. Methodology

Study Area: This study was conducted in Imo State of Nigeria. Imo State is bounded in the north by Anambra State, in the east by Abia State and south by Rivers State. The State comprises of 27 Local Government Areas, each with several communities and villages. It has three Agricultural Zones, namely Okigwe, Owerri and Orlu Agricultural Zones. Imo State covers an area of 5100 km^2 with a population of about 3.934 million people in 2006. Agriculture is the major occupation of the people of the State. Almost all the families farm either as primary or secondary occupation. The ecological zone favours the growing of tree crops, roots and tubers, cereals, vegetables and nuts (Nwaru, 2004).

Sampling and Data Collection: A multi-stage sampling technique was used in choosing the sample. In the first stage, two out of the three Agricultural zones were purposively selected based on performance in sweet potato production and these were Owerri and Okigwe. In the second stage, two Local Government Areas were purposively selected from each Agricultural Zone based on sweet potato production performance; they were Ohaji/Egbema and Owerri North from Owerri Zone and Ihitte Uboma and Okigwe from Okigwe Zone. In the third stage, two communities were selected randomly from each Local Government Area giving a total of eight communities sampled. The lists of sweet potato farmers in each sampled community were prepared with the help of the community leaders and agricultural extension agents assigned to the communities sampled. These lists formed the frames from which a random sample of one hundred and twenty sweet potato farmers (64

females and 56 males) was chosen for a detailed study.

The researchers, supported by some trained enumerators, visited the farmers forth nightly (using the cost-route approach) in the 2009 cropping season to collect pieces of information from them. Primary data collected were on sweet potato output, prices, size of land cultivated, labour input, farming experience, other farm costs and materials used in sweet potato production such as sweet potato vines, fertilizer and farm implements. Some socio-economic and demographic characteristics of the respondents such as age, sex, household size, occupation (primary and secondary), farm size and membership of cooperative societies were obtained.

Analytical Procedure: Descriptive statistics were used to analyse the socio-economic characteristics of the farmers. The Cobb-Douglas functional form, using the stochastic frontier was used to estimate the technical efficiency of the farmers and their determinants. A stochastic frontier production function is given as:

$$Y_i = f(X_i; \beta) \exp.(V_i - U_i), \quad i = 1, 2, \ldots, n \qquad \textbf{(1)}$$

Where Y_i is the output of the i-th farm, X_i is the vector of input quantities used by the i-th farm, β is a vector of unknown parameters to be estimated, f( ) represent an appropriate function such as Cobb-Douglas, translog, etc; V_i is a symmetric error accounting for the effect of random variations in output due to factors beyond the control of the farmer e.g. weather, disease outbreaks, measurement errors, etc. V_i is assumed to be independently and identically distributed as $N(O, \delta_v^2)$ random variable independent of the U_is. It is a non-negative random variable representing inefficiency in production relative to the stochastic frontier. The U_is are assumed to be non-negative truncations of the $N(O, \delta_v^2)$ distribution, that is, half normal distribution. They are non-negative random variables associated with technical inefficiency in production.

The stochastic frontier model was independently proposed by Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977). Its major advantage is that it provides numerical measures of technical efficiency for an individual farmer. This is defined in terms of the ratio of the observed output to the corresponding frontier output given the available technology.

Technical efficiency (TE) = $Y_i/Y_i^* = f(X_i; \beta) \exp.(V_i - U_i)/ f(X_i; \beta) \exp.(V_i)$
$= \exp(-U_i)$ **(2)**

Where Y_i is the observed output and Y_i^* is the frontier output and other parameters remain as defined in equation (1). The parameters of the stochastic frontier models are estimated using the maximum likelihood techniques (Aigner *et al.,* 1977).

The empirical model used in estimating the level of technical efficiency was specified as:

$$\ln Y_i = \beta_o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + V_i - U_i \quad \textbf{(3)}$$

Where, In is natural logarithm; Y_i is the output of potato in Kg; X_1 is labour input (mandays); X_2 is quantity of sweet potato vine planted (kg); X_3 is fertilizer used (kg); X_4 is capital (Naira) which was measured as depreciation charges on farm tools and equipment, interest on borrowed capital and rent on land; X_5 is farm size (hectares); β_o is intercept estimated and which represents autonomous output; β_1 - β_5 are parameters estimated while V_i and U_i are as defined in equation (1).

Determinants of Technical Efficiency

In order to examine factors contributing to the observed technical efficiency in sweet potato production, equation (4) was formulated and estimated jointly with equation (3) in a single stage maximum likelihood estimation procedure using the computer software Frontier Version 4.1 (Coelli, 1996).

$$TE_i = b_0 + b_1 Z_1 + b_2 Z_2 + b_3 Z_3 + b_4 Z_4 + b_5 Z_5 + b_6 Z_6 + b_7 Z_7 + b_8 Z_8 \quad \textbf{(4)}$$

Where TE_i is the technical efficiency index of the i-th farmer; Z_1 is the age of the farmer (in years); Z_2 is the household size (in number); Z_3 is the farm size (in hectares); Z_4 is the level of education (in years); Z_5 is the farming experience (in years); Z_6 is the access to credit (access = 1; otherwise = 0); Z_7 is membership of co-operative society or local farmers' association. This is a dummy which is unity if the farmer is a member to a co-operative society or local farmers' association and zero if otherwise; Z_8 is number of extension visits to the farmer; $b_{i(i=0,1,..8)}$ and $\beta i_{(i=0,1,...5)}$ are parameters yielded together with the individual efficiency indices by the estimation of equations (3) and (4).

3. Results and Discussion

The average statistics of the sampled sweet potato farmers were summarized and presented in Table 1. On the average, a typical male sweet potato farmer was 45 years of age with 7.33 years of formal education, about 9 years of farming experience, a household size of about 7 persons, cultivated 0.41 hectares of land, employed 28.56 mandays of labour and produced an output of 138.91kg of sweet potato per annum. For a typical female sweet potato farmer, she was 44 years old, with 8.18 years of formal education, about 8.30 years of farming experience, household size of 6 persons, cultivated 0.36 hectares of land, employed 24.80 mandays of labour and produced 104.70kg of sweet potato per annum.

Table 1: Average statistics of male and female sweet potato farmers in Imo State

Variable	Mean Value		Maximum Value		Minimum Value	
	Male	Female	Male	Female	Male	Female
Age (yrs)	49.893 (10.243)	45.188 (8.972)	68.00	62.00	25.00	29.00
Formal education (yrs)	9.357 (5.065)	11.203 (5.769)	19.00	16.00	0.00	0.00
Farm size (ha)	0.413 (0.036)	0.360 (0.034)	0.76	0.68	0.01	0.01
Farming experience (yrs)	9.321 (4.005)	8.308 (2.480)	16.00	17.00	1.00	1.00
Household size (no.)	8.000 (2.630)	7.000 (2.537)	14.00	15.00	3.00	2.00
Labour (mandays)	28.566 (4.157)	24.580 (3.885	91.20	83.40	3.43	2.90
Fertilizer (Kg)	30.143 (19.340	21.609 (18.079	75.00	70.00	0.00	0.00
Capital (N)	278.071 (83.791)	355.390 (101.905)	530.00	614.00	134.00	120.00
Output (kg)	138.911 (49.822)	104.703 (44.647)	322.85	307.50	38.30	24.10
	n = 56	n = 64				

Source: Survey data, 2008 (.) Standard deviation

Results in Table 2 indicate maximum likelihood estimates of the stochastic frontier production function for sweet potato. The Table indicates that the total variance is

statistically significant for male (p= 0.05) and female (p=0.01) farmers. This indicates goodness of fit and the correctness of the specified distribution assumptions of the composite error terms. The variance ratios were significant and estimated at 0.9848 and 0.9750 for the male (p=0.01) and female (0.01) farmers. These indicate that 98.48 percent and 97.50 percent of the total variation in sweet potato output for the male and female sweet potato farmers respectively was due to technical inefficiency. The coefficients for fertilizer and farm size had the desired positive signs and were statistically significant for both farmer groups, implying direct relationship with output. Sweet potato vine had a direct relationship with output and statistically significant at 10 percent for the male farmers only. Labour and capital had positive and significant coefficients for the women farmers only.

Table 2: Estimated production functions for male and female farmers

Variable	Parameter	Male	Female
Intercept	β_0	6.5047	5.6653
		(16.8866)***	(12.1401)***
Labour	β_1	-0.1563	0.3348
		(-1.3668)	(2.1383)**
Sweet potato vine	β_2	0.1256	0.1092
		(1.7315)*	(1.0690)
Fertilizer	β_3	0.0211	0.0363
		(9.3362)***	(2.0650)**
Capital	β_4	-0.2157	0.2143
		(-0.4565)	(3.5535)***
Farm size	β_5	0.3436	0.2209
		(9.1988)***	(3.7483)***
Diagnostic statistics			
Total variance	σ^2	0.1396	0.3265
		(5.2533)***	(2.4436)**
Variance ratio	γ	0.9848	0.9750
		(106.4513)***	(74.9917)***
LR Test		68.3924	56.9761
Log-likelihood function		25.8206	21.1464

Source: Computed from Survey data 2008, (.) are computed t-value.
***, **, * are significant levels at 1%, 5% and 10% respectively.

The frequency distribution of technical efficiency in sweet potato production is presented in Table 3. The result indicates that the male technical efficiency indices

ranged between 31 percent and 98 percent with a mean of 85 percent, while the female technical efficiency indices ranged between 73 percent and 99 percent with a mean of 92 percent. The Table further indicates that about 80.36 percent of the male and 92.19 percent of the female farmers had technical efficiency indices of 80 percent and above. This implies that an average sweet potato farmer has some room for productivity increase through increases in efficiency. It would take the average and the least efficient male farmers about 13 percent derived by (1 – 0.85/0.98)100 and 65 percent derived by (1 – 0.31/0.98)100 cost saving respectively to become the most efficient farmer. Similarly, for the average and the least technically efficient female farmers to attain the efficiency level of their most efficient counterparts, they would need cost saving of about seven percent derived as (1 – 0.92/0.99)100 and 26 percent derived as (1 – 0.73/0.99)100 respectively.

Table 3: Distribution of the farmers according to technical efficiency indices

Range of technical efficiency indices	Male		Female	
	Frequency	Percentage	Frequency	Percentage
0.30 – 0.39	3	5.36	-	-
0.40 - 0.49	1	1.78	-	-
0.50 – 0.59	2	3.57	-	-
0.60 – 0.69	1	1.78	-	-
0.70 – 0.79	4	7.15	5	7.81
0.80 – 0.89	10	17.86	8	12.50
0.90 – 0.99	35	62.50	51	79.69
Total	56	100.00	64	100.00
Maximum	0.98		0.99	
Mean	0.85		0.92	
Minimum	0.31		0.73	

Source: Computed from Survey data 2008

The estimated determinants of technical efficiency in sweet potato production were summarized and presented in Table 4. The coefficients for age, level of education and membership of cooperatives of potato farmers were positive for both group of farmers but insignificant even at 10 percent level indicating that none of them had meaningful effects on technical efficiency in potato production. These are contrary to *a priori* expectations and to Idiong (2007) who reported significant result between

technical efficiency and education and membership of cooperative but reported an insignificant result for age and extension visits to the farmer.

These results are in agreement with Seyoum *et al.* (1998) and indicate that the pieces of advice from extension workers were beneficial in helping farmers implement the practices associated with new technology. Nwaru (2001) opined that, by ensuring that resources are better mobilized and more efficiently used, a vibrant and functional extension system could be a solution to the problem of acute scarcity of resources in the rural economy which is complicated by inefficiency of use of such resources.

Table 4: Estimated determinants of technical efficiency

Variable	Parameter	Male	Female
Intercept	Z_0	-0.001 (-0.001)	1.263 (1.112)
Age	Z_1	0.021 (1.433)	-0.022 (-1.011)
Household size	Z_2	0.080 (1.737)*	0.116 (1.360)
Farm size	Z_3	-10.991 (-2.138)**	3.955 (9.800)***
Level of education	Z_4	-0.024 (-1.067)	-0.001 (-0.013)
Farming experience	Z_5	0.183 (5.311)***	0.441 (3.052)***
Credit access	Z_6	0.513 (2.399)**	0.905 (1.947)*
Co-operative membership	Z_7	0.147 (0.739)	-0.538 (-0.012)
Extension visit	Z_8	-0.304 (-1.553)	0.831 (2.637)**

Source: Computed from Survey data 2008, (.) are computed t-value.
***, **, * are significant levels at 1%, 5% and 10% respectively.

Coefficient for extension visits was negative and insignificant for the male farmers contrary to *a priori* expectations but positive and significant (p=0.05) for the female farmers in agreement with *a priori* expectations. Pieces of advice from extension

workers were expected to be beneficial in helping farmers implement the practices associated with new technology. The present result indicates that the more the number of contacts a female farmer makes with extension services, the more she receives superior technical advice which translates to higher levels of entrepreneurship and efficiency, *ceteris paribus*. Therefore, policies and programmes aimed at strengthening the extension system especially when targeted more at the female farmers would be good.

The coefficient of farming experience was positive and significant for both farmer groups. This implies that farmers with more years of experience tend to be more efficient in sweet potato production. This result agrees with *a priori* expectations and Adeoti (2004), Idiong (2005), Okoye (2006) and Nwaru (2007) but differed from Onu *et al*. (2000) who reported a negative relationship between technical efficiency and experience and Idiong (2007) who reported appositive but insignificant relationship between technical efficiency and experience. Experience may be defined as the knowledge and skill gained by contact with facts and events (Nwaru, 2004). It gives an indication of the practical knowledge and skills gained over time on how to overcome most of the core problems confronting increased agricultural production and output processing and marketing. The present result implies that programmes and policies for enhancing efficiency in sweet potato production should be targeted more at experienced farmers.

The coefficient for credit was positive and significant for both farmer groups. The implication is that farmers with more access to credit are expected to have higher technical efficiency level than those with less access to credit. This result agrees with *a priori* expectations and Onyenweaku and Nwaru (2005), Idiong (2007 and) Ndukwu (2010) but differs from Okike (2000), who reported a negative relationship between credit and technical efficiency. Farmers' access to credit at the right time and amount enhances their adoption of improved technologies and timely acquisition of necessary and complimentary production inputs, *ceteris paribus,* which leads to higher levels of farm efficiency and output. Therefore, efforts at enhancing farmers' access to credit would be highly rewarding.

Farm size was significant for both farmer groups. This agrees with *a priori* expectations and Onyenweaku and Okoye (2007) and Dimelu *et al*. (2009). However,

coefficient for farm size was negative for the male farmers, implying probable use of farmland beyond its marginal value product. On the other hand, it was positive for the female farmers, implying a direct relationship with technical efficiency. These relationships may be consistent with the practice in the rural setting in which access to land is majorly by inheritance through descent and this is in favour of the male farmers. They further point to the need for land resource reallocation from the male farmers to the females as a step towards increasing efficiency and optimal use of land resources. This is more pertinent because land and labour are the most critical inputs in traditional agriculture (Nwaru, 2004).

Traditionally, rural households count more on their household members than hired workers as sources of farm labour. The coefficients for household size had a direct relationship with technical efficiency and was significant (P=0.10) for the male farmers but insignificant for the female farmers. This is at variance with Nwaru (2004) who reported a significant but negative relationship between technical efficiency and household size and with Dimelu, *et al*. (2009) who rather reported a significant and positive result for the female farmers and insignificant although positive result for the male farmers. The present result implies that female household size does not influence their efficiency in sweet potato production .

4. Conclusion

The results of this study indicate that individual technical efficiency levels for the male farmers ranged between 31 percent and 98 percent with a mean of 85 percent, while that of the female farmers ranged between 73 percent and 99 percent with a mean of 92 percent. That none of the farmer group members achieved an individual efficiency index of unity implies that ample room exists for increases in output through increases in technical efficiency. Important factors directly related to technical efficiency for both farmer groups are farming experience and credit. Therefore, policies aimed at improving the technical efficiency and hence output of the farmers should involve making credit accessible to them and should be targeted more at experienced farmers.

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