PROFITABILITY AND TECHNICAL EFFICIENCY OF SWEET POTATO PRODUCTION IN NIGERIA

MATTHEW O. ADEWUMI*
FATIMOH. A. ADEBAYO*

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Abstract
This study examined the economics of sweet potato production in Kwara State of Nigeria. The study was conducted within the framework of the rural farming households who constitute the backbone of the Nigerian agricultural sector, producing about 80 per cent of the total national agricultural outputwith the cutlass-hoe technology and under rainfed conditions. Using cross-sectional data collected from 152 randomly selected sweet potato farmers from Oyun and Offa Local Government Areas of Kwara State, the study measured the profitability of and the technical efficiency of sweet potato production in the area. Primary data were collected from the sampled farming households using a structured interview schedule. Descriptive and inferential statistics was used to analyze the data. A Cobb Douglas production function was further employed to analyze the data using the maximum likelihood estimation (MLE) procedure to derive the stochastic frontier production function. The study revealed that the typical sweet potatofarmer in the area is a male of about 52 years, with up to 23 years experience in farming and without formal education. The farmers have an average farm size of 1.05ha. The study revealed a positive gross margin of N15,29315 ha-1. Farm size, planting material and labour inputs were significant variables having positive impact on sweet potato output. Fertilizer was found to have negative effect on output. The study further revealed a mean technical efficiency of 0.473. For better efficiency, the land area cultivated, the educational status of the farmers, accessibility to credit facility, and development of the rural areas as well as farmers' contact with the extension agents are some of the key issues to address.

* Department of Agricultural Economics and farm Management, University of Ilorin, Nigeria.

Ⅰ. INTRODUCTION

In view of the serious challenges of feeding a world population that reached 6.1 billion in mid-2000 and is likely to approach 9.3billion in 2050 (Department of Economic and Social Affairs, DESA, 2000), it has become relevant to pay more attention to food production issues. About 215 million (43%) Sub-Saharan African population is chronically undernourished and unless strong action is taken this may increase to around 315 million by the year 2010 (World Food Programme, WFP, 1995).

If food production is to keep pace with rapid population growth and demand for food, a new and creative approach to agricultural development must be developed. In a country where millions of people are not adequately fed, Nigeria's unexploited food resources must be unearthed and utilized. The rural farmers constitute the backbone of the Nigerian agricultural sector producing about 80 percent of the total national agricultural output (Fayinka, 2004) by using traditional methods under rain-fed conditions.

It is important to emphasize that despite the potential benefits stemming from the expansion of the agricultural sector through various government efforts, its overall productivity remains low and the poor performance of agriculture is most clearly evidenced by the low standards of living of these small-scale rural farmers (Dogon-daji, 2005). Sweet sweet potatoes offer a particularly significant potential for increasing food production and income in Nigeria. Like other agricultural crops, sweet potato has a role to play in the developing economies. Its production provides job opportunity for the farmers, thus raising their income. Sweet potato is consumed without much processing in most parts of the tropics. It is either eaten boiled, roasted or fried. In countries like the United States, it is dehydrated into chips, canned, cooked and frozen, creamed and used as pie fillings. It is also dried and ground into flour to make biscuits, bread and other pastries. Sweet sweet potato can also be pounded together with yam to give a delicious meal. Although sweet sweet potato is a crop that is consumed in all parts of the country, its level of production still remains low. The world sweet potato sector is however undergoing major changes. Worldwide, sweet potato's production and consumption is huge. All over the world people eat and use this super food. The crop ranks among the five most important food crops in over 50 developing countries. (All about

Sweet Potatoes, 2008)

The demand is quite higher than the supply (Ajakaiye and Akande, 1999). The roots can also be slightly fermented in water for 2-3 days to reduce the sweetness, then sun dried and milled mixed with either yam or cassava flour for eating. The leaves and tender shoots of sweet potato are used as vegetable food. The leaf contains, on dry-matter basis, about 8% starch, 4% sugar, 27% protein and 10% ash. The leaves are much richer than the root in protein, minerals and vitamins and therefore are more nutritious. It also contains about 56mg carotene per 100g dry matter. The leaves are usually eaten boiled or incorporated into soup and stews.

Both the leaf and roots of sweet potato are used as animal feed. Roots to be used for feed are cleaned, by washing or brushing, and they are then shredded or sliced, treated with sulfur dioxide and dried rapidly, either in the sun or heated in air at 80oC or higher. The dried product can be fed whole or ground to cattle, sheep, pigs, goats and poultry. The leaf may also be fed to livestock either fresh or in the form of silage. Greatly esteemed as feed for farm animals, 3kg green sweet potatoes is equivalent to 1kg of corn, with a food value rated 95-100% that of corn. Dry vines have feed value that compares favorably with alfalfa hay as forage (Reed, 1976).

Industrially, sweet potato flour can be used to substitute wheat flour in bread making or maize flour in balanced feeds. Baby foods have been formulated using sweet potato while some bakeries blend 15-30% of sweet potato-flour for making bread and 20-30% for pastries. It is also used in the brewing of alcoholic drinks and as sweeteners in non-alcoholic drinks. (Agbo and Ene, 1992). Sweet potato starch can also be used in textile, glue, paint and cardboard industries. Sweet potatoes also have medicinal value. According to Hartwell (1967-1971), the leaf decoction is used in folk remedies for tumor of the mouth and throat. Reported to be alterative, aphrodisiac, astringent, bactericide, demulcent, fungicide, laxative and tonic, sweet potatois a folk remedy for asthma, bug bites, burns, catarrh, ciguatera, convalescence, diarrhea, dyslactea, fever, nausea, renosis, splenosis, stomach distress, tumors and whit lows (Duke and Wain, 1981). Industrial potentials of sweet potato have not been exploited due mainly to a chronic lack of awareness the commercial benefits derivable from sweet potato (Azogu and Olomo, 2002).

Little research is known to have been undertaken on the economics of sweet potato production compared to other roots and tubers like cassava and

yam. (Akinwumi 2002, Azogu and Olomo, 2002). In an economy where resources are scarce and opportunities for new technology are lacking, efficiency studies can show the possibility of raising productivity by improving efficiency without expanding the resource base. This study will therefore serve as a guide to agricultural key players on sweet potatoes investment decisions in Nigeria. It will also provide useful information to other countries facing a similar situation.

This study describes the socio-economic characteristics of sweet potato farmers in a major producing area in Nigeria; evaluates the profitability and the technical efficiency of its production in the study area.

II. METHODOLOGY

1. Area of Study

This study was carried out in Kwara State of Nigeria. With a population of about 1.55 million (1991 Census), the state is made of sixteen Local Government Areas, and it has about 247,975 farm families and 254,242 hectares of cropped area. The state lies between latitudes 7°45´N and 9°30´N and longitudes 2°30´E and 6°35´E. The annual rainfall pattern across the state extends between the months of April and October with minimum temperature ranging from 21.1℃ to 25℃ while maximum average temperature ranges from 30℃ to 35℃. The main crops grown are sweet sweet potato, cassava, yam, cowpea, groundnut, maize, sorghum, wheat, melon, okra, pepper and some leafy vegetables. (KWADP, 1996).

Both primary and secondary data were used for this study. A combination of purposive and two-stage random sampling technique was used to select the respondents for this study. Offa and Oyun LGA's were purposively selected in the first stage, because the area produces 80% of sweet potato output in the state (KWADP, 1996). In the second stage, 19 villages from 38 villages in Oyun and one from the three villages in Offa Local Government were randomly selected based on proportional allocation. Eight sweet potato farming households were finally selected randomly from each of the villages giving a sample

size of 160 respondents. Of the 160 interview schedules, 152 were however found useful for analysis. The sampling frame was the Kwara State Agricultural Development project (KWADP) village and household listing.

2. Analytical techniques

Simple descriptive statistics such as percentages, frequency distribution, mean, mode and ratios were utilized to describe the socio-economic characteristics of the respondents. The gross margin analysis was used to determine the profitability of the sweet potato production in the area. Gross margin is expressed as

$$GM = TR - TVC$$

Where,

GM = Gross Margin (N/ha)
TR = Total Revenue (N/ha)
TVC = Total Variable Cost (N/ha)

A stochastic production frontier model was used to measure technical efficiency, and inefficiency of resources. The approach specifies the relationship between output and input levels using two error terms. One error term is the traditional normal error term with a mean zero and constant variance. The other error term represents the technical inefficiency which is subsequently estimated via Maximum Likelihood Estimation method (MLE) (Aigner, Lovell and Schmidt 1977, Rahji, 2005). The MLE has the property of generating a consistent and asymptotic efficient estimator. The frontier production model with a multiplicative disturbance term was used in this study.

$$Y = F(X_{ai}\ \beta)e^{E} \quad \text{..... (1)}$$

where, Y = output of sweet potatoes in kilogram
X_a = is a vector of input quantities

β = is a vector of parameter and E is a stochastic disturbance term con-

sisting of two independent elements u and v where E = u + v

The symmetric component, v, accounts for random variation in output due to factors outside the farmer's control such as weather and diseases. It is assumed to be normally, independently and identically distributed as $N\sim(0, d^2_v)$. A one-sided component ≤ 0 reflects technical inefficiency relative to the stochastic frontier. Thus, U = 0 for a farm output which lies on the frontier and U < 0 for output which is below the frontier; hence, the distribution of U is half normal. Sweet potato production in the study area is assumed to be specified by a Cobb Douglass frontier production function defined as

$$\ln Y = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + V_i - U_I \quad \cdots\cdots (2)$$

Where, Y = output of sweet potato in kilogram
X_1 = Land measured in hectares of cultivated areas
X_2 = fertilizer used measured in kilogram
X_3 = seed (number of vine cuttings)
X_4 = labour in man-days
β_0 = technical efficiency level
β_1, β_2 , β_3, β_4 = coefficients of the various inputs with respect to output level.
V_i= random error due to mis-specification of the model and variation in output due to exogenous factors outside the farmer's control. The Cobb Douglas function is very useful in empirical analysis. The partial elasticities are equal to each of the parameters and when linearized in log, the function is easy to fit and the coefficients are direct elasticities.
U_i = inefficiency component of the error term. The inefficiency model is of the form:

$$U_i = d_0 + d_1 Z_1 + d_2 Z_2 + d_3 Z_3 + d_4 Z_4 + \cdots\cdots + d_n Z_n \quad \cdots\cdots (3)$$

Where, U_i = technical inefficiency
Z_1 = Years of experience of the farmers (years)
Z_2 = Level of education (years)
Z_3 = Farm size (hectares)
Z_4 = Access to formal credit (Yes = 1, No = 0)

Z_5 = Land ownership form (Privately owned = 1, Otherwise = 0)
Z_6 = Membership of cooperatives/farmers association (Yes=1, No= 0)
Z_7 = Extension visits (Yes = 1, No = 0)
Z_8 = Household size (number)
d_0, d_i $\cdots d_8$ = parameters to be estimated

Since the dependent variable of the inefficiency model represents the mode of inefficiency, a positive sign of an estimated parameter implies that the associated variable has a negative effect on efficiency but positive effect on inefficiency and vice versa.

III. RESULTS AND DISCUSSIONS

The socio-economic characteristics of the respondents are

The household heads interviewed were all males. Female members in the family are usually engaged in activities like fertilizer application, fetching water for spraying and transportation of harvested sweet potatoes from farm to the roadsides. The men are actually the farm owners and heads of households and are involved in more tedious works than their female counterparts. The modal age group for these men sweet potato farmers in the study area is 41-50 years. A mean age of 52 years was recorded for the farmers, with the youngest farmer being 25 years old and the oldest 75 years. The majority (about 88%) of the farmers are between 41 and 75 years of age while the remaining 12% are below 40 years. This shows that most of the young adults are not involved actively in sweet potato farming. This could be a result of the rural urban drift prevalent in Nigeria. Many young people always seek a more lucrative job in the cities rather than farming in the villages. This has implication for policy. Nigeria is actually recognized as one of the countries in the world with very high rural-urban dichotomy. The number of rural inhabitants that migrate to cities with high hope of overcoming powerlessness consistent with rural life is unprecedented (Nwokocha, 2008).

The marital status of the respondents was skewed: 149 of the household heads were married. This probably explains why women and children were available as family labour.

TABLE 1. Socio-Economic Characteristics of the Respondents

Characteristics	Frequency	Percentage
I. Age of the Household Head		
21-30 years	3	1.97
31-40years	15	9.87
41-50years	59	38.82
51-60years	57	37.50
>60years	18	11.84
Total	152	100
II. Family Size of Respondents		
0-5 Members	10	6.58
6-10 Members	94	61.84
11-15 Members	40	26.32
>15 Members	8	5.26
Total	152	100
III. Education Status of the Household Head		
No formal education	96	63.16
Adult education	15	9.87
Primary education	21	13.82
Secondary education	9	5.92
Post secondary education	11	7.24
Total	152	100
IV. Primary Occupation of the Household Head		
Farming only	106	69.74
Formal	4	2.63
Non-formal	42	27.63
Total	152	100
V. Household Head's Farming Experience		
1-10years	33	21.71
11-20years	48	31.58
21-30years	50	32.89
>30years	21	13.82
Total	152	100
VI. Membership of Association		
Cooperative	9	5.92
Farmers Association	46	30.26
Nil	97	63.82
Total	152	100

Source: Field survey, 2006.

Family size is an important source of family labour. About 93 per cent of the respondents have their family size to be greater than five. The modal family size is 6-10 members while average household size is nine persons. About 48 percent of the respondents have their family size to be greater than this average size. This implies a likely reduction in the cost of hired labour (Table 1).

More than half of the respondents (63.16%) have no formal education. This is a reflection of quality of labour. This may be responsible for the low level of innovation and technology adoption by the farmers. This could also explain why the farmers do not keep appropriate farm records. About 70% of the farmers have farming as their main occupation. The few that were engaged in farming on part time were mainly school teachers, bricklayers, carpenters, traders, drivers, painters and tailors. The average number of years of farming experience of the farmers is 23years. Over 60% of the respondents have been planting sweet potato for the past 11 to 30 years. This indicates that the farmers are highly experienced in the cultivation of sweet potatoes.

IV. FARM INPUT CHARACTERISTICS

Access to land is not a constraint in the study area, as respondents claimed not having problem in acquiring land for production. However, majority acquired land through inheritance (Table 2). This mode of land acquisition encourages land fragmentation. The average land size cultivated is 1.05 ha. About 70% of the respondents cultivated below this average, which implies that they grow sweet potato on a small-scale level, and the likely implication of this is low output.

Farming households used “only family labour (2.63%),” “hired labour (28.95%)” or the “combination of the two (68.42)” for their sweet potato farming activities. For those that supplement the hired labour with family labour, family labour was used in operations such as planting, fertilizer application and harvesting while hired labour was used mainly for land clearing, ridging, weeding and spraying. A majority of the respondents claimed to have experienced shortage of labour during land clearing and ridging leading to a high cost of performing such operations. The average labour input per household is 188.84 man-day ha-1, out of which 52% are family labour.

About 84% of the sweet potatofarming households (84.21%) used their personal savings to finance their farm activities. Capital from this source is usually very small and this may be one of the reasons why the farmers cultivated small farm sizes.

About 96% of the respondents source the vine cuttings planted from previous harvest, friends, or relatives while only a few purchased theirs. Use of fertilizer was inadequate as only a few used it. Those that did not use complained of non-availability of fertilizer in the village and high cost of procurement from the cities. Some also claimed that they have fertile land that does not require fertilizer. An average of 142 kilogramme ha^{-1} of inorganic fertilizer was used. Only 5.9 % of the respondents used agrochemicals. Chemicals are expensive and not available in the villages. There may be a need for more extension agent visits to educate these farmers on the use of fertilizer. An average of 3.4 liters ha^{-1} of agro-chemical was used.

TABLE 2. Land Area under Sweet Potato Cultivation

Characteristics	Frequency	Percentage
I. Source of Land		
Family	67	44.08
Inherited	72	47.37
Hired	8	5.26
Inherited/Hired	3	1.97
Family/Hired	2	1.32
Total	152	100
II. Farm Size		
0.1-0.499	24	15.79
0.5- 0.990	82	53.95
1.0-1.499	25	16.45
1.5-1.990	15	9.90
2.0-2.990	6	3.90
Total	152	100
III. Number of Plots		
1	23	15.13
2	81	53.29
3	32	21.05
4	16	10.53
Total	152	100

Source: Field survey 2006.

TABLE 3. Distribution of Respondents According to Farm Inputs Sources

Characteristics	Frequency	percentage
I. Source of Capital		
Personal savings	128	84.21
Friends & relatives/personal savings	11	7.24
Cooperative society	8	5.26
Cooperative/personal savings	5	3.29
Total	152	100
II. Source of planting materials		
Own farm	62	40.79
Friends and relatives/own farm	54	35.53
Friends and relatives	30	19.74
Purchased	06	03.93
Total	152	100
III. Usage of Fertilizer		
Used	18	11.84
Not used	134	88.16
Total	152	100

Source: Field survey 2006

Gross Margin Analysis

Farmers sold their produce in the nearest markets or at the farm gate while others took it to urban areas to sell at higher prices. An average gross income of N73, 972.82 ha-1 of sweet potato was obtained in the study area (Table 4).

TABLE 4. Gross Margin Analysis

		Value (N/Ha)
Gross Income /Ha	=	73,972.82
Less Variable Cost		
Cost of Fertilizer /Ha	=	6,859.67
Cost of Seed /Ha	=	3,537.71
Cost of Chemical /Ha	=	3,211.76
Cost of Hired Labour	=	28,047.63
Imputed Cost of Family Labour	=	6,561.72
Transportation cost	=	10,461.18
Total Variable Cost /Ha	=	58,679.67
Equals Gross Margin	=	15,293.15
(USD 1.00 = N128.00))		

The average gross margin is N15,293.15 ha-1. Labour cost constituted the largest component of variable cost. This is in agreement with previous findings on small scale farming systems in the country (Tsoho, 2004).

TABLE 5. Maximum Likelihood Estimates of the Stochastic Frontier Production Function.

Variables	Parameters	Coefficient	Standard error	t-ratio
Stochastic frontier				
Constant	b_0	0.776	0.112	6.963
Land	b_1	0.476**	0.170	2.791
Fertilizer	b_2	-0.140**	0.386	-3.634
Seed	b_3	0.077**	0.022	3.534
Labour	b_4	0.121	0.109	1.1163
Inefficiency Model				
Constant	d_0	-0.102	0.509	-2.002
Experience	d_1	0.727**	0.248	2.931
Education	d_2	-0.859**	0.317	-2.713
Farm size	d_3	-0.259*	0.141	-1.837
Formal credit	d_4	-0.360*	0.191	-1.882
Land ownership form	d_5	-0.155	0.985	-1.575
Membership of association	d_6	-0.627**	0.213	-2.943
Contact with extension agent	d_7	-0.128*	0.664	-1.935
Household size	d_8	0.356*	0.188	1.897
Variance parameters				
Sigma-squared (δ^2)		0.513*	0.281	1.826
		0.950	0.429	0.230
Lambda(λ)		4.36		

* Significant at 10%; ** Significant at 5% levels of probabilities.

The variance parameter (δ^2) is positive and significant at 10%. This indicates the goodness of the specified distributional assumptions of the composite error. The value of lambda (λ) is also greater than one implying a good fit for the estimated model and also correctness of the specified distributional assumption of the error terms. This is also evident from the estimated Gamma of 0.950, which is close to one. This confirms that the technical inefficiency effects are significant in the estimated model.

In consonance with *a priori* expectation, the coefficients of land, sweet potato sets, and labour are positive and statistically significant. This im-

plies that the more the area of land cultivated, quantity of planting materials and labour input, the more the output. However against *a priori* expectation, fertilizer has negative sign that could be traced to the inadequate use of fertilizer by those who even used it.

The coefficients of farmers' experience in farming and household size are both positive and significant in the inefficiency model. All the other significant coefficients in the inefficiency model are negative. This implies that increase in educational level of the farmer, farm size, and contacts with extension agents have the tendency of reducing the inefficiency level in sweet potato production in the study area. The positive correlation between education and technical efficiency is consistent with previous findings (Amaza and Olayemi 2000). Extension contact leads to more efficient transmission of information to farmers as well as enhancing the adoption of innovation.

The positive and significant farming experience coefficient may be a reflection of the ageing nature of the sweet potato farmers. In a few years to come, if nothing is done to address the situation, there may not be any sweet potato farmers again in the study area. This result is consistent with that of Onu, et al (2000).

Credit sourceshowed a positive relationship with technical efficiency. This implies that the farmers who have greater access to credit tend to be more efficient in production. This agrees with the findings of Onyenweaku, Igwe and Mbanasor (2004).

Membership of association is positively and significantly related to technical efficiency. Being a member of association enables the farmers to have access to agricultural information, credit and other inputs as well as enhanced ability to adopt innovations. Household size is negatively and significantly correlated with technical efficiency. This implies that as household size increases, technical efficiency decreases.

The study revealed a mean technical efficiency of 47.3. This mean value indicates that if input usage is increased by 52.7%, the sweet potato farms in the study area will be operating on the production frontier. Thus, opportunity still exists for increasing productivity and income through increased efficiency in resource utilization. About 28% of the farmers fall below this mean efficiency level compared with about 72% of the farmers who have their technical efficiency greater than the mean technical efficiency.

A wide gap exists between the efficiency of best technically efficient

farmer (91.2%) and that of the average farmer (47.3%). This type of wide variation in farmer's specific efficiency levels is a common phenomenon in developing countries (Amaza, et al. 2000). The result, however, indicates that great potential exists for the sweet potato farmers to further increase output using the available resources.

V. CONCLUSION

Given the profitability of sweet potato production and abundance of land in the area, it is suggested that more land be put into sweet potato cultivation to improve the efficiency at which farmers operate. Farmers in the study area also show the willingness to grow sweet potato on a large scale provided the inputs are available. There is also the need to launch initiatives and enlighten the various sectors of the economy on the usefulness of sweet potato. Industries such as flour mills, bakeries, textiles industries etc. could be enlightened and encouraged to exploit the potentials of sweet potato. There is also the need to ensure that the extension agents visit the sweet potato farmers for proper information dissemination. Farmers need be well informed on the use of agro-chemicals, fertilizer and improved varieties of stem cuttings. Farmers need to know that indiscriminate application of fertilizer does not necessarily improve the soil nutrients.

The rural areas should be provided the necessary infrastructure and utilities to discourage rural urban migration. This can help to retain young people including extension agents in the rural places where they are mostly needed. Farmers should also be encouraged to form farmers association and cooperatives to increase their chances of obtaining loan from financial institutions and benefit from various farm credit schemes. The problem of inadequacy of fertilizer supply in the rural areas needs be addressed as well. If research effort is geared towards the development of cheap and cost effective farm implements, as well as post-harvest technologies addressing storage and processing, post-harvest losses may be reduced.

This study, although based in Nigeria, may have implications for other developing countries with a similar situation

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