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Opportunities for Smallholder Spinach Farmers in Nigeria: A Profit Efficiency Analysis

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ABSTRACT This study applied the stochastic frontier profit function to evaluate the profit efficiency of smallholder spinach farmers in Benue State, Nigeria in order to examine the opportunities available to farmers in the state. The average profit efficiency was 89 percent suggesting that an estimated 11 percent of the profit was lost owing to a mixture of both technical and allocative inefficiency in spinach production among the sampled farmers. In other words, profit efficiency among the sampled spinach farmers can be increased by 11 percent through improved use of existing production resources, given the current state of technology. Results further showed that the profit efficiency of the spinach farmers were positively influenced by educational level, farming experience, access to credit and access to extension services. Consequently, investments in farmers' education through effective extension delivery program and provision of credit will help farmers to increase their profit efficiency.

INTRODUCTION

Agricultural production in Nigeria is dominated by small-scale farmers who produce more than 90 percent of the food consumed in the country. One of the major crops produced are vegetables which represent an essential part of agricultural products. Their production remains entrenched in Nigerian agriculture and forms an important condiment in the national diet (Ibekwe and Adesope 2010). Amongst the different foods, production and consumption of vegetables are very important because of their contribution to good health by providing inexpensive sources of minerals and vitamins needed to supplement people's diet which are mainly carbohydrates (Adedoyin et al. 1996). Vegetables are the most important and extensively cultivated food and income generating crops in many parts of Africa (Adebisi-Adelani et al. 2011). According to Mohammed (2002), they can give high yield per unit area of land and hence generate high income for the farmers. Spinach (*Amaranthus Spp*.) is one of the leading green leafy vegetables in Nigeria. Spinach takes an important place in the population diet because of its affordability and the nutrients it provides. Spinach is often grown and consumed in rural, urban and peri-urban areas in Nigeria. Spinach is produced mainly by small-scale farmers who earn their living from it, using limited farm inputs.

Growing vegetables is particularly suited for small-scale farmers and their families because of their limited resources (Robert 2003). According to Rahji and Omotesho (2006), the efficiency with which farmers use resources and technologies available to them are imperative in Nigeria agricultural production since the main problem in the country revolves around low productivity. This has resulted in low farm income which has weakened the financial position of smallholder farmers who produce most of the food crops in Nigeria, a condition that has led to poor funding of their economic activities. The implication is that there is scope for further increase in output from existing hectares of food crop if resources are accurately exploited (Rahji and Omotesho 2006).

Efficiency is concerned with relative performance of the processes used in transforming given input into output (Ohajianya and Onyeweaku 2001). Efficiency measurement has received significant attention from researchers in different fields of study. Measuring efficiency is vital because this is the first measure in practice that might lead to considerable resource savings, which have important implications for both policy formulation and firm management (Bravo-Ureta and Rieger 1991). There are two main frontier approaches to the measurement of efficiency: the parametric, which entails econometric methods, and the non-parametric, which uses mathematical programming methods. The parametric stochastic frontier analysis (SFA) approach depends on the parametric specification of a production function, cost function, or profit function fitted to the data (Forsund et al. 1980). The non-parametric Data Envel-

opment Analysis (DEA) approach for measuring efficiency entails mathematical programming methods. Contrary to econometric approaches, programming methods circumvent the problem of misspecification of functional form. Also, programming methods can simply handle disaggregated inputs and multiple output technologies. Being non-stochastic, the DEA approach does not differentiate data noise and inefficiency (Coelli 1996). On the other hand, SFA takes into account measurement errors and other noise in the data. Thus, SFA is very important for studies of farm level data that usually include measurement errors.

Increasing efficiency of resource use and productivity at the farm level, among many other factors, is one of the basics for sustainable agriculture (FAO 1997). To achieve this increase, effort must be taken to examine the productive efficiency of farmers in the country using profit efficiency (Ogundari 2006). Profit efficiency is defined as the ability of a firm to attain the highest possible profit given the prices and levels of fixed factors of that firm while profit inefficiency in this framework is defined as loss of profit from not operating on the frontier (Ali and Flinn 1989). Put differently, profit inefficiency measures the level to which a firm's profit falls below the profit of the best-practice firm (Kasman and Yildirim 2006). The profit function is an extension of the production function (Sadoulet and de Janvry 1995). It combines the concepts of technical and allocative efficiency in the profit relationships and any errors in the production decision would translate into lower profits or revenue for the farm (Rahman 2003). Consequently, estimating profit efficiency represents a vital source of information for policy makers than the partial vision presented by analysing cost efficiency (Maudos et al. 2002).

Given that profit efficiency improvement could lead to larger remuneration for agricultural producer, particularly the smallholder farmers in the country, it became necessary to assess the opportunities for smallholder spinach producers in Benue state, the acclaimed 'food basket' of the nation.

The main objective of this study is to evaluate the profit efficiency of smallholder spinach farmers in Benue state, Nigeria, using a stochastic profit frontier approach in order to examine the existing opportunities in spinach production. It will also assess the effects of selected socio-economic variables on the profit efficiency of the sampled spinach farmers. The study will provide significant information that will be useful in improving the performance of spinach farms by distinguishing the "best-practises" and worst practices associated with the individual efficiency level. This will in turn facilitate the endorsement of sound policies that could encourage smallholder farmers' participation in spinach production with the aim of raising the income levels of poor farming household and poverty reduction.

MATERIALS AND METHODS

Study Area and Data

The study was conducted in Makurdi, Benue State, Nigeria, which lies between latitude 7.2 to 8^{o} north and longitude 8.2 to 9^{o} west. The region is characterized by a rainy season, from April to October, and a dry season, from late-October to March. Data were collected during the 2008–2009 cropping seasons. Ten areas were selected based on the population of spinach farms. Ten farmers from each council ward were randomly selected for interview for a total of 100 respondents. However, only 75 questionnaires were suitable for analysis. Respondents were interviewed by administering a questionnaire designed to collect information on output, cost of inputs and some selected socio-economic characteristics. Input data included cost of land, cost of seed, costs of fertilizer and cost of labour. Data on socio-economic variables included age, education, household size, experience, access to credit and extension services

Model Specification

Following Rahman (2003), the general specification of a stochastic profit function is given as:

$$\pi_i = f(P_i, z_j).\exp(\varepsilon_i);\ \varepsilon_i = V_i - U_i \quad \text{.........} (1)$$

where π_i is the normalized profit of the ith farm defined as gross revenue less total variable cost, divided by farm specific output price; P_i is *the* price of variable inputs faced by the ith farm divided firm specific output price; Z_j is the level of the fixed factor on the ith farm; and ε_i is an error term; and i = 1,.., n, is the number of farms in the sample. The error term ε_i is assumed to behave in a way consistent with the

frontier concept (Ali and Flinn 1989; Rahman 2003). Consequently, these two components of the error term (V_i and U_i) are assumed to be independently distributed $v_i \sim iid\ N(0, \sigma^2_v)$ and $u_i \sim iid\ N^+(0, \sigma^2_u)$. V_i is a two-sided error term representing the usual random effect found in any system, U_i is a one-sided error term representing profit inefficiency. The U_i's are assumed to have a half normal non-negative distribution $N(0, \sigma^2_u)$. The V's are assumed to have a half normal non-negative distribution (Abdulai and Huf-fman 1998). According to Ali and Flinn (1989), U_i measures profit inefficiency in that it measures profit loss from its maximum possible value given by the stochastic frontier. Thus, given the above model specification, the profit efficiency of the *ith* firm in the context of stochastic frontier profit function can then be defined as:

$$\pi E = E\left[\exp\left(-U_j\right)/\varepsilon_i\right] \quad (2)$$

where πE (profit efficiency) takes the value between 0 and 1. Adopting Coelli's (1996) model, this study specifies a Cobb-Douglas stochastic frontier function with behaviour inefficiency components. The explicit Cobb-Douglas functional form for the smallholder spinach farmers in Benue state, Nigeria, is expressed as:

$$\ln \pi_i = \ln \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln P_{1i} + \beta_3 \ln P_{2i} + \beta_4 \ln P_{3i} + \beta_4 \ln P_{3i} + \beta_5 \ln P_{4i} + (V_i - U_i) \quad (3)$$

Where: π_i represents normalized profit computed as total revenue less variable cost divided by farm specific spinach price; X_i represents farm size (ha); P_1 represents rent on land (in Naira), P_2 represents cost of seed (in Naira); P3 represents cost of fertilizer (in Naira); P4 represents cost of labour per man day (in Naira).

Inefficiency causes costs to rise, which in turn leads to a fall in profit. Thus, to examine the effect of the possible determinants of profit inefficiency, the following inefficiency (Ui) model was estimated:

$$U_i = \delta_0 + \delta_1 W_{1i} + \delta_2 W_{2i} + \delta_3 W_{3i} + \delta_4 W_{4i} + \delta_5 W_{5i} + \delta_6 W_{6i} \quad (4)$$

Where W_1, W_2, W_3, W_4, W_5 and W_6 represents age, educational level, household size, farming experience, access to credit and extension service. These socio-economic variables were included in the model to indicate their possible influence on the profit efficiencies of the spinach farmers. All parameters of the stochastic frontier profit function and the inefficiency model were estimated together using the program Frontier Version 4.1c (Coelli 1996).

RESULTS AND DISCUSSION

Majority (54.7%) of the sampled spinach farmers were above 41 years of age (Table 1). This is an indication that spinach farmers in the study area were relatively younger farmers. This has a positive effect for improved efficiency, given that younger farmers are more likely to take risk by adopting better spinach production methods, than older farmers who are more often than not conservative (Nwaru 2004). Majority of the farmers (56%) had family size of between 6–10 members, an indication that a large family is still a common practice among farmers as they often depend on family labour. The importance of family labour cannot be overemphasized, because household size is the principal determinant of labour availability in small-scale farming given the relatively soaring cost of hired labour. Most of the farmers (73.3%) had no access to credit. This is the case with most small-scale farmers in Nigeria. This observation confirms results of an earlier study by Agom et al. (2011). Credit has the ability of eliminating the constraint of timely acquisition and utilization of inputs in production. Thus, lack of credit implies that spinach farmers will not be able to use resources optimally and consequently making them less efficient. Furthermore, more than half of the farmers (69.3%) had no access to extension services, implying that their adoption of innovation will be hampered. With regards to experience, results revealed that majority of the farmers (57.3%). had farming experience of 6-10 years (Table 1) implying that most of the farmers were relatively new.

The maximum likelihood estimates of the parameters of the stochastic profit frontier model are presented in Table 2. Only the coefficients of the farm size and cost seeds were found to be positive while the cost of land, fertilizer and labour were negative. Demonstrating that farm size and cost of seed had positive effect on the profit efficiency of spinach farming in Nigeria while the rent on land, fertilizer and labour had negative effect on profit efficiency. The negative sign of rent on land may be due to high cost of rental paid on land while the negative cost of fertilizer may perhaps be due to wrong use leading to too much application of fertilizer by the spinach farmers, therefore resulting in extra cost sustained by the farmers. The estimated sigma squared (σ^2) was significantly different from zero at the 5 percent level, implying that the Cobb-

Table 1: Socio-economic characteristics of sampled farmers (n = 75)

Variables	*Frequency*	*Percentages*
Age		
21-40	34	45.3
41 and above	41	54.7
Sex		
Male	54	72
female	21	28
Household Size		
<5	12	16
6-10	42	56
11-15	17	22.7
>16	4	5.3
Education (Years)		
1-6	41	54.7
7 years and above	34	45.3
Experience (Years)		
<5	10	13.3
6-10	43	57.3
11-15	13	17.3
>16	9	12
Access to Credit		
Yes	20	26.7
No	55	73.3
Access to Extension Service		
Yes	23	30.7
No	52	69.3

Douglas stochastic profit frontier model is an adequate representation of the data. This conforms to (Sharma et al. 1999; Rahman 2003). In addition, the estimated gamma parameter (γ) of 0.61 was significant at 5 percent level of significance (Table 2), indicating that about 61 percent of the variation in actual profit from maximum profit (profit frontier) among spinach farms was due mainly to differences in farmers' practices rather than random variability.

The results further showed that the profit efficiency of the spinach farmers were positively influenced by educational level, farming experiences, access to credit and access to extension services (Table 2). This result is in agreement with Lockheed et al. (1980), Ali and Flinn (1989), Abdulai and Huffman (1998) and Sharma et al. (1999). Thus, investments in rural education through effective extension delivery program and provision of credit will boost farmers' efficiency. The result of this study has clearly shown that opportunities exist in spinach production. Therefore, engaging in spinach production could be one sure way that would assist resource poor farm household to increase their income levels thereby reducing poverty in the country.

Results revealed that profit efficiency among the sampled spinach farmers varied between

Table 2: Estimates of the parameter of the stochastic profit function for spinach farmers in the study area

Variables	*Parameter*	*Coefficient*	*Standard error*	*t-ratio*
Stochastic Frontier Model				
Constant	β_0	11.72	1.43	8.23***
In (farm size in hectares)	β_1	0.07	0.06	1.16*
In (Rent on land in ₦)	β_2	-0.22	0.20	-1.10*
In (cost of seed in ₦)	β_3	0.38	0.12	3.17***
In (cost of fertilizer in ₦)	β_4	-0.03	0.12	-0.25
In (cost of labour in ₦)	β_5	-0.13	0.03	-3.36***
Inefficiency Model				
Constant	δ_0	4.11	2.37	1.73*
Age	δ_1	5.04	0.52	9.69***
Education	δ_2	-1.15	0.22	-5.26
Household size	δ_3	4.57	0.54	8.46***
Experience	δ_4	-5.78	0.58	-9.97
Access to credit	δ_5	-0.41	0.42	-0.98
Extension service	δ_6	-0.98	0.87	-1.13*
Sigma squared	$\square^2$	0.14	0.06	2.33**
Gamma	Υ	0.61	0.21	2.90**
Log likelihood function	LLF	-5.41		

Notes: ₦ = Naira (Nigerian currency); *** Significant at 1%; ** significant at 5%; *significant at 10%

0.53 and 0.97 with a mean profit efficiency of 0.89 (Table 3). This implies that on an average about 11 percent of profit is lost due to both technical and allocative inefficiencies. In other words, profit efficiency among the sampled farmers can be increased by 11 percent through improved use of existing production resources, given the current state of technology. This would allow the farmers to obtain maximum profit and hence increase their farm incomes thus reducing poverty.

Table 3: Profit efficiency estimates for the sampled spinach farmers

Profit efficiency level	*Frequency*	*Relative percentage*
0.51-0.70	6	8.0
0.71-0.90	25	33.3
>0.91	44	58.7
Total	75	100
Mean	0.89	
Minimum	0.53	
Maximum	0.97	

CONCLUSION

A stochastic profit frontier function was used to evaluate the profit efficiency of smallholder spinach farmers in Benue State, Nigeria, in order to examine the prospects available to farmers in the state. The average profit efficiency

was 89 percent suggesting that an estimated 11 percent of the profit was lost due to a combination of both technical and allocative inefficiency in spinach production among the sampled farmers. Results further showed that profit efficiency of the spinach farmers were positively influenced by educational level, farming experiences, access to credit and access to extension services. Consequently, provision of credit as well as investments in rural education through effective extension delivery program will help farmers to overcome their inefficiency all things being equal. Judging from the results of the study it is clear that considerable opportunities exist in spinach production if resources are used efficiently.

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