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MEASUREMENT OF FARM LEVEL EFFICIENCY OF HOME GARDENS IN UYO, NIGERIA: A STOCHASTIC PRODUCTION FRONTIER APPROACH

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ABSTRACT

To investigate the farm level efficiency of home vegetable gardens in Uyo, a stochastic production function which incorporates a model for the technical inefficiency effects was used. Using farm-level data from 80 home gardeners obtained through structured questionnaire, the parameters were estimated simultaneously with those of the model of inefficiency effect. Variables included in the model for the efficiency effects were land, family labour, fertilizer, hired labour, manure and capital. Asymptotic parameter estimates were evaluated to describe efficiency determinants using the maximum likelihood estimation technique. Results reveal that the most important resource inputs were family labour, land, manure and hired labour and were significant at (P < 0.01, P < 0.05, P < 0.10). Results further reveal a mean technical efficiency of 0.80 suggesting that output from home gardening could be raised by 20 percent using resources and technology available.

KEY WORDS: Measurement, Efficiency, Gardens, Nigeria.

INTRODUCTION

Home Gardens refer to traditional land-use practices near the homestead where different plant species (predominantly vegetables combined with fruits, fodder, medicinal herbs and ornamental plants) are maintained by members of the household with the products intended primarily for household consumption (Gautam *et al.,* 2007). They are common throughout Sub-Saharan Africa (as well as other developing regions), such that many different types have evolved to make the best of local conditions (Shackleton *et al.,* 2009). Well-known systems include the Kibaiya or banana-based agroforestry home gardens in northern Tanzania (Baijukya and Peters, 1998), the Chagga systems around Mount Kilimanjaro (e.g. Soini, 2005) and dambo gardens in Zimbabwe and Zambia (e.g. Bell and Hotchkiss, 1989). Home Gardens are so widespread that most authors examining household livelihoods or agricultural practices in rural areas throughout the continent report that all or over 90 percent of households maintain home gardens, whether in East (e.g Musotsi, 2004; Soini, 2005), West (Dabi and Anderson, 1999) or Southern Africa (e.g. High and Shackleton, 2000; Campell *et al.,* 2002). Home gardens are typically much smaller than arable fields, and range from a few square metres to perhaps half a hectare. In extreme cases, where land or space is limited, home gardens can be established on verandas or rooftops using growing containers (e.g. plastic pots, plastic bags, clay pots or other convenient containers) (Oluoch *et al.,* 2009). Home gardens exist in different parts of the world under different names that include kitchen garden, dooryard garden and backyard garden. In home gardens, vegetables that can tolerate some extent of shading can be grown under taller plants. Vegetables grown in home gardens are those that are eaten b y the family and can be easily grown without too much attention or expenses. According to Etim *et al.,* (2006); Udoh and Etim, 2008), farming activities within and around the city primarily centre on the production of vegetables in home gardens in which water-leaf cultivation features prominently.

Shackleten *et al.,* (2009) noted that home gardens can sometimes be located away from home depending upon the availability of land, water and other facilities. Home gardens offer numerous benefits to the household, including fresh supply of vegetables at the familyôs doorstep, occasional extra income from selling excess vegetables, a place where the home waste or city waste can be used as a compost for vegetable growing, protection for the environment and, increase in food production and ensuring food security. Home gardening like every other agricultural activity employs resources. But these resources have to be efficiently allocated and used in order to optimize production. Recent and empirical studies by Udoh and Akintola (2001), Etim *et al* (2005), Etim and Udoh (2006), Udoh and Etim (2006), Udoh and Etim (2007), Udoh and Etim (2010) suggest that farming has to use available input as efficiently as possible to optimize production and farmers being primary managers of land need to manage problems arising from deteriorating natural resources (Rosegrant *et al.,* 2005; Udoh and Etim (2008). In agriculture, inefficiency in resource allocation and use can seriously hamper or jeopardize production (Udoh and Etim 2006). The sustainable use of natural resources is essential for poverty reduction and economic growth (World Bank, 2010). There is a strong correlation between sound natural resource management and poverty reduction (DFID, EC, UNDP and World Bank, 2002). This study measures the farm level determinants of technical efficiency of home

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gardening in Akwa Ibom State. Efficiency of a firm can be defined as its ability to produce the largest possible quantity of output from a given set of inputs. The modern theory of efficiency dates back to the pioneering work of Farrell (1957) who proposed that the efficiency of a firm has two components, namely: technical and allocative efficiency and the combination of these two components provide a measure of total economic efficiency (overall efficiency). Technical efficiency which is ability to produce a given level of output with minimum quantity of inputs can be measured either as input-conserving oriented technical efficiency or ouput-expanding oriented technical efficiency (Jondrow *et al.,* 1982; Ali 1996).

Measurement of farm efficiency via frontier approach has been widely utilized and studied. The term frontier involves the concept of maximality in which the function sets a limit to the range of possible observations (Forsund *et al.,* 1980). The observation of points below the production frontier for firms producing below the maximum possible output can occur, but there cannot be any point above the production frontier given the available technology. Deviations from the frontier are attributed to inefficiency. Frontier studies are however classified according to the method of estimation. Kalaizandonakes *et al*. (1992) grouped these methods into two broad categories ï parametric and non-parametric methods. The parametric method can be deterministic, programming and stochastic depending on the specification of the frontier model.

Many researchers including Schmidt (1976) have argued that efficiency measures from deterministic models are affected by statistical noise. This however led to the alternative methodology involving the use of the stochastic production frontier models. The major feature of the stochastic production frontier is that the disturbance term is a composite error consisting of two components; one symmetric, the other one-side component.

The symmetric component, V_i, captures the random effects due to measurement error, statistical noise and other influences, and is assumed to be normally distributed. The one-sided component U_i, captures randomness under the control of the firm. It gives the deviation from the frontier attributed to inefficiency. It is assumed to be either half-normally distributed or exponentially distributed.

By definition, stochastic frontier production function is modelled as:

$Y_i = F(X_i; \beta) \exp(V_i - U_i) i = 1, 2, ., N$ (1)

Where Y_i is the output of the ith firm; X_i is the corresponding (MX2) vector of inputs; β is a vector of unknown parameter to be estimated; F(.) denotes an appropriate form, V_i is the symmetric error component that accounts for random effects and exogenous shock; while $U_i \leq 0$ is a one sided error component that measures technical inefficiency.

METHODOLOGY

Study area, sampling and data collection procedure

The study was conducted in Uyo metropolis, Akwa Ibom State, Nigeria, Uyo is situated 55 kilometers inland from the coastal plain of South-East Nigeria. The area lies within the humid tropical rainforest zone with two distinct seasons-the rainy and short dry seasons. The annual precipitation ranges from 2000-3000mm per annum. According to Etim and Ofem (2005); Udoh and Etim (2008) this rainfall regime received in most part of the state encourages farming throughout the year. The area is located between latitude $5^0 17^1$ and $5^0 27^1$N and longitude $7^0 27^1$ and $7^0 58^1$E and covers an area of approximately 35 square kilometers. Most of the inhabitants are public and civil servants. According to Etim *et al* (2006); Udoh and Etim (2006; 2008), these people engage in part-time farming activities and other commercial ventures within and around their homes as a way of augmenting and supplementing family income and food supplies.

Primary data were used for this study and were obtained from well structured questionnaire in 2009 cropping season. Using a two stage sampling procedure, 80 home gardeners were selected. The first stage involved the random selection of 2 clans viz: Oku and Offot clans. The second stage was the random selection of 40 gardeners to make a total of 80 gardeners. Baseline information on socio-economic characteristics, input use and output levels were collected and analysed.

The Empirical Model

The study utilized stochastic production frontier, which builds hypothesized efficiency determinants into the inefficiency error components (Coelli and Battese 1996). We specified a Cobb-Douglas Production function as presented, $Ln(Qty) = \beta_0 + \beta_1 L_n(Land) + \beta_2 L_n(Farm\ Lab.) + \beta_3 L_n(Fert) + \beta_4 (Hired\ labour) + \beta_5 L_n(manure) + \beta_6 L_n(Capital)$ - - - - - - - (1)

Where Qty is the quantity harvested measured in kg, land is the farm size measured in square metres, farm labour is the family labour employed in farm operations measured in man days, fertilizer is in organic fertilizer applied measured in kg, hired labour is labour employed measured in mandays; manure is organic fertilizer applied on the soil measured in kg; capital is the depreciation value of the implements used measured in naira.

With $Vi \sim N(O, \sigma v^2)$; and

$e^{-ui} = \delta_0 + \delta_1 (Exp) + \delta_2 (Ext) + \delta_3 (Edu) + \delta_4 (Age) + Zi$ - - - - - - (2)

Where Exp is farming experience in years;
Ext is access to technical assistance (dummy)
Edu is the level of educational attainment of the farmer (years);
Age is the age of the farmer (years); Zi is an error term assumed to be randomly and normally distributed. The value of the unknown co-efficients in equations (1) and (2) are jointly estimated by maximizing the likelihood function (Yao and Liu, 1998; Udoh and Akintola, 2001).

RESULTS AND DISCUSSION

Maximum Likelihood estimate Results

The model specified was estimated by the maximum likelihood (ML) method using a FRONTIER 4.1 software developed by Coelli (1995). The ML estimates and inefficiency determinants of the specified frontier are presented in Table 1. The sigma square (0.0983) is statistically significant and different from a zero ($p < 0.05$). This indicates a goodness of fit and the correctness of the specified distribution assumption of the composite error term.

The variance defined as $\gamma = (\sigma_u^2/\sigma_u^2 + \sigma_v^2)$ is estimated to be 68.66 percent. Result implies systematic influences that are unexplained by the production function as the dominant sources of random errors. In other words, the presence of technical inefficiency among vegetable gardeners explain about 68.66 percent in the output level of home vegetable gardening. The presence of one-sided error component in the specified model is thus confirmed suggesting that the ordinary least squares estimation would be inappropriate and inadequate representation of the data.

The importance of productive function is revealed in the production function estimates. The coefficient of all the explanatory variables are significant and have the expected signs and magnitude except fertilizer and capital resources. Family labour appears to be the most important resource input with an elasticity of 2.0712. Result is synonymous with earlier findings of Udoh and Etim (2006; 2008), who in their study of farm level efficiency among cocoyam and water leaf farmers respectively found that labour was the most important resource input. Result suggests that young people who provide the bulk of labour in agricultural production should be encouraged to work in the sub-sector. Shaib *et al*. (1997) reported that rapid rural-urban migration of the youths and the resultant dwindling of an active farm labour has become a major constraint to expanding agricultural production.

Land is the second most important factor, with an elasticity of 10.8720, followed by manure and hired labour with elasticity of 1.0019 and 0.9260 respectively. The estimated coefficients of the inefficiency function explain the technical inefficiency levels among individual home gardens. Except for technical assistance and age, the coefficients of other inefficiency variables were significant at ($P < 0.05$) and ($P < 0.10$). Result suggests that both educational level of home gardeners and their experiences in gardening positively affect the garden level technical efficiency effects. Findings confirm the fact that higher educational attainment motivates farmers to acquire and utilize innovations more effectively. Rosegrant and Cline (2003) reported that education works directly to enhance the ability of farmers to adopt more advanced technologies and crop-management technique thereby achieving higher rates of return on land and the development of a particular area of knowledge on specialization is by experience which eventually leads to improvement in production methods and higher technical efficiency level (Udoh, 2005; Etim et al, 2005; Udoh and Etim 2006).

The summary statistics of explanatory variables is shown in table 2. The maximum value of output is 5402kg whereas the minimum and mean values are 151kg and 2101kg respectively. Results also show that the maximum values of farm size, family labour, age, inorganic fertilizer are 192 square meters, 21 man days, 62 years, and 50kg respectively. The mean and minimum values of land, capital and education are 89 square meters, ₦1,412 and 9 years respectively.

One important feature of the stochastic production frontier is its ability to estimate individual, farm specific technical, allocative and economic efficiencies. Table 3 shows farm specific efficiency indices. It also reveals considerable variation of efficiency index across the home gardens. The fact that the technical efficiencies of all the sampled home gardens are below one implies that none of the gardens reached the frontier of production. With a mean technical efficiency index of 0.80, there is scope for increasing output and efficiency.

CONCLUSION

The study measured the farm level efficiency of home gardens using the stochastic parametric estimation method. Using the Cobb-Douglas production function estimated by maximum likelihood estimation technique, the parameters of the maximum likelihood estimated and efficiency determinants were asymptotically efficient, consistent and unbiased. The mean age and farm size were 44 years and 50 square meters respectively. The most important farm resources that increased garden outputs are family labour, land, manure and hired labour. The distribution of technical efficiency of individual gardens shows that none of the gardeners reached the frontier threshold. Given the mean efficiency of 0.80, within the context of efficient agricultural production, output can be raised by 20 percent given available resources and technology.

Table 1: ML estimates and inefficiency function

Variable	Coefficients	Asymptotic t-value
Stochastic Production Frontier		
Constant term (ɓ$_0$)	2.015	1.7201*
Land (ɓ$_1$)	1.8720	2.6132***
Family (ɓ$_2$)	2.0712	3.0910***
Fertilizer (ɓ$_3$)	1.6825	1.4887
Hired labour (ɓ$_4$)	0.9260	1.7138*
Manure (ɓ$_5$)	1.0019	2.1134**
Capital (ɓ$_6$)	-0.0352	1.6143
Explainers of inefficiency		
Constant (ŭ$_o$)	1.0821	1.9213*
Experience (ŭ$_1$)	-0.0215	1.8019*
Technical Assistance (ŭ$_2$)	0.0818	1.2963*
Education (ŭ$_3$)	0.0488	2.1008**
Age (ŭ$_4$)	0.0124	
Diagnostic statistics		
Sigma-square (ŭs$_2$)	0.0983	2.0588**
Gamma ə-	0.6866	2.8091***
Ln (likelihood)	14.3812	
LR test	7.8210	
Quasi function	1.5022	
Number of observation	80	

Source: Computer print out of frontier

Note: All explanatory variables are in natural logarithms. A negative sign of the parameters in the inefficiency function implies that the associated variable has positive effect on technical efficiency and a positive sign indicate the reverse is true. Asterisk indicate significance ***1%, **5%, *10%.

Table 2: Mean, minimum and maximum values of output and explanatory variables

Variables	Unit	Mean value	Minimum value	Maximum value
Output	Kilogram	2101	151	5402
Land	Square meters	89	50	192
Family labour	Man days	4.8	12	21
Inorganic fertilizer	Kilogram	22	5	50
Hired labour	Man days	5.2	11	18
Manure	Kilogram	14	10	20
Capital	Naira	1,412	582	2,100
Experience	Years	9	10	28
Education	Years	9	7	18
Age	Years	44	25	62

Source: Field Survey, 2009

Table 3: Farm Specific Technical Efficiency

Efficiency Class	Frequency	Percentage
0.01 - 0.10	4	5
0.11 ï 0.20	2	2.5
0.21 ï 0.30	4	5
0.31 ï 0.40	5	6.25
0.41 ï 0.50	7	8.75
0.51 ï 0.60	8	10
0.61 ï 0.70	10	12.5
0.71 ï 0.80	11	13.75
0.81 ï 0.90	14	17.5
0.91 ï 1.00	15	18.75

Mean efficiency = 0.80
Minimum = 0.01
Maximum = 0.92

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