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Determinants of Profit Efficiency of Small-Scale Dry Season Fluted Pumpkin Farmers Under Tropical Conditions: A Profit Function Approach

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Producers strive to reduce cost and improve profit. An investigation of factors affecting producer performance was undertaken using measures of profit/profit margin as indicators of performance. A stochastic frontier approach was used to examine profit efficiency of small-scale dry season fluted pumpkin (*Telferia occidentalis* L.) producers in Nigeria using farm-level survey data collected from 100 respondents. Gross margin analysis indicated that average gross margin per farmer was ₦21,252; ₦156 is equal to US$1. Economic efficiency averaged 0.925. Stochastic frontier model analysis indicated that farm size and labor were significant factors contributing to the economic efficiency of producers. Years of experience and farm size contributed significantly to the explanation of inefficiency levels of fluted pumpkin farmers. Household size reduced efficiency. It is necessary to ease difficulties associated with land acquisition so that producer efficiency can be improved.

Keywords Production, Marketing, Nigeria, Stochastic frontier, Vegetable.

Over 70% of the Nigerian population is engaged in agriculture and agriculture-related activities (Central Bank of Nigeria [CBN], 1996, 2003). The food production growth rate in Nigeria is 2.5% per year but the population growth rate is 3.5% per year (CBN, 2003). Fluted pumpkin (*Telferia occidentalis* L.), an indigenous crop, is grown mainly in southeastern Nigeria. The leaves and seeds of the plant are nutritious (Schippers, 2000). The fresh shoot yield is

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about 0.5–1 Mt but could be more if the crop receives adequate nutrition (Akinsami, 1975; Schippers, 2000). Overdependence on rain-fed agriculture has led to seasonal vegetable shortage, fluctuation in vegetable prices, and nutritional inadequacy, which dry season vegetable production could solve if irrigation were available (Ayoade, 1988). Fluted pumpkin production in Nigeria is decreasing due to water scarcity associated with dry season production. Irrigation of vegetables relies on the high cost of manual labor (Navaratne, 2009). Farmers hesitate to grow vegetables under irrigation, even though the economic value of vegetables is high compared to other crops. Fluted pumpkin has the potential to provide nutritional security because it is affordable, available, easy to grow, requires minimum production inputs, and is rich in vitamins and minerals, phytochemicals, and antioxidants (Eusebio, 2009).

Computing profit efficiency is an important source of information for policy makers rather than cost efficiency analysis alone (Maudos et al, 2002). The estimation of a frontier profit function captures firm-level production specialization, allowing higher revenues to compensate for higher costs of production. Technical efficiency indicates producer ability to achieve maximum output from a given quantity of inputs and existing technology. Studies have failed to critically examine the importance of producing fluted pumpkin during the dry season under irrigation versus rainy season production to ascertain economic efficiency. However, considerable effort has been directed at examining productive efficiency of producers exclusively focused on technical efficiency (Ajibefun et al., 2002; Ogundari, 2006; Ojo, 2004). Little attention has been given to measuring the profit efficiency of producers even when output and input prices are known in an attempt to examine allocative efficiency of farmers. Technical efficiency is important for production efficiency, but profit efficiency will lead to greater benefits to agricultural producers.

If fluted pumpkin is to play a role in ensuring future food availability, food security, and nutrition, its production has to be developed and expanded in an economically viable and environmentally sustainable manner. The objective of this study was to evaluate the factors affecting profit efficiency of small-scale fluted pumpkin producers using a stochastic profit frontier approach.

MATERIALS AND METHODS

The study was carried out in Ilorin, Nigeria. The area has distinct dry and rainy seasons. Fluted pumpkin is grown in the area throughout the year.

Data Collection

Respondents were producers who used irrigation. Ten areas were randomly selected and 10 households from each production area were randomly selected for a total of 100 respondents. Data were collected through a questionnaire followed by personal interviews. Additional information for the study was from readily available literature. A unit cost of labor per man-day, which is the total expenditure per farm, included the cost of family labor at the wage rate paid to permanent hired labor, farm size, and input price including fertilizer, seed, and cost of irrigation based on volume of water used. Data were collected on education, farming experience, and household size. Data on yield and output price were used to compute total farm revenue. Farm-level profit was computed as the difference between total revenue and total variable cost of production.

Stochastic Frontier Normalized Profit Model Specifications

Profit efficiency was defined as profit/gain from operating on the profit frontier. A normalized profit function was used to test the economic efficiency of fluted pumpkin producers so that the function can (a) differentiate between maximizing profit and (b) avoid simultaneous bias between quantity and price (Lau, 1978; Lau and Yotopoulos, 1971), with (b) being the major consideration in using the normalized profit function because the physical component of the efficiency model needs to be decomposed.

The Coelli (1997) model was used to specify the stochastic frontier function with behavior inefficiency components and to estimate all parameters together in a one-step maximum likelihood estimation. An explicit Cobb-Douglas functional form with sex, age, educational level, farming experience, and household size as variables was used to indicate the possible influence on profit efficiencies of fluted pumpkin producers. The share of inefficiency in the overall residual variance with values in intervals of 0 and 1 can be seen as evidence in favor of ordinary least square (OLS) estimation. The estimate for all parameters of the stochastic frontier normalized profit function and the inefficiency model were simultaneously obtained. A two-stage estimation method was used to obtain the final maximum likelihood estimation for two models. Model 1 is the traditional response function OLS in which efficiency effects were not present. It is a form of the stochastic frontier production function model in which the total variation in output due to technical inefficiency is zero. Model 2 is the general model where there is no restriction and technical inefficiency is zero. The models were compared for the presence of profit inefficiency effects using the generalized likelihood ratio test.

RESULTS AND DISCUSION

Costs and Return Analysis of Fluted Pumpkin Production

Average total revenue of producers was ₦99,556 and variable cost was the major cost involved in production (₦, naira, Nigerian currency, 156₦ =

Table 1: Costs and return analysis of fluted pumpkin production.

Item	Value (₦/season)	Total
A: Revenue (Output × Price)		
Sale of fluted pumpkin leaf (vegetable)	99,556	99,556
B: Variable cost		
Seed	26,854	
Fertilizer	5,650	
Rent of farm plot	10,000	
Labor	25,800	
Irrigation charges[a]	10,000	
Total		78,304
C: Average gross margin (A − B)		21,252

[a]Irrigation applied weekly; charges are for rent of water pump and land access.

US$1). Almost all equipment used for production was rented (Table 1). The average total gross margin was ₦21,252. According to Adegeye and Ditto (1985), the fixed cost for small-scale producers is usually insignificant, which agrees with the findings in this study. Revenue was entirely from the sale of fluted pumpkin leaves. Because water from the stream is relatively free, the only cost reimbursement associated with irrigation was for land access and rent of the pump.

Stochastic Frontier Normalized Profit Models

The estimated coefficients of parameters of the normalized profit function based on the assumption of competitive markets were positive except for cost of fertilizer (Table 2). The positive coefficient of price per man-day of labor is

Table 2: Result of maximum likelihood estimate of the Cobb-Douglas based on a normalized profit frontier function.

Variable per parameter estimates	Coefficient	Std. error	*t*-Value
General model			
Constant (β0)	0.250**	0.559	0.447
Farm size (β1)	0.500*	0.200	0.250
Average price of fertilizer (β2)	0.12	−NAN[a]	−NAN
Average price of seed (β3)	−0.166	0.309	−0.537
Average price per man/day of labor (β4)	0.313***	0.367	0.851
Average price paid for irrigation (β5)	0.213	0.432	0.256
Diagnostic statistics			
Sigma-squared ($\sigma s^2 = \delta u^2 + \delta v^2$)	0.103***	0.140	0.312
Gamma ($\gamma = \delta u^2/\delta v^2$)	0.900	0.232	0.243
Log (likelihood) (θ_0)	0.896		
Mean efficiency	0.925		

[a]NAN (not a number) is a designation of the numeric data type representing an undefined value or a value that cannot be represented, especially in floating point.
*, **, ***Significant at 10%, 5%, and 1%, respectively.

Table 3: Generalized likelihood ratio of test for parameter inefficiency.

Log likelihood	χ^2 Statistics	χ^2 v.095	Decision
0.150	3.08	24.62	Accept H_0

contrary to the expected sign. This may be because fluted pumpkin production is labor intensive. Inefficiency existed as confirmed by the test of hypothesis for the presence of inefficiency effects using the generalized likelihood ratio test and significance of the gamma estimate (Table 3).

The entire delta estimates were not zero and they contributed to the inefficiency of fluted pumpkin producers. (Age ($\delta 1$) = −0.176; Household size ($\delta 2$) = −0.182; Level of education ($\delta 3$) = −0.783; Experience in years ($\delta 4$) = 0.965; Farm size ($\delta 5$) = 0.151.) The calculated χ^2 was less than the tabulated χ^2 (Table 2), indicating that variables in fluted pumpkin production were relevant. Diagnostic statistics of the stochastic frontier normalized profit function indicated a total variance of 0.103, which was statistically significant at 1.0%. This parameter measures the goodness of fit and correctness of the specified distributional assumption of the composite error term. Farmers exhibited economic efficiency estimates ranging from 76% to 98%, with an average of 92.5%. The minimum efficiency of 76% indicated underutilization of resources while the most economically efficient farmer operated almost on the frontier. The result supports the assertion of Kalirajan and Shand (1989) and Shapiro and Muller (1977) that given a technology to transform inputs into output, some producers are able to achieve a maximum efficiency of up to 100%, whereas others are technically inefficient.

The explanatory variables indicated that coefficients for the price of labor and farm size were significant at 1% and 10% risk levels (Table 2). With positive coefficients of 0.313 and 0.500 for labor and farm size, respectively, fluted pumpkin producers operate in stage one of the classical production function. Expansion of farm size and labor should be encouraged because they are underutilized. Farm size has a coefficient of 0.5, implying that a 0.5% increase in farm size would increase profit level by 0.5% (Wadud and White, 2000).

Relative Efficiency Indices

Estimation of economic efficiency (Table 4) indicates efficiency indices of at least 0.9% or above for all but one age category. The age group 40–49 operated at 0.87%, which is below the average.

The inefficiency sources model (Table 5) indicated that years of experience and farm size contributed to the explanation of efficiency levels of fluted pumpkin producers. The larger the farm, the higher the economic efficiency. Farming experience had a positive coefficient but was significant only at the 1% probability level. The implication is that producers with more years of

Table 4: Relative efficiency indices by age for fluted pumpkin producers, estimation of economic efficiency.

Age category (years)	No. of farmers	Avg. economic efficiency (%)
<40	9	0.904
40–49	23	0.878
50–59	29	0.931
>60	39	0.901
Total	100	

Table 5: Determinants of economic efficiency in fluted pumpkin production.

Variable parameter	Coefficient	SE	*t*-Value
Constant (δ0)	−0.678	0.153	−0.444
Age (δ1)	−0.176	0.796	−0.223
Household size (δ2)	−0.182	0.156	−0.117
Level of education (δ3)	−0.783	0.717	−0.109
Experience (years) δ4	0.965**	0.971	0.994
Farm size (δ5)	0.151*	0.924	0.163
Sigma-squared ($\sigma s^2 = \delta u^2 + \delta v^2$)	0.517	0.180	0.287
Gamma ($\gamma = \delta u^2/\delta v^2$)	0.535	0.117	0.459
Log (likelihood) (θ_0)	0.150		
Mean efficiency	0.978		

*, **Significant at 5% and 1%, respectively.

experience achieve a higher level of economic efficiency than less experienced farmers who have not been exposed to new ideas (Ayanwale and Abiola, 2008; Ugwu, 1990). The coefficients of age and household size agree with the expectation that increasing age would lead to decreased efficiency because an aging farmer would be less energetic (Abaelu, 1998; Akinsami, 1975). An increase in household size may likely produce a condition where much of what is produced is consumed, leaving little or nothing for sale in the market, which contradicts the popular belief that larger household sizes can be used as a workforce (Mubarik and Flinn, 1998). Level of education negatively affected fluted pumpkin production. An increase in level of education reduced output by 7.83 units. The methods employed in production are crude and mainly traditional; the more educated people are, the less willing they are to participate in farm operations. Labor for farm operations was almost 100% hired by producers who had attained higher education levels. Due to a paucity of resources and the basic idea of no waste on which economists have built theories, efficiency studies have become relevant. Dry season fluted pumpkin producers were not operating at full economic efficiency. These inefficiencies could be attributed to larger family sizes, which impose pressure on farm output, leaving little or nothing for the market. The variables age, farming experience, and farm size influenced efficiency. Review of land use policy is necessary to ease difficulties associated with land acquisition and provision of required incentives to encourage the use of irrigation.

Fluted pumpkin farmers need to adopt irrigation to improve profit and become more economically efficient. It is recommended that government should provide an environment for the establishment of modern irrigation facilities for dry season farming and encourage younger adults to practice dry season vegetable farming.

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