Quantifying Profit Efficiency in Sweet Potato Marketing in Owerri, Nigeria: A Stochastic Frontier Analysis

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ABSTRACT

Despite significant production volumes, marketing inefficiencies constrain sweet potato profit margins in Nigerian urban markets. The study therefore analyzed the efficiency of sweet potato marketing in the study area. Data were collected with the aid of a well-structured questionnaire from 40 randomly selected sweet potato marketers from 2 purposively selected markets. Data were analyzed using descriptive statistics and stochastic profit function. Results showed that the mean age of the sweet potato marketers was 37 years and majority (57.5%) were female. All the parameter estimates such as cost price of sweet potato, transportation, market space (rent) are negative and are statistically significant at 1% and 5% respectively showing that increase in them decreases total profit associated with sweet potato marketing in the study area. The maximum likelihood estimates for the stochastic profit function used in explaining the inefficiency parameters for the sweet potato marketers indicated that all the parameters such as sex, marital status etc except age had the *a priori* expected signs (negative) and are all statistically significant showing that an increase in any of them decreases inefficiency. The marketing efficiency scores of the sampled marketers ranged from 0.11 to 0.75.with a mean profit efficiency is 0.45 meaning that an average sweet potato marketer in the study area has a scope for increasing profit efficiency by 55%. It was concluded that sweet potato marketers are not profit efficient from their profit efficiency indices.

Key words; Marketing Efficiency, Sweet Potato, Stochastic Profit Frontier.

INTRODUCTION

Sweet potato, a neglected food crop in the past has found its place in the global market because of its ability to respond to the pressing need of boosting food security, wealth creation and nutrition (Donyina, *et.al.,* 2025). According to Hounkpatin *et.al.,* (2025), neglected food crops are crops that have been cultivated by local people in the community over the years which however have been ignored by agricultural policies and the agricultural research scientists for a long time. Sweet potato (*Ipomoea batatas)* is a herbaceous plant that belongs to the family of *Convolvulaceae* and genus of Ipomoea (El Bilali, *et.al.,* 2025). Nigeria is the largest producer of sweet potato in West Africa (Isbor *et.al.,* 2021; *Girei et.al.,* 2019; Anyanwu *et.al.,* 2025). It is a source of food to humans, while the leaves and roots are used as animal feed (Islam, 2024). It is a great source of vitamin A (Hagenimana *et al.,* 2000). Anudu (2021) reported that Nigeria's sweet potato production is estimated at 1.2 million MT (Metric Ton) while demand is 6 million MT leaving a supply gap of 4.8 million MT of untapped market potentials. This could be linked to inefficient marketing system resulting from differentials in transportation cost, storage cost etc. Bridging this demand and supply gap of sweet potato in Nigeria through domestic production and efficient marketing offers a great investment potential to the Nigerian populace.

Marketing efficiency refers to the ability to make maximum marketing profit given the purchase and selling prices of the products and the level of fixed factors of the firm. Inefficiency is defined as loss of profit from

not operating on the profit frontier (Rahman and Awerije, 2014). The stochastic profit frontier as used by Truong *et al.,* (2020) is defined as where π is the vector of profit defined as gross revenue minus variable cost divided by output price (Py).

$$\pi^* = \frac{\pi}{Py} = f(Pi, Zi).\exp(Vi - Ui) \ldots . (1)$$

Where π* is the normalized profit computed for the ith firm,

Pi is the vector of variable input prices,

Py is the output price,

Zi is the vector of fixed inputs,

and i = 1…n is the number of firms in the sample.

Vi is the independently distributed two sided random errors which represents random variations in profit attributed to factors outside the marketers control, Vi- N (0, δ^2 v), Ui is the non-negative random variables associated with inefficiency which are assumed to be independent and normally distributed with zero mean and constant variance $\sigma_{\mu 2}$ ($\mid N(\mu, \sigma u^2 u \mid$) When u = 0, it means that the firm's profit is on the efficiency frontier and when u < 0 it means that the firm's profit is below the efficiency frontier. (Battese & Coelli (1995 ; Aigner, Lovell & Schmidt, 1977).

The marketing profit efficiency of an individual firm in this study using stochastic frontier profit function is defined as the ratio of the predicted or actual profit (πi) to the corresponding predicted maximum profit (πi*) for the frontier profit given the price of variable inputs and the level of fixed factors of production of that farmer. The formula is given as:

$$EE = \frac{\pi i}{\pi i^*} = \frac{(Pi,Z)\ exp(Vi-Ui)}{(Pi,Z)\ exp(Vi)} \ldots.(2)$$

$$EE = \exp\frac{(Vi-Ui)}{exp(Vi)} \ldots.. (3)$$

Where: EE is the profit of an individual marketer in the context of the stochastic frontier profit, πi is the predicted profit, πi* is the predicted maximum profit for the best marketer or frontier profit given the price of variable inputs (Pi) and the level of fixed factors (Z) used by the marketer. Vi and Ui are as stated above Many studies have been carried out on marketing efficiency of sweet potato and its determinants using parametric and non-parametric efficiency measures such as efficiency index ratios, the Shepherd-Futrel method and OLS multiple regression model as can be seen in Ejechi *et al.,* (2016), Girei, *et al.,* (2019), Sarma (2010), Isbor *et.al.,* 2021 and Kyomugish *et al.,* (2018) etc However, to the best of our knowledge, this is the first application of a Cobb-Douglas stochastic profit frontier to quantify sweet potato marketer efficiency in Nigerian urban markets. Based on the above, this study therefore examined the following: Socio economic characteristics of the marketers, Marketing efficiency and inefficiency of sweet potato marketers using stochastic profit frontier.

Hypothesis

H_0: Sweet potato marketers in the study area are not profit efficient.

MATERIALS AND METHODS

The study was conducted in Owerri Municipal Council of Imo State. The study area was selected due to the predominance of major markets in the area. Owerri Municipal has a population of about 127,213 according to 2006 population census. It is the headquarters of Imo State. Owerri Municipal area has two main seasons, the dry and wet season. The area has an annual rainfall of between 2250mm to 2500mm with average annual

temperature of between 25-27^{0}c and annual relative humidity of 80% (Njoku and Igbokwe, 2021; Nwajei, *et al.,* 2017). Two markets were purposively selected which include the Relief and Owerri main market (Eke Ukwu Owerri). The purposive selection is because of the full business activities that go on in these markets on daily basis compared to those in the rural areas. Simple random sampling was used to select 20 potato marketers (retailers) from each of the 2 markets given a total of 40 marketers. Descriptive statistics was used in describing the socio economic characteristics of the marketers, while stochastic profit frontier was used to determine the profit efficiency and inefficiency of the marketers.

Stochastic Profit Frontier Function

Following Truong *et al*., (2020) the stochastic profit frontier was used to estimate the marketing profit efficiency of the marketers in the study area. The explicit Cobb-Douglas profit frontier for sweet potato marketers is specified as;

$$Ln\pi^* = \beta_0 + \sum_{j=1}^{6} \beta_j \, LnX_{ij}^* + \beta_k LnX_k + \nu i - \mu i \quad \ldots\ldots (4)$$

$$Ln\pi^* = Ln\beta 0 + Ln\, \beta_1 X_{1i} + Ln\, \beta_2 X_2 i + Ln\, \beta_3 X_3 i + Ln\, \beta_4 X_4 i + Ln\, \beta_5 X_5 i + Ln\, \beta_6 X_6 i + \nu i - \mu i \ldots (5)$$

Where,

$Ln\pi^*$ = Natural Log of profit function,

, Ln = Natural Log,

X_i = vector of variable input prices faced by ith marketers (Naira/kg),

X_k = vector of fixed factors of the ith marketers (Naira/unit),

$\beta_0 - \beta_6$ and k = parameters to be estimated,

X_1^*= Cost price of Sweet Potato (₦/kg),

X_2^* = Cost of loading and off -loading (₦/kg),

X_3^*= Cost of transportation (₦/kg),

X_4^*= Cost of storage (₦),

X_5^* = Rent (Market space) (₦),

X_6^* = Association fee (₦),

$\beta_1 - \beta_6$ = Parameters to be estimated,

β_0 = Constant term,

ν_i = Two sided random error,

μ_i = One sided random error,

$e_i = \nu_i - \mu_i$ = Error Term.

The inefficiency model (μ_i) is specified thus:

$$\mu_i = a_0 + a_1 Z_1 + a_2 Z_2 + a_3 Z_3 + a_4 Z_4 + a_5 Z_5 + a_6 Z_6 + a_7 Z_7 \ldots\ldots\ldots (6)$$

Where,

Z_1 =Age (years),

Z_2 = Sex (2, Male; 1, Female),

Z_3 = Marital status (4, Married; 3, Single; 2, Widowed; 1, Divorced),

Z_4 = Household size (Number of persons),

Z_5 = Years of Education (Years),

Z_6 = Marketing Experience (Years),

Z_7 = Member of marketing Association (2, Yes; 1, No),

a_0 - a_7 = Parameters to be estimated.

RESULTS AND DISCUSSION

Table 1: Socio Economic Characteristics of Sweet Potato Marketers.

Variable	**Frequency**	**Percentage (%)**
Age (Years)		
21-30	6	15.0
31-40	22	55.0
>40	12	30.0
Mean = 37		
Sex		
Male	17	42.5
Female	23	57.5
Marital Status		
Single	12	30.0
Married	18	45.0
Widowed	8	20.0
Divorced	2	5.0
Household Size (No. of Persons)		
1-4	14	25.0
5-8	20	50.0
>8	6	15.0
Mean 5 persons		
Years of Education		
1-6	13	32.5
7-12	23	57.5
>12	4	10.0

Mean = 8		
Marketing Experience (years)		
1-10	15	37.5
11-20	19	47.5
>20	6	15.0
Mean = 9		
Marketing Association		
Yes	32	80.0
No	8	20.0

Table 2: Maximum Likelihood Estimates of Stochastic Frontier Function

Variables	**Parameters**	**Coefficients**	**Standard Error**	**t-ratio**
Constant Term	β_0	0.9622***	0.1074	7.45
Cost Price of sweet potato	β_1	-1.07381***	0.1753	-6.64
Cost of loading /off loading	β_2	-3.1079**	1.0744	-2.80
Cost of Transportation	β_3	-0.7223***	0.2624	-5.40
Cost of Storage	β_4	-4.2527**	1.6542	-2.66
Rent (Market Space)	β_5	-3.3317***	0.6754	-5.85
Association Fee	β_6	-6.7761**	2.0833	-3.02
Inefficiency Effects				
Age	a_1	0.8710**	0.2845	2.97
Sex	a_2	-0.7334*	0.3521	-1.91
Marital Status	a_3	-0.6643**	0.3255	-2.77
Household Size	a_4	-0.7116*	0.0267	-1.97
Years of Education	a_5	-0.1475**	0.0770	-2.75
Marketing Experience	a_6	-0.8481***	0.1975	-5.71
Member Marketing Asso	a_7	-4.8432**	1.7053	-2.90
Diagnostic Statistics				
Sigma Squared	**0.1152**			
Wald Chi^2	**46455.04**			
Prob > Chi^2	**0.0000**			
Log-Likelihood	**-1025.83**			
F-Test Value	**102.52*** **			

Note: *** Significant at P ≤ 0.01, ** Significant at P ≤ 0.05, * Significant at P ≤ 0.10.

Source: Field Data, 2025.

Table 3: Marketing Efficiency Scores of Sweet potato Marketers

Efficiency Scores	Mid Point	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage	Squared Deviation
0.11-0.21	0.16	4	10.0	4	10.0	0.3364
0.22-0.32	0.27	5	12.5	9	22.5	0.164
0.33-0.43	0.38	10	25.0	19	47.5	0.049
0.44-0.54	0.49	9	22.5	28	70.0	0.0144
0.55-0.65	0.60	5	12.5	33	82.5	0.1125
0.66-0.76	0.71	7	17.5	40	100	0.4732
Total		**40**	**100**			**1.1475**
Mean		**0.45**				
Minimum		**0.11**				
Maximum		**0.75**				

Source: Field Data, 2025.

The formula for the sample variance (s^2) is: $s^2 = [\Sigma(f * (xi - \bar{x})^2)] / (N - 1)$.

$$= 1.1475/39 = 0.029$$

The formular for Standard Deviation is shown below:

$$S = \sqrt{\frac{\sum f(xi - x)^2}{n - 1}}$$

$$\sqrt{0.029} = 0.17.$$

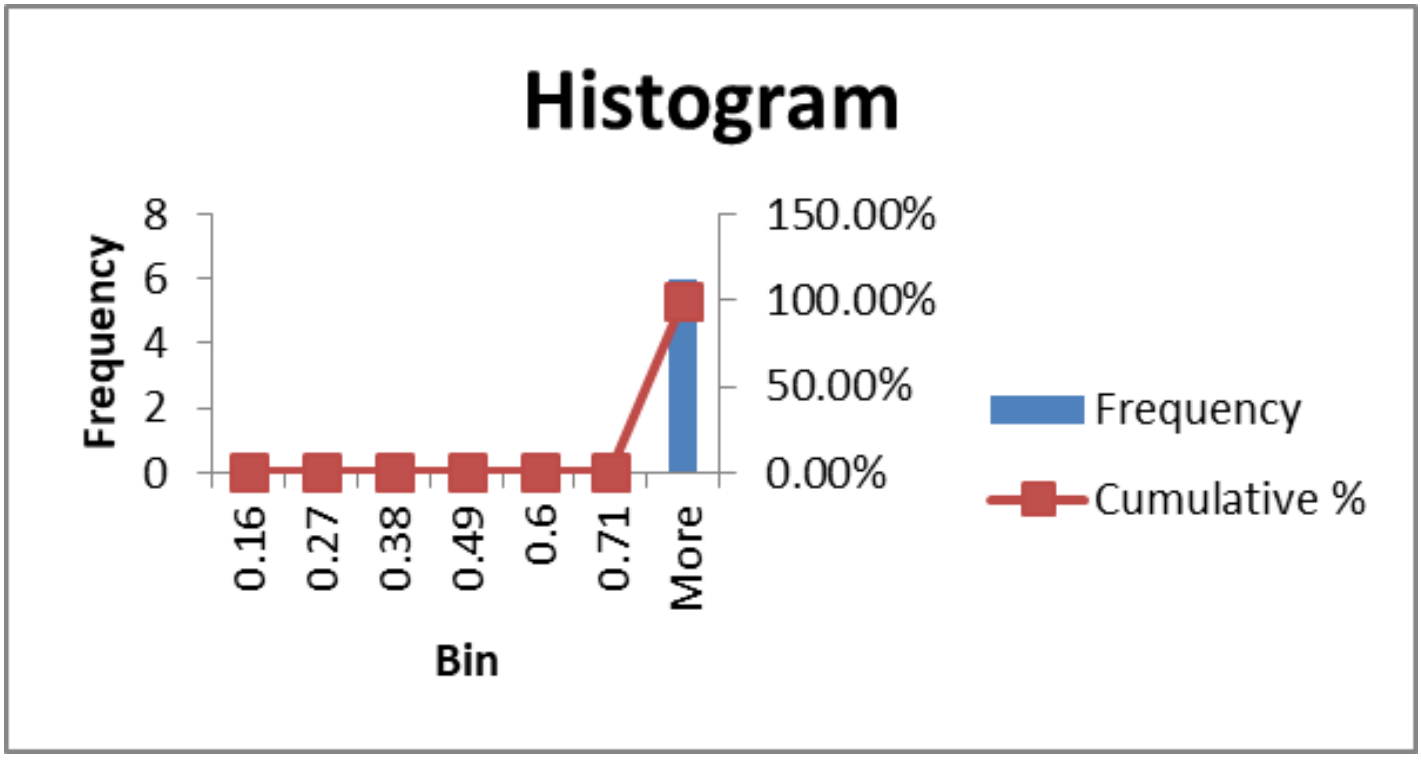

Fig 1: Histogram of Efficiency Scores

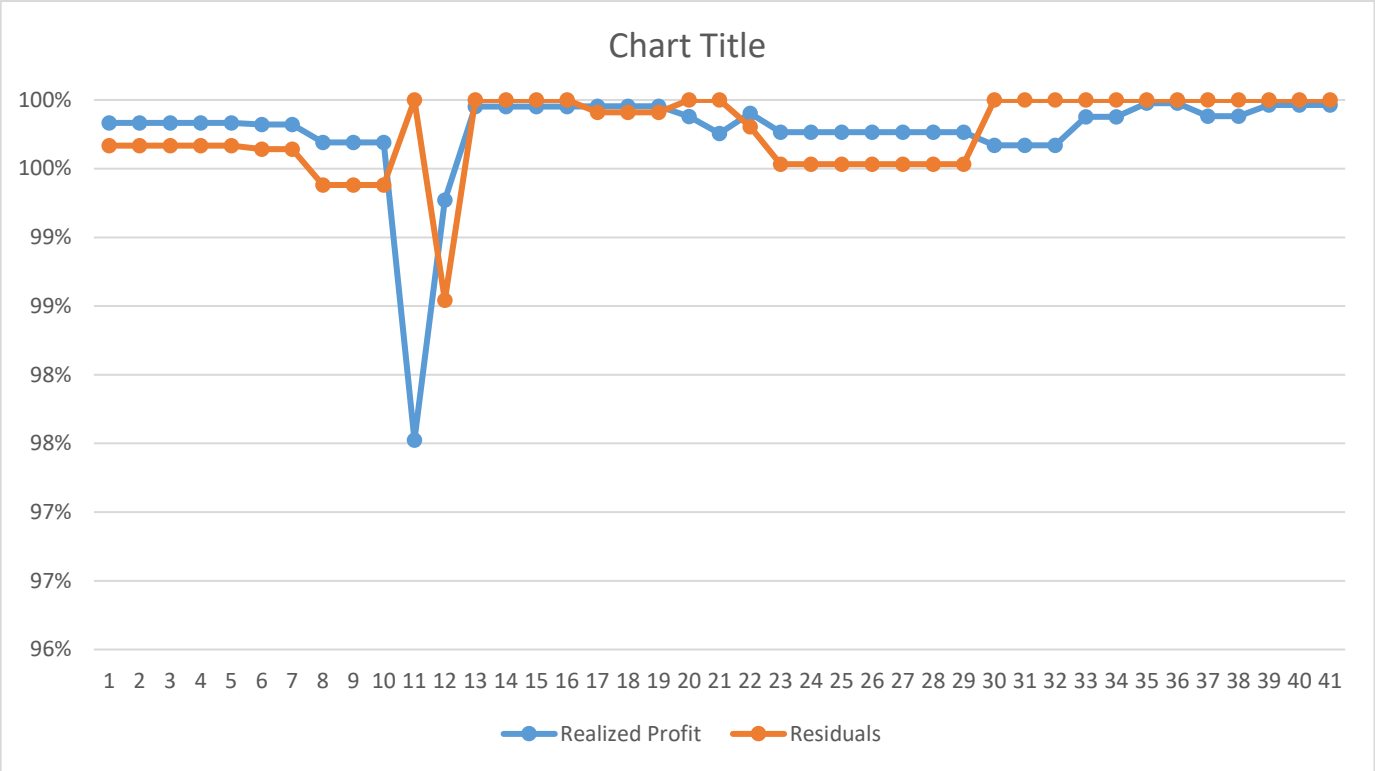

Fig 2: A Scatter Plot of Realized Profit vs Predictor Residuals against the Frontier.

The socio-economic characteristics of the sweet potato marketers are presented in Table 1. The results show that the sweet potato marketers have a mean age of 37 years, 57.5% were female. This indicates that young women are more in sweet potato marketing which is in line with the findings of (Udemezue, *et al.,* 2018). The results also show that majority of the marketers (80%) belongs to marketing association with half of the respondents (50%) having household size of 5-8 persons. This is contrary to the findings of (Nkamigbo *et al.,* 2021). Majority (45%) are married with a mean marketing experience of 9 years and have spent some years in school showing that they are literates which is in line with (Ejechi *et al.,* 2016). The result of the maximum likelihood estimates of the stochastic profit frontier model is presented in Table 2. The elasticity values of the 6 parameter estimates were negative and have the expected signs and are statistically significant at 1% and 5% respectively. This shows that 1% increase in any of these factors (cost of sweet potato (-1.7381), loading and off- loading (-3.1079), transportation (-0.7223), storage (-4.2527), rent (-3.3317) and association fee (-6.7761)) will reduce profit of sweet potato marketing in the study area. by 1.7%, 3.1%, 7%, 4.2%, 3.3% and 6.8% respectively. This result confirms the findings of (Odondo *et al.,* 2014). The maximum likelihood estimates for the stochastic profit function used in explaining the inefficiency parameters for the sweet potato marketers is also presented in Table 2. The coefficients of six (sex, marital status, household size, years of education, marketing experience and marketing association) out of the seven variables used had apriori expected signs and are significant and negative at 1%, 5% and 10% respectively indicating that increase in them decreases inefficiency except for age which has positive relationship and significant at 1% with marketing inefficiency conforming with (Konja *et al*., 2019). This shows that as the respondents gets older, marketing inefficiency increases and the respondents may find it difficult to get adequate and current information. The Wald chi-square value of 46455.04 and sigma (0.1152) were statistically significant at 1% and 10% respectively indicating that the explanatory variables jointly explain the marketing efficiency of sweet potato. The image in fig 2 shows the scatter plots of the individual respondents in the study area which was gotten from realized profit and predictor residuals against the frontier. It can be seen from the figure that most of the respondents whose realized profit was high were located further to the right while residual profits was higher up on the graph. This shows that as realized profit increases, residual profits also increases. Furthermore, some of the respondents fell below the frontier. This makes them an exception or outliers. This shows that as realized profit increases, residual profits also increases.

The marketing profit efficiency scores is presented in table 3. The marketing efficiency of the sampled marketers ranged from 0.11 to 0.75. The mean profit efficiency is estimated to be 0.45, meaning that an

average sweet potato marketer in the study area had a profit inefficiency gap of 0.55 leading to the acceptance of the null hypothesis. This is however low compared to the findings of Nyor *et.al.,* (2019) who noted a mean efficiency score of 0.76 for potato farmers in North central Nigeria. Accordingly, the histogram of efficiency scores (fig.1) shows that the efficiency scores have left –skewed distribution showing that almost all of the respondents in the study area performed below the efficiency level.

CONCLUSION

The study established that the number of female marketers of sweet potato were more than the male marketers in the study area. The cost of sweet potato, loading and off- loading, transportation, storage, rent and association fee are important determinants of total profit associated with sweet potato marketing in the study area. More so, the study concluded that the sweet potato marketers are not profit efficient because their marketing (profit) efficiency indices indicates that there are still inefficiency gaps to be filled in other to operate fully on the profit frontier. It is recommended that male marketers should be encouraged to join sweet potato marketing to enhance efficiency. .Secondly, policy makers should look into policies that would boost sweet potato marketing. Also government and traders at different levels should improvise appropriate storage facilities for sweet potato to curtail the problem of high spoilage that occur in the marketing process. In addition, the Agricultural Development Projects would need to organize workshops for the market participants to enlighten them on good storage techniques as well as provide an enabling environment through the provision of needed infrastructural facilities such as good roads to reduce cost thereby boosting the marketing efficiency of sweet potato as well as a mechanized loading and off-loading facilities. More so, the various sweet potato market associations in the study area should address the issue of high cost of association fee.

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