Direct Research Journal of Agriculture and Food Science

Direct RESEARCH JOURNALS

Vol.7 (2), pp. 30-35, February 2019
ISSN 2354-4147
DOI: https://doi.org/10.26765/DRJAFS.2019.1290
Article Number: DRJA85631290

http://directresearchpublisher.org/journal/drjafs
Research paper

Profit and Technical Efficiency Estimation of Onion Farms in Aliero Local Government Area of Kebbi State, Nigeria

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Received 3 January 2019; Accepted 4 February, 2019

The study investigated profitability and technical efficiency of irrigated onion production in Aliero Local Government Area of Kebbi State, Nigeria. The primary data used for the study were developed using a structured questionnaire administered to 120 randomly selected onion farmers. Descriptive statistics, farm budgeting (gross margin, net farm income, gross ratio, operation ratio, return on investment) and Cobb-Douglas stochastic frontier production function model were employed in analyzing the data. The result indicated that estimated gross margin; net farm income; gross ratio; operating ratio; and return on capital investment gives estimated values of ₦427,578.82 per hectare, ₦ 409,642.25 per hectare, 0.24, 0.21 and 3.46, respectively. The mean efficiency obtained was 83.6% indicating that there was a 16.4% opportunity for improving efficiency. The result also showed that farmers' educational level, years of farming experience and access to extension service significantly influenced the farmers' efficiency positively. It is recommended that relevant policies that would enhance the technical skill of the farmers and access to extension services should be developed by the stakeholders.

Keywords: Cobb-Douglas, gross margin, onion farms, profit, Stochastic Frontier production function

INTRODUCTION

Onion grown mostly in Kano, Kaduna, Jigawa, Sokoto, Plateau, Bauchi and Kebbi States, the Aliero Community, a local council area in Kebbi State, Nigeria, can lay claim as its home in Nigeria. In Aliero, onion is produced in such large quantities and most of the people in Aliero and its environs, including Maiyama and Gwandu, both in Kebbi State, are onion farmers. The people of the land make a livelihood out of it and meet their needs with it. Hence, Aliero is described as the *Land of Onion*. The people of Aliero pride themselves as the largest onion farming community in West Africa, not just because they get high patronage from other onion traders in the Southern, Eastern and other Northern parts of Nigeria, but also because they export their commodity to neighboring countries such as Benin Republic, Niger, Cameroon and Ghana.

The price of a bag of onion could go for as much as ₦ 20,000, but could fall to as low as ₦2,000 when there are no proper distribution channels. The cultivation of the commodity usually commences during the dry season, or as soon as the rain subsides, usually at the middle of September to October, every year. The onion is planted for 40 days, after which it is removed from the soil for replanting. Afterwards, a local fertilizer is applied on it and, after 60 days, it becomes ready for the market.

The harvested onions are preserved in silos because of the absence of modern ways of preserving them. It is sad that most other Nigerian onion producing communities such as Aliero lack modern processing and preservation plants. These are the areas the Ministry of Agriculture

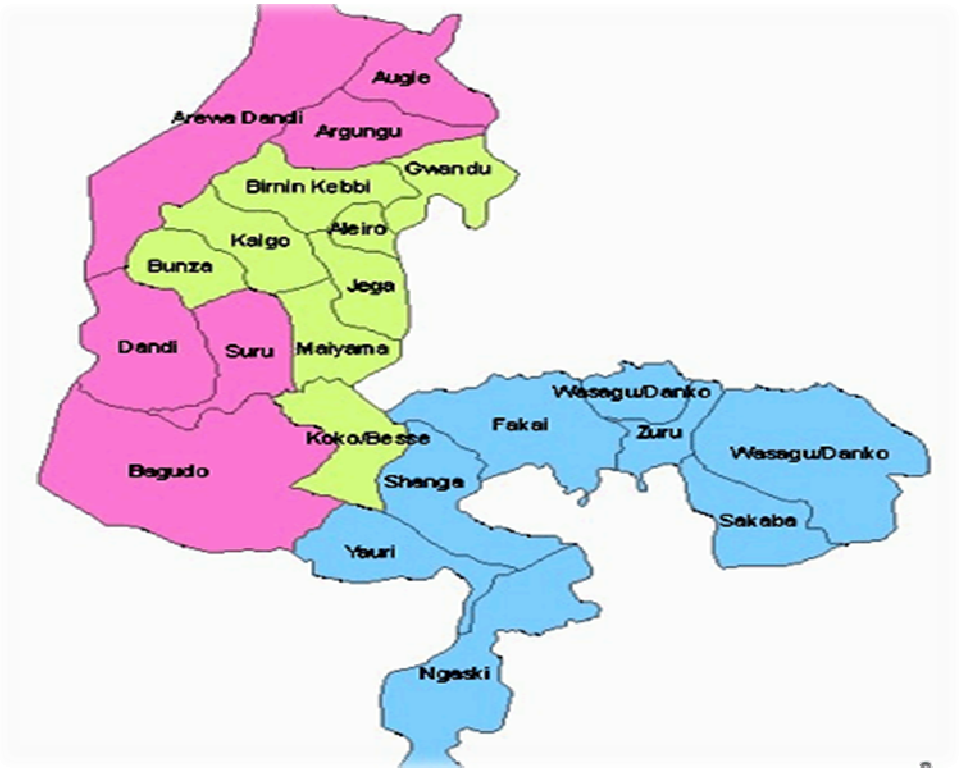

Figure 1. Map of Kebbi State. Source: https://en.wikipedia.org/wiki/Kebbi State

needs to look into. It is also an opportunity for private business people to explore. If Aliero can produce this much using local methods of processing and preservation, it is left to be imagined how much more Nigeria can produce if onion cultivation, preservation and export is made a priority.

The general objective of this study is to evaluate the profitability and technical efficiency of irrigated onion production in Aliero Local Government Area, Kebbi State, Nigeria. The specific objectives are to: (i) describe the socio-economic characteristics of sampled farmers in the study area; (ii) evaluate the gross margin of sampled onion farmers and (iii) to estimate farmer's technical efficiency and its determinants.

MATERIALS AND METHODS

Study area

The study was conducted in Aliero Local Government Area of Kebbi State. The choice of this area is on the basis of being prominent onion producing area in the state. It lies between latitude 12° 16^{1} 42`N and longitude 4° $27^{1}$ 6`E of the equator. It has total land area of 412 Km^2 with an estimated population of about one12, 570, 0083 persons (NPC, 2006). It is boarded in the North-East by Gwandu local government area, Jega local government in the South-East and Birnin Kebbi local government area in the North-West (Figure 1). The area enjoys a tropical climate which is generally characterized by 2 weather seasons (dry and wet). The rainfall begins in May/June and ends in October/September with heaviest fall occurring in July and August. The extremely cold harmattan period is usually accompanied with dusty winds and fog with alarming intensity occurring in November till January. The annual temperature varies considerably but usually ranges between 26° C to 38°C. The mean annual rainfall is about 500 MM (Dogondaji et al., 2006). Aliero Local Government is made up of three districts i.e. Aliero, Sabiyal and Dan Warai districts. Majority of the local government population are farmers with two major ethnic groups Hausa/Fulani. Major crops cultivated in the study area include millet, maize, Onion, groundnut, tomatoes and pepper. The people of Aliero pride themselves as the largest onion farming community in West Africa, not just because they get high patronage from other onion traders in the Southern, Eastern and other Northern parts of Nigeria, but also because they export their commodity to neighboring countries such as Benin Republic, Niger, Cameroon and Ghana (Yahaya et al., 2012).

Sampling procedure and sample size

Onion is generally cultivated in almost all part of Aliero Local Government Area. Multi-stage and simple random sampling techniques (MSST) were used in arriving at the sample size. At the 1st stage 2 district areas were selected using simple random sampling method out of the 3 districts in the study area. The 2nd stage is the selection of 6 villages from each of the selected district given a total of 12 villages. The 3rd and which is the final stage is the random sampling of 10 farmers from each of the selected village to arrive at a total number of 120 respondents to save as a sample size of the study.

Data collection

Both primary and secondary data were used for the study. The primary data were collected with the help of questionnaire administered by trained enumerators under the supervision of the researcher. Data collected include the farmer`s socio-economic characteristics, input-output information such as yield obtained, various inputs used, prices of output and prices of input. Secondary data were sourced from relevant literatures, journals, web pages and all other important documents from ministry. Data collected were edited, summarized, tabulated and analyzed to fulfill the objectives of the study.

Analytical techniques

The data collected was subjected to descriptive statistics in the form of tables, frequencies and percentages to describe the socio-economic characteristics of the respondents. Gross margin analysis was adopted to determine the profitability of Onion production and finally a stochastic frontier production technique was used by employing frontier 4.1 version in estimating the technical efficiency of the respondents.

Model specification

Gross margin specification

Gross margin (GM) analysis is a method of computing profitability of small-scale enterprises (Olukosi et al., 2006). It is a useful planning tool in situations where fixed capital is negligible portion of the farming enterprises in the case of small-scale (Olukosi and Erhabor, 1998).The gross margin employed in this study is expressed as:

$$GM = TR - TVC \quad (1)$$

Where GM = gross margin (₦/ha), TR = total revenue (₦/ha). Other ratios computed are:

Gross ratio (Gr) which is the profitability ratio that measures the overall success of the farm enterprise and the lower the ratio indicate higher the return per naira, mathematically expressed as: $Gr = \frac{TEE}{GR}$, where TEE = total Enterprise Expenses and GR = gross revenue. Operating Ratio (OR) which is related to the farm variable input utilization statistically stated as: $OR = \frac{TOC}{GR}$, where TOC = total operating cost. Lower OR ratio indicate higher profitability of the farm business and Return on Investment (RI) which is expressed as: $RI = \frac{GM}{TVC}$, where GM and TVC are as stated above.

Production function specification

A stochastic frontier production function that incorporated inefficiency factors were estimated using Maximum Likelihood Estimation (MLE) technique to obtain farm specific technical efficiencies as well as their determinants. The stochastic frontier production function was specified as:

$$InY_i = B_0 + \sum B_j InX_{ij} + V_i - U_i \quad (2)$$

Where: Ln = Natural logarithm; i = ith sampled smallholder farm; Y_i = Value of farm output from farm i; X_i = input variables in the model, and X_1 = Farm Size (in hectares); X_2 = Labour (in man-day); X_3 = Fertilizer (kg); X_4 = Herbicides (liters); β_0 and β_j = Unknown coefficients to be estimated; U_i = Farmer specific characteristics related to production efficiency; V_i = Statistically disturbance term.

The explicit form of the Cobb-Douglas functional form is written thus:

$$InY_i = \beta_0 + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + V_i - U_i \quad (3)$$

Technical efficiency of an individual firm is defined in terms of the ratio of the observed output (Y_i) to the corresponding frontier output (Y_i*), given the available technology, conditional on the levels of input used by the firm.

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{f(X_i;\beta)exp(v_i - u_i)}{f(X_i;\beta)exp(v_i)} \quad (4)$$

$$TE_i = exp(-u_i) \quad (5)$$

Where: Y_i = Observed output, Y_i^* = Frontier Output, X_i, β, v_i and u_i are as explained above. That is technical efficiency which is obtainable by the use of Frontier 4.1 (Coelli, 1996). Based on the individual farm's technical efficiency, the mean technical efficiency for the sample is obtained (Rahji, 2005). Ui's are non-negative random

variables called technical inefficiency of production of the respondent farmers which are assumed to be independent of the V_i's such that U_i's are the non-negative truncation (at zero) at the normal distribution with mean μ and variance δ^2.

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 \quad (6)$$

Z_1, Z_2, Z_3, Z_4 and Z_5 are the age, household size, level of education; years of farming experience and access to extension agents (number of contact) of the i^{th} farmer respectively and the βs and δ_s are known scalar parameters to be estimated.

RESULTS AND DISCUSSION

Socio-economic characteristics

A summary of the statistics of farmers in the study area is presented in (Table 1). The results showed that a typical farmer sampled is about 42 years old, married and had eight family members, had attained at least primary school level of education and cultivated 0.88 hectares of land. A typical farm household had 23 years of farming experience and had at least two contact with an extension agent during the production period. The preponderance of experienced farmers in the study area will fast track the decision making process. Previous experience enables the farmer set realistic time and cost targets by identifying production risks and constraints with ease. A large family size provides a ready source of cheap family labour. Small holder farmers over rely on meagre household resources and would strive to ensure minimum usage of paid labour as a result of the paucity and dearth of resources (Tanko et al., 2012). Education plays a crucial role in technology dissemination and adoption. The ability of the farmer to cope with complexities of new innovations, the intricacies of the product and factor markets increases as the level of education increases. Smallness of cultivated area of land is a common feature in small holder agriculture. Farmers usually own several plots devoted to crop in scattered locations.

Gross margin analysis

Gross margin (GM) analysis is a method of computing profitability of small-scale enterprises. It is a useful planning tool in situations where fixed capital is negligible portion.

The estimated gross margin analysis for onion production of farmers is presented in (Table 2). The table revealed that cost of fertilizer constituted 40.33% of the total cost of production in onion farming followed by labour, pump rent and maintenance with 21.10% and 10.97% respectively. A confirmation of profitability of onion production is shown by a net income of ₦ 409, 642.25. Also, the return on a naira invested was ₦ 3.46 while gross and operating ratios were 0.24 and 0.21 respectively. All the ratios were less than 1 indicating profitability of the onion farming.

Maximum likelihood estimates

The stochastic frontier production function estimates of onion producers are presented in (Table 3). The Table showed that the coefficients of farm size, labour, fertilizer and herbicide had the expected positive signs which indicated that a unit increase in these inputs will lead to increase in the gross output of onion. These variables were statistically significant at 10%, 10%, 5% and 1% level respectively (Table 3).

The estimated elasticity of mean output with respect to farm size, labour fertilizer and herbicide were 0.6421, 0.8963, 0.3390 and 0.8641, respectively. This means that for 1% increase in area cultivated to onion, the output will increase by 64.21%. 1% increase in the amount of labour will result in an increase of 89.63%, fertilizer and herbicide applied to onion also increased onion output by 33.9% and 86.41%, respectively. The sum of the elasticity (2.7415) indicated that, the onion farmers were operating on the increasing return to scale.

The estimated coefficients of the inefficiency function provide some explanations for the relative efficiency levels among individuals' farms. Since the dependent variable of the inefficiency function represents the mode of inefficiency, a positive sign of an estimated parameter implies that the associated variable has a negative effect on efficiency and a negative sign indicates the reverse. The negative sign of household size, education, farming experience and extension contacts imply that educated farmers, the farmers with high farming experience and extension contacts in onion production were more technically efficient meaning that as the level of education, years of farming experience and access to extension services increased, the technical inefficiency of the farmers decreases. Also, positive coefficient for age implied that the farmers' level of technical inefficiency declined with increase in age. The sigma square (0.7721) is large and statistically significant at 1%. This indicates a good fit and the correctness of the specified distributed assumption of the composite error term. The gamma (γ) ratio of 0.9333 which is significant at 1% level implied that about 93.33% variation in the output of onion farmers was due to differences in their technical efficiencies.

Technical efficiency distribution of farmers

The technical efficiency scores were derived from the MLE of the stochastic frontier production function, using

Table 1. Socio-economic characteristics of sampled farmers.

Variable	Minimum	Maximum	Mean	Std. Deviation	Variance
Age	26	67	42.32	8.53	94.62
Household	2.00	13.00	8.41	2.33	4.56
Farm size(Ha)	0.20	5.00	0.88	1.00	1.00
Education	0.00	12.00	6.16	4.00	16.34
Experience	8.00	31.00	23.03	4.53	26.21
Ext. Contact	1.00	3.00	2.21	0.57	0.46

Source: Field Survey data.

Table 2. Estimated gross margin analysis for onion production/ha.

Cost Item	Cost (₦/ha)	% of total cost
Variable cost		
Water	6,012.65	4.23
Labour	30,000.93	21.10
Agrochemical	11,485.53	8.08
Fertilizer	57,346.35	40.33
Seed or Seedling	8,705.58	6.12
Packaging and Handling Charges	4,407.96	3.10
Transportation	5,587.33	3.93
Total Variable cost	123,546.33	86.89
Fixed Cost		
Depreciation (Farm tools)	3,042.47	2.13
Pump rent and maintenance	15,597.99	10.97
Total Fixed Cost	18,640.46	13.10
Total Cost	142,186.79	100.00
Returns		
Gross Revenue	569,765.61	
Gross margin	427,578.82	
Net Farm Income	409,642.25	
Returns on Naira Invested	3.46	
Operating Ratio	0.21	
Gross Ratio	0.24	

Source: Field Survey data.

Table 3. Maximum likelihood estimates of the Cobb-Douglas frontier production function.

Variable	Parameters	Coefficients	t-ratio
Intercept	β_0	0.3879	3.492[c]
Farm size	β_1	0.6421	1.864[a]
Labour	β_2	0.8963	1.679[a]
Fertilizer	β_3	0.3390	2.008[b]
Herbicide	β_4	0.8641	8.555[c]
Inefficiency Function			
Intercept	λ_0	0.0045	1.203
Age	λ_1	0.0429	2.607[c]
Household	λ_2	-0.5749	-1.775[a]
Education	λ_3	-0.279	-7.378[c]
Experience	λ_4	-1.0662	-2.731[b]
Extension Contact	λ_5	-0.0284	-1.997[b]
Sigma-Square	δ^2	0.7721	8.746[c]
Gamma	γ	0.9333	11.7254[c]
Log likelihood Function		-121.143	

Source: Field Survey data.
Note: [a], [b] and [c] denote significance at 10%, 5% and 1% level respectively.

Table 4. Technical efficiency distribution of onion farmers across the study area.

Efficiency scores	Frequency	Percentage
1.00	0	0.00
> 0.90 < 1	36	30.00
> 0.80 ≤ 90	39	32.50
> 0.70 ≤ 0.80	22	18.33
> 0.60 ≤ 0.70	14	11.67
> 0.50 ≤ 0.60	6	5.00
> 0.40 ≤ 0.50	3	2.50
Total	120	100
Mean	0.836	
Minimum	0.407	
Maximum	0.999	
Std. Dev.	0.132	

Source: Field Survey data.

FRONTIER 4.1 version. The scores in (Table 4) displayed that the technical efficiency of the sampled farmers was less than one (less than 100%), implying that all the farmers in the study area were producing below the maximum efficiency frontier. Some farmers demonstrated a range of technical efficiency of 0.999 (99.9%) while the worst farmer had a technical efficiency of 0.407 (40.7%). The mean technical efficiency is 0.836 (83.6%), implying that on the average, farmers in the study area were able to obtain a little over 83% of potential onion output from a given mix of production inputs. From the results obtained, although farmers were generally relatively efficient, they still have room to increase the efficiency in their farming activities as about 16.4% efficiency gap from optimum (100%) was yet to be attained by all farmers.

Conclusion

The study showed that irrigated onion production was profitable with a net income of ₦ 409, 642.25 per hectare. A Cobb-Douglas frontier production function was estimated by maximum likelihood estimation method (MLE). The MLE results revealed that technical efficiency of onion farmers varied due to the presence of technical inefficiency effects in the production process. Farm size, labour, fertilizer and herbicide were found to be the significant production factors which accounted for variations in the output of onion. The overall distribution of the technical efficiency scores revealed that most of the farmers were technically efficient with mean technical efficiency score of 0.836 (83.6%) and about 88.3% of the farmers had technically efficiency of 80% and above. The results of the inefficiency model indicated that education level, household size, farming experience and extension contacts significantly decreased the farmers' technical inefficiency. The study revealed that onion farmers were not fully technically efficient and therefore there is a chance of increasing their onion output through improving efficiency level by addressing some important policy variables that could negatively and positively influence farmers' technical efficiency in the area.

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