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Full-Length Research Paper

Economic efficiency of onion production and price trend in Kebbi State, Nigeria: a stochastic frontier cost function approach

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ABSTRACT: The research looks at the economic efficiency of onion production in Kebbi State. A structure questionnaire was used to collect primary data. Data from 210 sole onion producers were collected using a multistage sampling technique. The obtained data were analyzed using descriptive statistics, trend analysis, and a stochastic frontier cost function. The results revealed that respondents had an average farm size of 0.8 hectares, with the majority (44.2%) cultivating ≤ 0.5 hectares and the majority (81.4%) owning farmland by inheritance. The onion price pattern recorded a minimum average price of around ₦5,000.00 during the on-season (March to May) and a maximum of ≥ ₦30,000 between November and December. The estimated coefficients of labour cost (0.3453), seed (0.1673), inorganic fertilizer (0.2639), and so on are positive, indicating an increase in total cost of onion production, whereas inefficiency variables such as farming experience, level of education, and household size are negative, with education and farming experience having significant levels at 5%. Maximum likelihood estimates of the specified economic model revealed that the producers' cost efficiencies ranged from 20.00 % to 91.10 %, with a mean of 70.30%, implying that an estimated 26.8% of the return is lost due to a combination of technical and allocative inefficiencies in onion production. It is recommended that onion producers be linked with financial/insurance institutions for soft loans and insurance to further augment exhibited cost efficiency, and that they be encouraged to improve proper staggered planting of suitable varieties to bridge the gap between the offseason and on-season for sustained supply, better/stable prices, and good quality produced.

Keywords: Onion, producer, economic, efficiency, price and trend

INTRODUCTION

Almost half of the world population lives in urban areas and the urbanization trend is expected to continue and even to accelerates, especially in Africa and Asia. This phenomenon has given birth to an increased demand for fresh fruits and vegetables which needs to be met (Mike and Martin, 2009). According to East-West Seed (2018) Nigeria as one of the fastest growing countries in the world having population estimated growth from 200 million to 400 million by 2050, thus there are clear issues to address with urbanization, food security and migration. Vegetable production provides large quantities of produce from a very small area of farmland if the crops are given sufficient water, nutrients and free of pest and disease attacks. Onion production under good management practices can yields up to 5kg per meters-square in 90 days from planting date.

Therefore, production and trading of vegetables create an opportunity for the poorest members of a population to enhance their livelihood, due to increase in incomes, improving standard of living and providing an incentive for rural inhabitants to stay in rural areas stemming down migration to urban cities in search of white collar jobs (Mike and Martin, 2009).

Vegetables primary production for Nigeria between 1970 and 2019 grew substantially from 3.04 million to 16.7 million tonnes rising at an increasing annual rate that reached a maximum of 20.77 million tonnes in 2014 and then decreased to 3.81% in 2019 (Iyabo, 2020) . In the face of increase in pressure on agricultural land due to; urbanization, climate change, fragmentation on inheritance, rural population increase, declining soil fertility, conflict/insecurity, wide price fluctuation of onion as a risky vegetable and in the light of poor economic background among the smallholder onion farmers who are expected to increase productivity through efficient use of resources as against increase in farm size which may be relatively unavailable for sustained production. And understanding the cost efficiency with which producers operate the technologies as it comes at a cost, among other factors call for whether significant economic efficiency in the use of inputs for production of onion exists or not is very necessary for policy analysis. According to Ahmadzai (2017) empirical research suggests that farmers in developing countries fail to exploit fully the production technology and production resources and often make inefficient decisions. High levels of production are not achieved due to the low use of available economic resources and difficulty of obtaining other economic resources which led to higher production costs and lower net returns resulting in low economic efficiency far away from required level (Al-Haboobi, 2020). On the basis of the above confirmatory statements this research may benefit the existing and potential onion producers as well as policy makers, researchers and other stakeholders in the onion/agricultural production sector.

Empirical studies on economic efficiency of onion producers in Kebbi State are very scares and where available are far between the study area and other existing states that are into onion production in Nigeria. Most of the researches carried out paid attention on technical efficiency in agricultural production only few on economic efficiency (Aboki *et al*., 2013; Shettima *et al*., 2016; Yahaya *et al*., 2019). Flowing from the above assertion this paper is therefore aimed at evaluating the present level of economic efficiency among the onion producers in Kebbi State. The study's specific goals are as follows:

(i) Establish the planting and harvesting regimes and farm size distribution in the study area.
(ii) Determine inter-market and seasonal onion producer price pattern in the study area.
(iii) Assess the extent and causes of economic inefficiency in the study area.

METHODOLOGY

Study area

The study was conducted in Kebbi State located in the north-western part of Nigeria. Kebbi State is situated between latitudes 10º 8'N and 13º 15'N and longitudes 3º 30'E and 6 º 02' E. The State is bordered by Sokoto and Zamfara States to the east, Niger State to the south, Benin Republic to the west and Niger republic to the north. Kebbi State occupies an area of about 37, 699 square kilometers out of which 36.46% is made up of farmland (Kebbi State Government, 2018). The State has an estimated population of about 3.24 million, out of which 49.9% are males, while 50.1% are females (NPC, 2006). Kebbi State has tropical weather conditions with three seasons: rainy, dry and hot. The annual rainfall is variable and declining, being 600 mm to 850 mm and on average 650 mm. The monthly temperature in the region ranges from 25ºC to 45ºC. The state possessed two important agricultural lands namely: dryland (arid-prolonged dryness) and fadama (floodplains-significant alluvial clay particles). These two lands remained the key source of income to millions of people in the state (Usman *et al*., 2016). Agriculture is the most important economic activity, with riverine floodplains producing crops like groundnuts, cotton, rice, millet, sorghum and vegetables such as tomato, onions etc. Most of the land in the state is used for grazing cattle, goat and sheep. The major ethnic groups in the State include Fulani, Hausa, Dakarkari and Kambari (Amy, 2020).

Data collection

Both primary data and secondary information were used for the study. The primary data was generated by the use of structured questionnaire, administered to the sampled respondents in the study area with the assistance of trained enumerators. Information on socioeconomic characteristic of the onion producers and retailers were collected. Input-output information on onion production and marketing was also collected such as quantities and costs of inputs used and labour as well as output obtained and its prices and volume transacted with cost and price implications. Secondary information includes journals, government reports, text books and unpublished materials were implored to achieve the desired objectives of the research work.

Sampling procedure and sample size

A multistage sampling procedure was adopted for data collection to select the respondents from the study area. At stage I, purposive selection of seven local government areas namely; Aliero, Yauri, Gwandu, Birnin Kebbi, Maiyama, Shanga and Augie based on their relative involvement in high sole onion production in the study area. At stage II, two dominant villages were purposively selected from each of the seven local government areas based on the large number of sole onion producers in the area making a total of 14 villages. In stage III, in each of the 14 villages, a list of sole onion farmers was compiled and simple random sampling method was employed in the selection of 15 respondents in each of the villages given a sample size of 210 onion producers used as the entire sample size for the study.

Methods of data analysis

The collected data were subjected to both descriptive and inferential statistics as analytical techniques used for the analyses of data obtained. Descriptive statistics such as frequency counts, percentages, mean, minimum and maximum scores was used to determine planting/harvesting regimes as well as farm size distribution of the respondents and distribution of economic efficiency levels of the onion producers in the study area. Trend analysis was used to describe the onion producers' price (price trend) in the study area and inferential statistics was stochastic frontier cost function used to estimate the level of economic efficiency of onion production.

Stochastic frontier cost function model specification

Stochastic frontier cost function in its explicit form is written as: (Adopted from Ogundari and Ojo, 2007, Shettima *et al*., 2016).

$$lnC=\beta_o+ \beta_1 lnP_1+ \beta_2 lnP_2+ \beta_3 lnP_3+ \beta_4 lnP_4+\beta_5 lnP_5+ \beta_6 lnP_6+ \beta_7 lnP_7+ (Vi-Ui) \quad (1)$$

Where:

Ln= the natural logarithm
C= Total Cost of Production of i-th farm in naira (₦)
β_o= Constant term
β_1-β_9= Regression coefficients to be estimated
P_1= Cost of Labour (₦)
P_2= Cost of seeds (₦)
P_3= Cost of Inorganic fertilizer (₦)
P_4= Cost of Agrochemicals (₦)
P_5= Cost of Fuel/Maintenance (₦)
P_6= Cost of Depreciation (₦)
P_7= Output (₦)
V_i= Random error outside the farmers control
U_i= Economic inefficiency effects

The coefficients of independent variables in the cost function model as in equation (1) such as cost of labour, cost of seeds, cost of inorganic fertilizer, cost of agrochemicals, cost of fuel/maintenance and cost of depreciation are *a priori* expected to be negative. This is signifying that a unit increase in any of the affected variable may leads to decrease in total production cost of onion.

The determinant of economic inefficiency is defined by:

$$U_i= \delta_o+ \delta_1 Z_1+ \delta_2 Z_2+ \delta_3 Z_3+ \delta_4 Z_4 \quad (2)$$

Where:
U_i= Inefficient effects (i.e. the deviation from maximum potential output attributable to resource use inefficiency).
δ_o= Constant
δ_1 –δ_4= Parameters to be estimated
Z_1= Age of farmer (years)
Z_2=Formal education (years of formal schooling)
Z_3=Farmers experience (number of years in onion production)
Z_4=Household size (number of people)

The specification of the model for the inefficiency effects in equation (2) implies that, if the independent variables of the inefficiency model have a negative value on an estimated parameter, then the associated variable has a positive influence on efficiency while a positive sign indicates that the reverse is true. Thus, the *a priori* expectation is that the coefficients of the whole independent variables of the inefficiency model (i.e. Z_1, Z_2, Z_3, and Z_4) should all be negative (i.e. less than zero). Therefore, each variable is expected to have positive effect on technical efficiency

RESULTS AND DISCUSSION

Land ownership type and farm size

An individual or group of individuals interested in farming may own and work on farmland in a variety of legally or administratively accepted ways. As shown in (Table 1), the majority of onion producers (81.4%) inherited their

Table 1: Distribution of onion producers according to their land ownership and farm size.

Variables	Frequency (n=210)	Percentage
Type of land ownership*		
Inheritance	171.0	81.4
Purchase	32.0	15.2
Gift	6.0	2.9
Rent	48.0	22.0
Free lease	11.0	5.2
Farm size (Hectare)		
Up to 0.5	93.0	44.2
0.51-1.0	73.0	34.8
1.01-2.0	35.0	16.7
2.01-3.0	7.0	3.3
>3	2.0	1.0
Min	0.2	
Max	4.5	
Mean	0.8	

Source: Field Survey, 2019 *Multiple responses were considered

onion farmlands, while 22 % leased their onion farms. This is consistent with the findings of Ojo et al. (2009) and Shettima et al. (2016), who independently reported similar findings in different areas. This could significantly reduce the cost of producing onions and result in higher profits. A farm is a piece of land that is used for agriculture. It is an essential production facility in agricultural production and is frequently related to output quantity. In this study, farm sizes represent the estimated total land area cultivated by onion producers and for onion production in the study area. Table 1 also shows the respondents' farm size distribution. The majority of onion farmers (44.2%) cultivated less than or equal to 0.5 hectares of land, followed by 34.8 % of respondents who cultivated between 0.51 and 1 hectares, and 16.7 % onion farmers cultivated 1.01-2.0 hectares. According to the study, the average farm size of the respondents was 0.8 hectares. As a result, smallholder onion farmers dominate onion production in the study area. The table also shows the participation of medium (0.51-2.0hectares) and large (>2.5 hectares) commercial onion farmers who cultivate onion in the study area. This implies that the respondents' small farm holdings may be due to land fragmentation as a result of heirs' inheritance share. As a result, increased output through farmland expansion is limited. Respondents, on the other hand, may achieve better farm maintenance with ease by making better use of available inputs and technologies and increasing the efficiency of available inputs and technologies to maximize productivity. This finding is consistent with Tbilisi (2016), who stated that the majority of onion producers are small onion farmers who cultivate onions on 0.1-0.3 hectares, while medium and large commercial farmers cultivate 0.5-1.5 hectares and 2.5-3.5 hectares, respectively. The findings also agree with those of Shettima et al. (2016), who discovered that the majority of vegetable producers cultivated less than 1.5 hectares of farmland for vegetable production.

Planting regime

Onion seasonal calendar (Table 2) depicted three patterns of planting activities viz wet season, dry season and wet to dry season. The time and season of onion cultivation in the study area is favoured by the advantage of irrigable land geographically located. Majority of the onion producers (85.7%) opted for wet to dry season pattern (August-September), dry season (14.3%) with small proportion of wet season (3.3%). The findings revealed staggered planting pattern which would have addressed the supply gap if properly organized. It was also observed that wet to dry pattern is to take advantage of reduced number of irrigation per cycle, forecast of good price regime but forfeits growing other crops on onion farmland that may extend its life cycle between the months of August and September. The findings are in agreement with the report of Pankaj and Muthuselvan (2018) who observed three season of onion cultivation in some parts of India as early Kharif, Kharif and late Kharif, however, recommended for an enhanced staggered cultivation so that onions are available on regular basis.

Onion harvesting regime

In the study area, bulk onion harvesting typically begins in November and lasts until December of the same year, followed by January to April of the following year. According to the findings in (Table 2), the majority of onion producers (116%) harvested their onions between the months of October and December of the same year. However, 85% harvested theirs between the months of

Table 2: Distribution of onion producers according to their planting and harvesting regimes.

Variable	Frequency (n=210)	Percentage
Planting regime*		
Wet season (June –July)	7	3.3
Dry season (October-January)	30	14.3
Wet to Dry season (August-Sept)	180	85.7
Harvesting Regime*		
October –December	243	116.0
January-February	178	84.8
March-April	67	31.9

Source: Field Survey, 2019 *Multiple responses were considered.

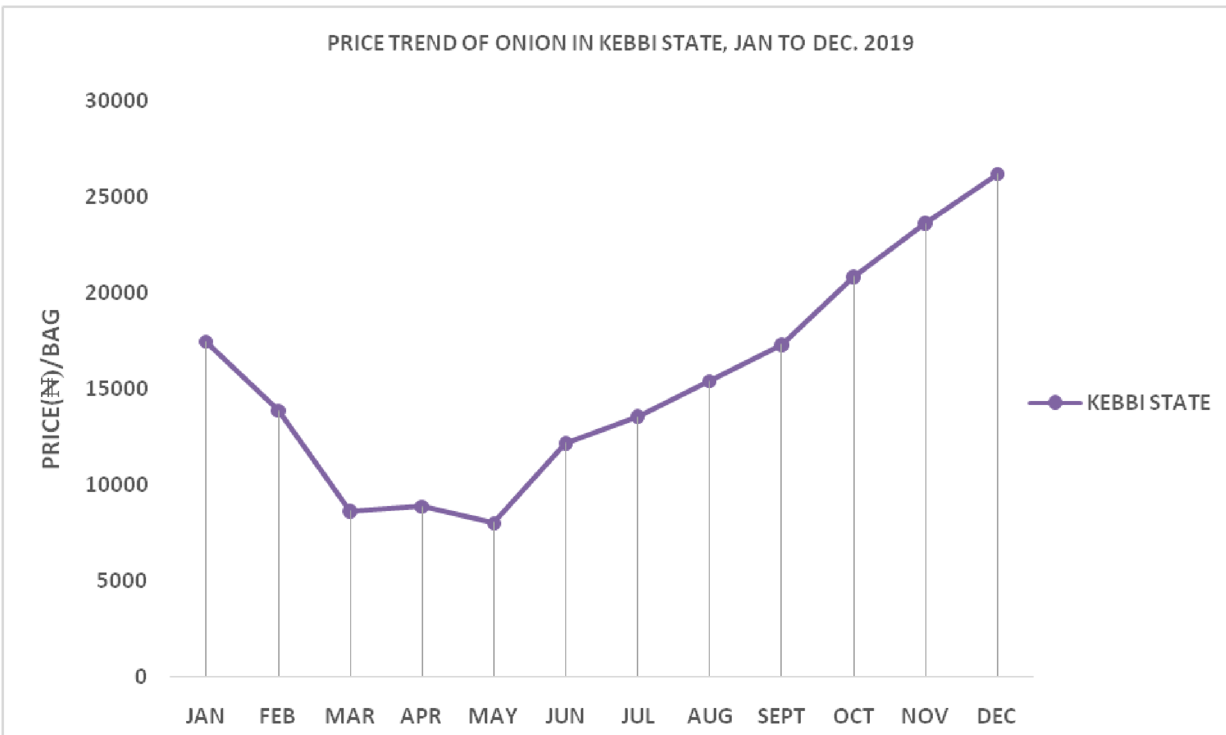

Figure 1: Onion producer price pattern of Kebbi State Jan. - Dec., 2019

January and February, while 32 percent harvested between March and April of the following year. The findings are consistent with Tsoho and Salau (2012)'s observation that the peak harvest time was between January and March, though a shift from complete dry season onion production to wet to dry has resulted in a deviation in the majority of harvest recorded in this study area. This suggests that the staggered harvest was caused by the onion producers' practice of staggered planting. The implications of onion planting staggering, if proper planning is taken into account in planting arrangement so as not to coincide, may assist the onion producer in gaining a better price when marketing the onion bulb.

Inter-market and seasonal onion producer price pattern

Agricultural commodities are typically supplied from farming areas to various markets ranging from semi-urban to urban areas. Vegetables, in particular, are characterized by a short shelf life after harvest, and shortages in marketing services such as adequate storage and processing facilities performed by various actors to satisfy the demand of the final consumer by way of form, time, and place may result in the price of a commodity stagnating and contracting at a specific time of year. Figure 1 depicts the seasonal onion producer price pattern in Kebbi State for the calendar year 2019

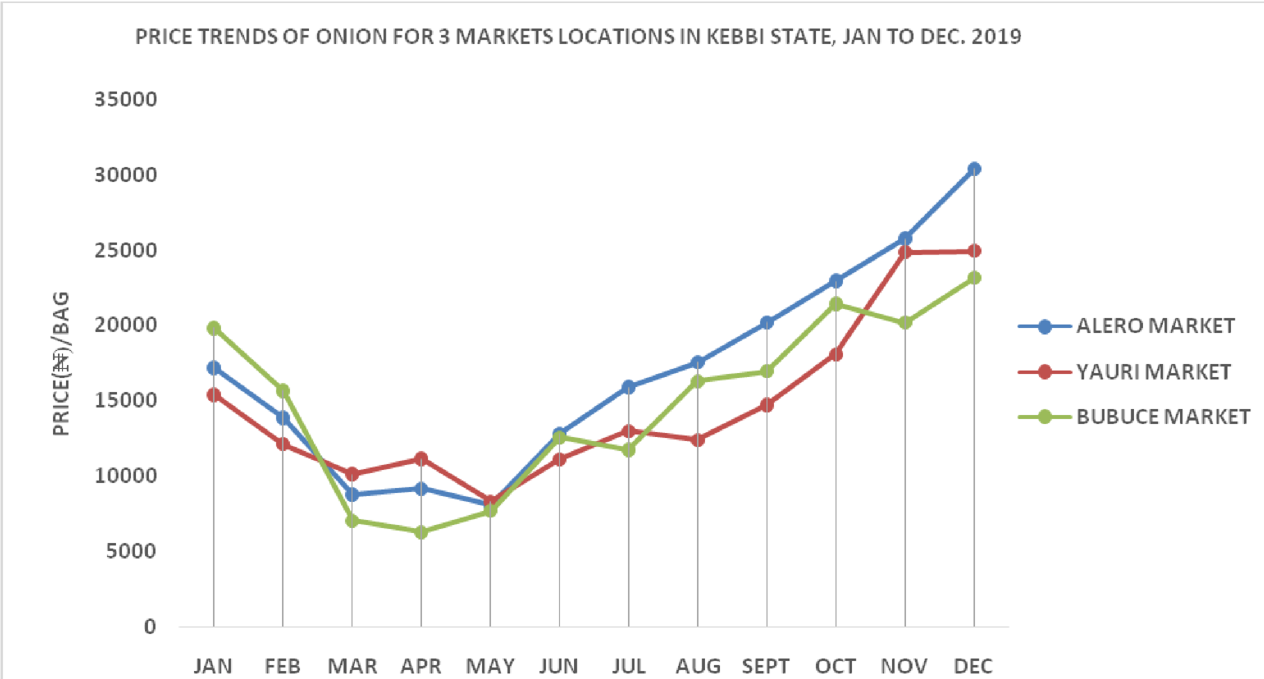

Figure 2: Onion producer price pattern of three notable onion central markets in Kebbi State Jan. - Dec., 2019.

(January to December). From June to December, the onion producer price rises, indicating an onion offseason in the study area. Some onion producers engaged in wet to dry season (August to September) production in the study area typically take advantage of this rise in onion price during this period. This is to take advantage of the relatively low prices in the months of November and December. The price decline begins in January and continues through March before stabilizing and concentrating at lower prices due to an excess supply of onions (between March and May) due to the predominance of harvest by dry onion producers. This is a clear manifestation of onion price volatility, as Anonymous (2019) reported that a bag of onion can be sold in areas such as Sokoto, Kano, Jigawa, Kaduna, Plateau, and Kebbi States at ridiculously low prices ranging from ₦1500 to ₦4000 during the period of plenty (January to March) and soars during the offseason between ₦25000 to ₦35000when it is scarce. Figure 2 depicts the rising and falling of onion producer prices at three prominent onion central markets in Kebbi State, namely Aliero, Yauri, and Bubuche. When monthly onion producer prices are closely examined, it is clear that only the Aleiro onion market exhibits a consistent rise in the average onion producer price from May to December. However, it also recorded a price decrease from January to April, which generally depicts a minimum average price of about ₦5000 during the on-season (March to May) and a maximum of at least N30000. The Bubuce onion central market had the lowest cost in December, with an unusual rise and fall in onion producer price from June to December. The month of May continues to be the confluence point for the start of price increases in onion produce by all onion central markets. The months of March to May also indicated a period associated with low onion producer price in the study area as it affects all market points which also represent the harvest period (Period of plenty), though Yauri witnessed a slight rise above others in the month of April. Seasonal differences in the surplus and deficit gap of onion could be attributed to producers' lack of proper staggered cultivation and storability of the commodity in order to meet consumer demand.

Efficiency analysis

Table 3 shows the maximum likelihood estimates of the parameters of the stochastic frontier cost function for onion production in the sample area. The table shows that the output is negatively related to the total cost of production, though this relationship is not statistically significant. As a result, if output is said to have increased by a certain unit of percentage, the total cost of production may be reduced by the corresponding value of its coefficient. This implies that the output continues to be

Table 3: Maximum log-likelihood estimates of the stochastic frontier cost function and technical inefficiency for onion production.

Variables	Parameters	Coefficients	Standard error	t-statistics
Constant	β_0	1.1157	0.1136	10.1834***
InLabour cost (₦)	β_1	0.3453	0.0171	20.2289***
InSeed cost (₦)	β_2	0.1673	0.0104	16.1589***
InInorganic fertilizer cost (₦)	β_3	0.2639	0.0118	22.4031***
InAgrochemical cost (₦)	β_4	0.0095	0.0016	6.0010***
InFuel/Maintenance cost (₦)	β_5	0.1520	0.0126	12.1090***
InDepreciation cost(₦)	β_6	0.1301	0.0133	9.7690***
Inefficiency functions				
Constant	δ_0	-0.3920	0.2864	-13.687***
Age (years)	δ_1	0.0018	0.0053	0.3474^{ns}
Education level (years)	δ_2	-0.0187	0.0084	-2.2262**
Farming exper. (years)	δ_3	-0.0073	0.0035	-2.0857**
Household size (number)	δ_4	-0.0048	0.0075	-0.6367^{ns}
Diagnosis Statistics				
Sigma-square	σ^2	0.0487	0.0209	2.3269**
Gamma	γ	0.9926	0.0045	221.5447***
Log likelihood	l/f	205.2107		
LR test		67.0357		

Source: Field Survey, 2019
*, **, ***=Significant at 10%, 5% and 1% levels respectively. ns=Not significant.

a significant contributor to the cost efficiency of onion production operations in the study area. The estimated coefficients of all explanatory variables of the cost function, however, are all positive and statistically significant at 1%, as confirmed by the t-ratio test at 1% level of significance. The estimated coefficients of labor (0.3458), seed (0.1673), inorganic fertilizer (0.2639), agrochemical (0.0095), fuel/maintenance (0.1520), and depreciation (0.1301) are all positive, indicating that the total cost of onion production is increasing. This implies that the variables in the model have a direct relationship with the total cost of onion production, i.e. the total cost of onion production increases by the corresponding value of each coefficient as the quantity of each variable increases by one. This result is consistent with the findings of many other researchers who conducted similar studies but were located outside of the study area, such as Ogundari and Ojo (2007), Berhan (2015), and Shettima et al. (2016). The estimated sigma-squared (σ^2) was 0.0487 and significant at 5% indicating goodness of fit. The gamma value (γ) of the MLEs of stochastic frontier cost function model is 0.9926 and significant event at 1% level which indicates that inefficiency effect exist, hence justifying the application of the stochastic frontier model. This value is implying that 99.26% of variability of cost efficiency from onion production is attributed to the output; however, the rest (0.74%) is due to random noises-factors beyond the realm of producers' control. The presence of technical inefficiency effect was treated by using the generalized likelihood ratio (LR) test which was 67.0357 and more than critical chi-square value at 1% level of significance with 11 degree of freedom χ^2 (1% 11) was30.542 (given by Kodde and Palmz, 1986). The null hypothesis of no technical inefficiency effects in the course of the producers production γ=0, was strongly rejected. The analysis of the inefficiency function in Table 3 also shows that the signs and significance of the estimated coefficients in the inefficiency model (U) have significant implications for the economic efficiency of onion producers in the study area. Though not statistically significant, the positive coefficients for age and farming experience imply a negative relationship with economic inefficiency. This finding is consistent with the findings of Ogundari and Ojo's study (2007). At the 5% level, the estimated coefficient of level of education (0.0187) was negative and significant, implying that as level of education increases, cost inefficiency decreases. The negative coefficient of household size (-0.0048) was found to be negatively related to economic inefficiency, but it was not

Table 4: Distribution of the levels of economic efficiency of onion producers.

Efficiency Class Index	Frequency	Percentage
> 0.80 ≤ 1.00	144.00	68.60
> 0.60 ≤ 0.80	32.00	15.20
> 0.40 ≤ 0.60	21.00	10.00
> 0.20 ≤ 0.40	13.00	6.20
Total	210.00	100.00
Mean Efficiency	0.723	
Minimum Efficiency	0.395	
Maximum Efficiency	0.911	
Std. Dev.	0.133	

Source: Computed from MLE result

significant, which agrees with the findings of (Bravo et al., 1997). Except for the insignificant age, the entire coefficients of the inefficiency variables in the model used agree with a priori expectation.

Level of individual economic efficiency scores of onion producers

The frequency distribution of farm specific efficiency scores for the onion producers is presented in (Table 4). The estimates showed that, considerable amount of cost is incurred from the onion production because of the existence of cost inefficiency in resource use among onion farmers. The findings revealed that onion farmers achieved on the average 70.30% level of cost efficiency.
The result had revealed cost inefficiency gap of about 29.70%. This implies that the average farmer in the study area could decrease cost by 29.70% by improving their technical and allocative efficiency. The onion farmers exhibited varied economic efficiencies ranging from 20.00% to 91.10%. However, the least cost efficient onion farmer needs an efficiency gain of 80.00% (1 - 0.20)100 of production if such a farmer is to attain the economic efficiency of the best efficient farmer in the study area. Likewise for an average cost efficient farmer, he will need an efficiency gain of 29.70% (1 - 0.703)100 to attain the most efficient level of production. Furthermore, the most cost efficient farmer in the study area needs about 8.90% gains in cost efficiency to be on the frontier efficiency. However, despite the variation in cost efficiency, it could be seen that about 83.80% of onion farmers seemed to be skewed towards efficiency level of greater than 60% and above.

Conclusion and Recommendations

Based on the findings of this research, it was concluded that onion producers owned land in perpetuity (i.e. by inheritance, gift, and purchase), allowing them to engage in any desired production. This implies that permanent structures can be erected, and the future of the onion enterprise is assured, with the onion value chain in the study area undoubtedly improving. The study area's onion production was characterized by an uncoordinated shift in planting date (staggered planting), resulting in the concentration and flooding of harvested onion in the market due to the lack of a local/modern preservation method to store the commodity, which causes onion price volatility. The result showed that respondents had an average farm size of 0.8 hectares with majority (44.2%) cultivated ≤ 0.5 hectare and most (81.4%) of the respondents owned farmland by inheritance. Onion price pattern recorded minimum average price of about ₦5,000 at the on-season (March to May) and maximum of ≥ ₦30,000 between the months of November and December. The estimated coefficient of cost of labour (0.3453), seed (0.1673), inorganic fertilizer (0.2639), etc. are positive depicting increasing total cost of onion production while inefficiency variables; farming experience, level of education and household size are negative with education and farming experience having significant levels at 5%. Maximum likelihood estimates of the specified economic model revealed that costs efficiencies of the producers varied between 20.00% and 91.10% with a mean of 70.30% suggesting that an estimated 26.8% of the return is lost due to a combination of technical and allocative inefficiencies in onion production. It is recommended that onion producers should be linked with financial institutions like Bank of Agriculture (BOA), Nigeria Incentive-Base Risk Sharing System for Agricultural Lending (NISAL) and other commercial and Micro-Finance Banks at their doorsteps for ease of access to soft loans/insurances to facilitate acquisition of new farm technologies/implements for planting, harvesting, sorting etc. and use them efficiently to further strengthen their cost efficiency using their available land for onion cultivation giving rise to efficiencies in onion production. Onion producers should evolve an enhanced staggered planting of suitable varieties of onion in order to address the glut and clashed in price as well as the gap at off-season which may help both onion farmers and traders to get better prices for good quality produced. Onion producers need to be trained on new storage techniques, while Kebbi State government should sponsor for a scientifically build onion storage structures within major onion producing and marketing areas to address seasonality problems and low price regime.

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