Land Tenure Systems and Agricultural Productivity in Nigeria: a Case of Rice Production

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Abstract
This study examined land tenure systems and rice productivity in Nigeria. Primary data were used for the study. Data were collected with the aid of a well-structured questionnaire. A four-stage sampling technique was used to select a total sample size of three hundred and forty-nine (349) rice farmers based on the number of questionnaires correctly filled and returned from the selected sampled size. Data were analyzed using descriptive statistics, total factor productivity, and Stochastic production frontier model. The study revealed that large portion of the land (over 94%) used for rice production were acquired through inheritance mode of land acquisition and communal type of land tenure system widely practiced. The result of total factor productivity indicated that 62.18% of the rice farmers were at sub-optimal productivity level. The results of the stochastic production frontier function revealed that seed (P< 0.10), and fertilizer application (P<0.01) were the significant factors influencing technical efficiency of rice production in the study area. Based on the findings, the study recommend that current land use act and policy should be amended to prevent concurrent grabbing of agricultural land for non-agricultural purposes in order to enhance availability and accessibility of land for agriculture.

Keywords: Land tenure, Agriculture, productivity, rice, Nigeria

Introduction
Land is one of the vital assets throughout the world either in urban centers or rural environments’ where lives and survival is based and build on the cultivation of land [1]. According to [2] smallholder farmers play key roles in achieving food security but unfortunately, they face limited access to land resources due to different socio-economic and land tenure factors. Land tenure is essentially, the methods by which individuals or groups acquire, hold, transfer or transmit property rights in land [3]. The term tenure means the sum of rights an individual, household or
community may have with respect to land or water or other resources for that matter. It is a mix or number of entitlements (rights and duties) concerning the use of land resources. It covers the rules under which those rights and duties are exercised and the time horizon or guarantee of continued claim to such entitlements. In simple terms, land tenure systems determine who can use what resources for how long and under what conditions. Land remains a limited resource and its distribution as well as tenure structures are key issues in nation’s agricultural developmental strategy. The development of the rice sub-sectors in Nigeria revolves, largely around the ownership and use of land resources, and type of labour [4]. Land is the main factor for agricultural production and rural livelihoods, it is one of the principal challenges of implementing agricultural programs for improved productivity and resource utilization. Consequently, access to, and security of land rights are major concerns for policies and strategies aimed at increasing rice production. Land is therefore, a very strategic socio-economic asset, particularly in poor societies where agricultural output are measured by control of, and access to land.

Land tenure systems affect agricultural productivity by influencing the efficient use of inputs and adoption of modern technology. [5] opined that land tenure system has generally been broadly described as rigid, creating obstacles in the way of agricultural development. Land as a factor of production and as a natural resource is critical in agricultural production. Its importance is expressed in terms of availability, accessibility, quantity and quality. In Nigerian agriculture, the accessibility and quality factors stand out as major determinants of productivity. The accessibility of most agricultural lands especially in the North-Central part of the country depends largely on land tenure system and the extent of competition by non-agricultural land uses [6]. Farm size and productivity is one of the oldest issues in the academic arena for analyzing the agrarian structure.
Rice (*Oryza sativa*) is an important traditional basic commodity contributing a significant proportion of the food requirements of Nigerians and it is cultivated in almost all the agro-ecological zone in Nigeria [7]. In recent years, rice production had been on the increase but not sufficient to meet the demand of growing population. According to [8], rainfed lowland and upland rice production have the potential to meet national demand. However, their average rice yield of 1.8 tons/ha fall short of the expected national average potential yield of 5.0 tons/ha and 3.0 tons/ha respectively [9]. The current average increase in yield of about 2.5-3.2 tons/ha for lowland rice is a tremendous growth but still below the optimal level of production. Hence, there is a gap in the optimum capacity of rice farmers in realizing the expected output. The research is therefore set to ascertain the validity of this claim.

An efficient system of land tenure and land right contributes to the general economic development by assisting agriculture in contributing to industrial development through the production of food, capital, raw materials, labour, foreign exchange and expanded market. Consequently, the system of land tenure in any place to a large extent determines the pattern of agriculture that prevails in that society. It has potential to determine the allocation of resources, systems of conserving land and the general productivity of the farm. [5] reported that land right system determines the type of farming systems, decisions regarding investment of factors of production such as capital, labour and management as well as the productivity of such farming systems. Even though land tenure is believed to strongly impact upon agricultural production in rural areas of Nigeria, relatively little is known about the types and mode of land acquisition, how and the extent of the impact and in what specific areas of agricultural activities the impact is evident particularly in Federal Capital Territory, Nigeria. The gap that existed on the dual mix of land tenure system and the effect on rice productivity in the Federal Capital Territory necessitated
the need for research of this nature to fill the identified vacuum. Furthermore, much of the little that is known about the effect of land tenure on agricultural production in Northern Nigeria is merely speculative and not sufficiently substantiated or clarified by empirical evidence. Hence, the need for a study such as this in Federal Capital Territory, Nigeria.

From time immemorial till the present period, there has been a great concern that the process of land tenure system and land ownership practices for agricultural purpose and other uses in Sub-Sahara Africa subdued productivity, resource-use and investments in agriculture [10]. The concern that land tenure disrupts free ownership and control of land resources are rarely backed with empirical evidence. Quantitative evidence to support the argument that there exits inverse relationship between land tenure practices and productivity are scanty and weak [11-12]. To some extent the weak evidence reflects the fact that either it is because it is difficult to measure the effect of land tenure on productivity or there is not enough empirical research that have been carried out in this area of human endaevour. Hence the need for research to be conducted on this subject area to fill the identified gap in literature. Therefore, the broad objective of the study was to examine the land tenure system and productivity of rice farmers in Federal Capital Territory, Nigeria. The specific objectives were to: -

(i) identify the types of land tenure system and mode of land acquisitions by rice farmers,
(ii) determine the productivity index of rice farmers, and
(iii) examine the factors influencing technical efficiency of rice production

2.0 Theoretical Framework

2.1 Land Tenure and Agricultural Productivity

Nigeria has about 84 million hectares of arable land that spreads across all the ecological zones and only about 5 million hectares is suitable for rice cultivation [13]. [14] suggested that a
much smaller area is available for cultivation leaving little room for agricultural expansion as a result of which great difficulties are going to be faced in producing enough food to sustain future populations, and the impact of tenure on land use and productivity is critical. The customary principle of communal land tenure is seen as setting limits on strategies that could be used to promote agricultural production or as warping the effects of the various strategies in use [15]. It is argued that this principle encourages fragmentation of holdings and land immobility which prevents progressive farmers from consolidating fragmented parcels or expanding their holding. The argument advanced by the critics of customary tenure emphasized the utility of private over communal (public) land-ownership, and the starting assumption appears to be that only private tenure can quickly adjust to the rigid social and economic change brought about by modernizing agriculture.

[16] stressed that the dominant source of output growth in Chinese agriculture during 1978-1984 was the change from collective - team large farms to individual household-based farming (despite the often-small size of household plots). Private plots usually are highly productive and account for significant national agricultural output; Individualized tenure facilitates the establishment of commercial agriculture; Communal tenure system under customary arrangement breeds uncertainty and insecurity of tenure [15].

[17] ownership insecurity causes low farm productivity due to a lack of investment incentives and limited access to credit; Tenant farmers have generally been found to be neglected in the allocation of credits and are subjected to insecurity as an additional source of risk to farmers. Therefore, its impact on productivity depends on the ability of farmers to bear additional risk. Corroborating this view, [15] stated that the right an individual exercise over his portion of communal land usually terminates at the end of the cropping season.
3.0 METHODOLOGY

3.1 The Study Area

The study was conducted in the Federal Capital Territory (FCT). The FCT was purposively chosen because it is a major rice belt and hub in the North Central part of Nigeria. FCT was created in 1976, while the city was built throughout the 1980s. It officially became Nigeria's capital on December 12, 1991, replacing the role of the previous capital, Lagos. FCT is located at the heart of Nigeria, approximately between latitudes $8^\circ 25'N$ and $9^\circ 20'N$ and longitude $6^\circ 39'$ and $7^\circ 45'$ East of the Greenwich meridian [18]. It lies just above the hot humid lowlands of the Niger - Benue trough and it is bounded on the north by Kaduna State, on the west by Niger State, on the east and southeast by Plateau State and on the southwest by Kogi state. It covers a land mass of about 8,000 sq. km, out of which 274,000 hectares are available for agricultural activities, 270,000 hectares under forest reserves, and 250,000 hectares earmarked for the Federal Capital Cities developments, and the remaining 6,000 hectares account for rocks, hills and rivers [19]. The vegetation of the FCT is normally classified as park savannah, with scattered trees, pockets of guinea, woodland and derived savannah. The FCT has two main seasons, rainy (April to October) and dry (November to March). Average annual temperature varies between $20^\circ C$ ($68^\circ F$) and $33^\circ C$ ($91.5^\circ F$) with a relative humidity, in the dry season, of between 20 and 30 per cent. Average annual rainfall range is in the order of 1,100mm to 1,600mm, with an annual average of 82 rainy days [20-21]. [22] put FCT at 3,564,126 people. The FCT is divided into six area councils namely, Abaji, Abuja Municipal, Bwari, Gwagwalada, Kuje, and Kwali (Fig. 1).
Figure 1: Map of the Federal Capital Territory Showing the Study Area

Source: [19]
3.2 Sampling Techniques and Sample Size

Federal Capital Territory was purposively selected because of the presence of rice farmers in the villages. Multi-stage sampling method was used for selecting the respondents. In the first stage, four (4) Area Councils were randomly selected using raffle-draw ballot-box method. In the second stage, four (4) wards were randomly selected each in Abaji, Bwari, Gwagwalada, and Kwali Area Councils respectively using raffle-draw ballot-box method. In the third stage, two (2) villages were randomly selected using raffle-draw ballot-box method from each of the 16 sampled wards making total of 32 villages. Fourth and the final stage, from equation (3.1) a proportionate – random sampling was used to select a total sample size of three hundred and forty-nine (349) smallholder rice farmers from the total sample frame of 2723 rice farmers (FCT, ADP 2018). However, two hundred and fifty (250) questionnaires were correctly filled and returned. The study used [23] for estimating sample size:

\[
n = \frac{N}{1 + N(e^2)} = 349 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3.1)
\]

Where,

\[
n = \text{Sample Size (Units)}
\]

\[
N = \text{Sample Frame/Population size (Units)}
\]

\[
e = \text{Level of Precision (5%)}
\]

3.3 Method of Data Collection

Primary data were used for this study. Primary data were collected from rice farmers in the study area. Trained enumerators from Agricultural Development Project (ADP) were employed for data collection using well-structured questionnaire. The questionnaires were sectioned appropriately to cover all the specific objectives stated such as types of land tenure systems, mode of land acquisitions by rice farmers, and production inputs used by the farmers.
3.4 Method of Data Analysis

Descriptive statistics involve the use of mean, frequency and percentages. It was used to identify the land tenure system, and mode of land acquisitions as stated in specific objective one (i),

To achieve specific objective two (ii), that is, determine the productivity index of rice farmers; TFP model following [24] was used. The TFP approach adopted is given as:

\[
TFP = \frac{Y}{TVC} \quad \cdots \cdots \cdots \cdots \cdots \cdots \cdots (3.2)
\]

\[
TFP = \frac{Y}{\sum P_i X_i} \quad \cdots \cdots \cdots \cdots \cdots \cdots \cdots (3.3)
\]

Where,

\( Y = \text{Output (Kg)}, \)

\( TVC = \text{Total Variable Cost (₦)}, \)

\( P_i = \text{Unit Price of i}^{\text{th}} \text{ Variable Input (₦)}, \)

\( X_i = \text{Quantity of i}^{\text{th}} \text{ Variable Input (Kg)}. \)

Total fixed cost is constant as it is fixed.

From Cost Theory:

\[
AVC = \frac{TVC}{Y} \quad \cdots \cdots \cdots \cdots \cdots \cdots \cdots (3.3)
\]

Where, \( AVC = \text{Average Variable Cost in naira (₦)} \)

Therefore, the transpose of \( AVC \) will be \( TFP \)

\[
TFP = \frac{Y}{TVC} = \frac{1}{AVC} \quad \cdots \cdots \cdots \cdots \cdots \cdots \cdots (3.3)
\]

As such, \( TFP \) is the inverse of the \( AVC \). The partial productivity estimate is the marginal products (MP) given as
\[ MP = \frac{\Delta TFP}{\Delta X} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3.3) \]

Note: At the time of undertaken this study, 1 dollar ($1) = 500 hundred naira (₦500)

The Stochastic Production Frontier Model following [25] Rahji (2005) is stated thus:

\[ Q_i = f(X_i \beta) + \varepsilon_i \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3.4) \]

Where,

- \( Q_i \) = Output of \( i \)th farmer (Kg),
- \( X_i \) = Vector of actual quantity used,
- \( \beta \) = Vector of Parameter to be estimated,
- \( \varepsilon_i \) = Composite error term denoted by Rahji (2005).
- \( \varepsilon_i = V_i - U_i \)
- \( V_i \) = Decomposed error term measuring technical efficiency of the farmer, and
- \( U_i \) = The inefficiency component of the error term.

Stochastic production frontier Model is stated explicitly as:

\[ \ln Q = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + V_i - U_i \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3.5) \]

Where:

- \( Q \) = Output (Total quantity of rice harvested in kg),
- \( X_1 \) = Farm Size (Ha),
- \( X_2 \) = Labour Input (Mandays),
- \( X_3 \) = Fertilizer Input (Kg),
- \( X_4 \) = Agrochemical Input (litres), and
- \( X_5 \) = Seed Input (Kg),
- \( V_i \) = Decomposed error term measuring technical efficiency of the farmer, and
- \( U_i \) = The inefficiency component of the error term.
The Inefficiency Component of the Stochastic Production Frontier Model is stated thus:

\[ U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7 + \alpha_8 Z_8 + \alpha_9 Z_9 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3.6) \]

Where,

\( U_i \) = Inefficiency Component,

\( Z_1 \) = Contact with Extension Agent (Number of contact/month),

\( Z_2 \) = Access to Credit (Naira),

\( Z_3 \) = Sex of the farmers (1, Male; 0, Otherwise),

\( Z_4 \) = Educational Level of Farmers (Number of years in School)

\( Z_5 \) = Farming Experience (Years),

\( Z_6 \) = Member of Cooperative Society (1, Member; 0, Otherwise).

\( Z_7 \) = Land Tenure System (1, Individual; 2, Communal; 3, Government),

\( Z_8 \) = Mode of Land Acquisition (1, Inheritance; 2, Lease; 3, Purchase), and

\( Z_9 \) = Labour Utilized (1, Hired; 2, Family; 3, Communal)

\( \alpha_0 \) = Constant Term

\( \alpha_1 - \alpha_6 \) = Regression Coefficients

The Stochastic production frontier model was used to achieve specific objective three (iii), which is, evaluate the factors influencing technical efficiency of rice production.

4.0 RESULTS AND DISCUSSION

4.1 Mode of Land Acquisitions by Rice Farmers and Types of Land Tenure Systems

4.1.1 Mode of Land Acquisitions by Rice Farmers

The modes of land acquisition are presented in Table 1 and Figure 2. Inheritance is the highest mode of farm land acquisition as indicated by 94.56% response. Inheritance refers to the
customary transfer of land to children on the death of the landholder. Inheritance ranks first and it is followed by purchase (3.44%). The title acquired under inheritance is permanent and heritable. The holder of such title exercises full management rights over his/her holdings. The finding is in line with [26] that concluded that inheritance is the principal mode of land acquisition in Northern part of Nigeria. However, the finding differs with [27] who reported that purchase was the major means of acquiring land in South Eastern Nigeria. Farmers that own land tend to have an edge over farmers renting lands.

Table 1: Mode of Land Acquisition by Rice Farmers in the Study Area

| Mode of Land Acquisition | Frequency | Percentage |
|--------------------------|-----------|------------|
| Inheritance              | 330       | 94.56      |
| Lease                    | 7         | 2.10       |
| Purchase                 | 12        | 3.44       |
| Total                    | 349       | 100        |

Source: Field Survey (2020)

![Figure 2: Bar Chart Showing Mode of Land Acquisition by Rice Farmers](image)

4.1.2 Types of Land Tenure System

The land tenure systems are presented in Table 2 and Figure 3. From the results, greater percentage (97.71%) of the sampled rice farmers rely on communal arrangement for the land they
use for cultivation. However, 2% of sampled rice farmers had their individual farm land, while 0.29% of the farm land was owned by the government. This implies that the farmers had restrictions and could not engage in farm practices suitable to them especially cultivating permanent crops. This finding agrees with the findings of [28].

Table 2: Types of Land Tenure Systems in the Study Area

| Land Tenure Systems | Frequency | Percentage |
|---------------------|-----------|------------|
| Communal            | 341       | 97.71      |
| Individual          | 7         | 2.00       |
| Government          | 1         | 0.29       |
| **Total**           | **349**   | **100**    |

Source: Field Survey (2020)

Figure 3: Bar Chart Showing Types of Land Tenure Systems

4.2 Total Factor Productivity of Rice Production in the Study Area

The result of the total factor productivity in Table 3 shows that most (62.18%) of the smallholder rice farmers had TFP index less than one which means that the productivity is sub-
optimal. Also, 19.2% of the respondents had TFP index greater than 1.10 which is in the super-optimal range, while 18.62% had TFP index within the optimal range of 1.00 and 1.09. This implies that most of the respondents performed less than the optimal level, meaning that there are low utilizations of production factors among the smallholder rice farmers. The result agreed with [29]. However, the finding contradicts that of [30] Ebe, Obike, Ug who posited that the average total factors were at optimal level among arable crop farmers. Figure 4 below represent a graph of total factor productivity. From the figure the total factor productivity was left skewed, which implies that most of the farmers were sub-optimal in productivity.

Table 3: Total Factor Productivity (TFP) Index of Smallholder Rice Farmers in the Study Area

| TFP Index          | Frequency | Percentage |
|--------------------|-----------|------------|
| Sub-Optimal (< 1.00) | 217       | 62.18      |
| Optimal (1.00–1.09) | 65        | 18.62      |
| Super-Optimal (≥ 1.10) | 67        | 19.2       |
| Total              | 349       | 100        |

Mean 0.52
Minimum 0.001
Maximum 5.17
Standard Deviation 0.91

Source: Field Survey (2020)
4.3 Factors Influencing Technical Efficiency of Rice Production in the Study Area

The result for the stochastic production frontier function for rice farmers showing the maximum likelihood estimates and inefficiency components are presented in Table 4. The study revealed that the Log-Likelihood value was -687.0619. The Log-Likelihood function implies that inefficiency exist in the data set. The estimated Chi square value of 57.90 was significant at 1% probability level. The Lambda value was 1.005, while the mean technical efficiency was 0.75. The Gamma value for the production function was 50.12%. This result is consistent with theory that postulated that gamma (\(\gamma\)) value should be greater than zero which means statistically different from zero [31]. The implication of the result is that 50.12% of the variations in the yield of the rice farmers are due to the farmer inefficiency rather than random variability. Therefore, since the factors are within the control of the farmers, reducing the effect of the gamma(\(\gamma\)) will greatly enhance the technical efficiency of the farmers and thereby improve potential yields of rice.
production. Hence, the values represent the total output made on the frontier production function attributed to technical efficiency [25]. The average technical efficiency of 0.75 implies that rice farmers are able to obtain 75% of the output from the mixtures of inputs used.

The estimated coefficient of seed was positive and statistically significant at 10% level of probability. The estimated coefficient of seed is 0.3186. The implication of the positive coefficient was that seeds input contributed significantly to the technical efficiency of rice production. This implies that a unit increase in seed by one percent, increases the output of rice by 31.86%. This is in line with [32-33] that poised that there is a positive relationship between seeds and farmers efficiency in the production process. Seed is very important in production as it determines to a large extent the kind of output obtained. Hence, farmers need to be mindful of the quality, seed rate and variety of seed used in order to obtain increased output. Output will be low in the absence of good quality and improved seeds even if other inputs are in abundance [32].

Similarly, fertilizer is negative and statistically significant at 1% level of probability. The negative sign implies that the factors had an indirect effect on rice production. The implication of the coefficient of fertilizer which was -0.2809 is that if the fertilizer increases by one percent, it could decrease output by 28.09%. Fertilizer is a major input for improving the performance of output per hectare of cultivated crops. Farmers in this instance had excessively apply fertilizer on their rice farms. The result is in consonance with the research findings of [34-36].

For the inefficiency effect components presented in Table 4, the result indicated that farming experience (P<0.10), sex (P<0.05) and labour utilization (P<0.10) were negative and statistically significant. The signs of the coefficients of these variables have an important policy implications as positive sign implies negative effect on technical efficiency and vice versa. Therefore, the implication of sex being negative and statistically significant at 5% level of
probability implies that as sex disparity increases, technical inefficiency declines thereby increasing the efficiency in production. That is, male farmers had the likelihood of lowering technical inefficiency. The result is in line with the findings of [37] that asserted that male farmers were more technically efficient than their female counterpart cultivating same crop. Also, farm experience is negative and significant at 10% level of probability which indicates that as farm experience increases, technical inefficiency decreases. Hence, experience in farming activities enhance better performance, improve knowledge and ability to make good farm decisions that will lead to efficiency and profitable enterprise. This finding is supported by [38-40] that concluded that farmers with more experience would be more efficient. Labour utilization on the other hand is negative and statistically significant at 10% probability level. Labour is significant probably because virtually all farming activities are carried out using human labour among small scale farming households in developing countries like Nigeria where mechanization is rarely deployed [31]. The coefficient of labour utilization was -0.35116. The result of the coefficient implies that a unit increase in labour utilization will likely lead to 35.11% decrease of technical inefficiencies in rice production in the study area. The results are in line with several studies that confirmed the importance of labour in farming activities. Such studies are [41-44].

The estimated coefficient of land acquisition is 0.2054 and it was statistically significant at 1% probability level. The result implies that a unit increase in land acquisition by one unit will decrease the technical inefficiency of the farmers output by 20.54%. The findings conform with the results of [45] in the analysis of rice production in Enugu State, Nigeria. Figure 4.5 shows the distribution of technical inefficiency of farmers. From the graph most of the farmers were between technical inefficiency units of 0.752 to 0.756.
Table 4: Maximum Likelihood Estimates of Stochastic Production Frontier Function for the Rice Farmers

| Variables                   | Coefficient | Std. Err. | t-ratio |
|-----------------------------|-------------|-----------|---------|
| Farm Size                   | 0.158527    | 0.235292  | 0.67    |
| Labour Input                | -0.52558    | 0.322612  | -1.63   |
| Fertilizer                  | -0.28094*** | 0.065376  | -4.3    |
| Agrochemicals               | 0.192247    | 0.17347   | 1.11    |
| Seed Input                  | 0.3186*     | 0.167276  | 1.9     |
| Constant                    | -0.37915    | 3.793474  | -0.1    |
| Inefficiency Component      |             |           |         |
| Extension Contacts          | -0.74766    | 0.918657  | -0.81   |
| Access to Credit            | -0.44847    | 1.711237  | -0.26   |
| Sex                         | -2.75452**  | 1.2339    | -2.23   |
| Level of Education          | -0.52105    | 0.367236  | -1.42   |
| Farming Experience          | -0.07036*   | 0.043318  | -1.66   |
| Land Tenure System          | 0.730972    | 2.39928   | 0.72    |
| Mode of Land Acquisition    | -0.205416***| 0.350196  | -3.44   |
| Labour Utilized             | -0.35116*   | 0.213176  | -1.65   |
| Member of Cooperative Society| 1.03889    | 1.54550   | 0.67    |
| Constant                    | 1.870889    | 1.653285  | 1.13    |

Chi-Square 57.90***

Lambda 1.005
Mean Technical Efficiency 0.75
Log Likelihood -687.0619
Total Number of Observations 349
Gamma 50.12%

Source: Computed Field Data (2020)

5. Conclusion

The study investigated land tenure system and its effects on rice productivity in Nigeria. The study revealed that communal and inheritance are the established forms of land tenure and mode of land acquisition respectively in the study area. These identified means of land control constitute constraints and negatively influence the productivity of the rice farmers particularly has it reduces their ability to possess full ownership and control in the used of the farm land. The stochastic production frontier function for rice farmers shows that fertilizer (P<0.01), seed input (P<0.10), land acquisition (P<0.01), and labour utilized (P<0.01) were statistically significant. Therefore, the study concluded that land tenure and acquisition play a significant role in the determination of agricultural productivity.
6. Recommendations

Based on the results of analysis from this study, the following recommendations are made:

(i). Land use act and policy that is currently in use should be amended. This is necessary to enhance availability and accessibility of land to individuals, groups and institutions for rice production and agricultural purposes. The amendment is also important in order to mitigate the preponderance of inheritance mode of land acquisition and communal tenure system.

(ii). Farmers should train on appropriate utilization of production factors such as fertilizer, seeds, land and agrochemicals so as to increase their technical efficiency and output.

Declarations

Availability of data and materials: Data used for the research was gathered through structured questionnaire administered. The questionnaire is attached herewith as appendix I. Also, the data gathered were analyzed appropriately and the result is presented as appendix II.

APPENDIX I
QUESTIONNAIRE

LAND TENURE SYSTEM AND AGRICULTURAL PRODUCTIVITY IN NIGERIA: A CASE OF RICE PRODUCTION

Dear Respondent,

This questionnaire and information gathered will be used for research purposes on the research subject titled above. Please, kindly respond or tick (✓) where necessary. All information will be treated with utmost confidentiality and will strictly be used for the purpose of research only. Thanks for your cooperation.

Instruction: Kindly tick (✓) or fill in the blank spaces as appropriate

SECTION A
Background Information of the Farmer

Questionnaire No…… Village/Ward……………………… L.G.A……………………

SECTION B
Socio-Economic Characteristics of the Farmer

1) What is your gender? (a) Male { } (b) Female { }
2) How many are you in your house (household size)?...............................Units
3) Total number of persons below 18 years old ............Units
4) Total number of persons above 65 years old............Units
5) Marital status? Married { } Single { } Divorced { } Widow { }
6) Age (years) ?.................................................................
7) What is the highest level of education of the household head?
   (0) Non-Formal Education { } (1) Primary Education { } (2) Secondary Education { }
   (3) Tertiary Education { }
8) Do you belong to any Cooperative Organization? Yes { } No { }
9) How long have you been into Rice farming? ................... (years)
10) What is your annual income from Rice farming? .......... (Naira).
11) What is your annual income from other activities apart from Rice farming?..... (Naira)
12) What are the types of land tenure systems practiced in your community?
   (a) Individual { } (b) Communal { } (c) Government { }
13) Did you have access to Credit facilities? Yes { } No { }
14) Do you have access to Extension Services Yea { } No { }
15) How many rice farm plots do you have? .... Please indicate the size in the Table below.

| Plot size (m²) | Acre(m²) | Hectare (Ha) |
|----------------|---------|--------------|
|                |         |              |

23. How did you acquire your land? (Please Tick below)
(a) Inheritance… { } (b) Lease …{ } (c) communal…{ } (d)Purchased…{ }

24. What does it cost to rent one Hectare of land per season in your village? ........ Naira

25. What is the quantity of seed you used?

| Quantity of Seed (kg) | Unit Price (kg) | Total Quantity (kg) | Total Cost (₦) |
|-----------------------|----------------|---------------------|----------------|
|                       |                |                     |                |
| Total                 |                |                     |                |

26. What is the total quantity and type of fertilizer you used?

| Fertilizer Type (S) | Quantity (kg) | Unit Price (₦) 50kg | Total cost (₦) |
|---------------------|----------------|----------------------|----------------|
|                     |                |                      |                |
| Total               |                |                      |                |

27. What is the total quantity and type of agrochemical used?

| S/n | Agrochemical Type | Quantity(Litres) | Unit price(₦)/Litre | Total Cost(₦) |
|-----|-------------------|------------------|----------------------|---------------|
| 1   |                   |                  |                      |               |
| 2   |                   |                  |                      |               |
28. What type of labour do you use for farming operation?
   (a) Family Labour ( ) (b) Hired Labour ( ) (C) Both Family and Hired Labour ( ) (d) Communal ( )

29. Complete the following Table for Hired Labour.

| S/N | Farming Activities | Women | Men | Children | Total no of People | No of Hours | No of Mandays | Unit cost (₦)/Mandays | Total cost (₦) |
|-----|--------------------|-------|-----|----------|--------------------|-------------|---------------|----------------------|----------------|
| 1   | Land preparation   |       |     |          |                    |             |               |                      |                |
| 2   | Planting           |       |     |          |                    |             |               |                      |                |
| 3   | Fertilizer Application |       |     |          |                    |             |               |                      |                |
| 4   | Manure Application |       |     |          |                    |             |               |                      |                |
| 5   | Chemical Application |       |     |          |                    |             |               |                      |                |
| 6   | First Weeding      |       |     |          |                    |             |               |                      |                |
| 7   | Second weeding     |       |     |          |                    |             |               |                      |                |
| 8   | Harvesting         |       |     |          |                    |             |               |                      |                |
| 9   | Threshing/Bagging  |       |     |          |                    |             |               |                      |                |
| 10  | Storage            |       |     |          |                    |             |               |                      |                |
|     | total              |       |     |          |                    |             |               |                      |                |
30. Complete the following Table for Family Labour:

| S/N | Farming Activities       | Woman | Men | Children | Total No of People | Total No of Hours | No of Mandays | Unit cost (₦) | Total Cost (₦) |
|-----|--------------------------|-------|-----|----------|--------------------|------------------|--------------|--------------|----------------|
| 1   | Land Preparation         |       |     |          |                    |                  |              |              |                |
| 2   | Planting                 |       |     |          |                    |                  |              |              |                |
| 3   | Fertilizer Application   |       |     |          |                    |                  |              |              |                |
| 4   | Manure Application       |       |     |          |                    |                  |              |              |                |
| 5   | Chemical Application     |       |     |          |                    |                  |              |              |                |
| 6   | First Weeding            |       |     |          |                    |                  |              |              |                |
| 7   | Second Weeding           |       |     |          |                    |                  |              |              |                |
| 8   | Harvesting               |       |     |          |                    |                  |              |              |                |
| 9   | Threshing/Begging        |       |     |          |                    |                  |              |              |                |
| 10  | Storage                  |       |     |          |                    |                  |              |              |                |
|     | Total                    |       |     |          |                    |                  |              |              |                |

31. Complete the following Table for Communal Labour:
| S/N | Farming Activities  | Women | Men | Children | Total No of People | Total No of Hours | No of Mandays | Unit cost (₦) | Total Cost (₦) |
|-----|---------------------|-------|-----|----------|--------------------|------------------|---------------|---------------|----------------|
| 1   | Land Preparation    |       |     |          |                    |                  |               |               |                |
| 2   | Planting            |       |     |          |                    |                  |               |               |                |
| 3   | Fertilizer Application |     |     |          |                    |                  |               |               |                |
| 4   | Manure Application  |       |     |          |                    |                  |               |               |                |
| 5   | Chemical Application |     |     |          |                    |                  |               |               |                |
| 6   | First Weeding       |       |     |          |                    |                  |               |               |                |
| 7   | Second Weeding      |       |     |          |                    |                  |               |               |                |
| 8   | Harvesting          |       |     |          |                    |                  |               |               |                |
| 9   | Threshing/Begging   |       |     |          |                    |                  |               |               |                |
| 10  | Storage             |       |     |          |                    |                  |               |               |                |
| Total|                     |       |     |          |                    |                  |               |               |                |

32. How much do you pay to transport output to the market per bag? ..................
### 33. Rice Output

| Number of Bags Produced (Kg) | Total Quantity Sold | Price/Units | Total Revenue (₦) |
|-----------------------------|---------------------|-------------|-------------------|
| 50Kg Bags                   |                     |             |                   |
| 100Kg Bags                  |                     |             |                   |

### 34. Home consumed quantity (in bags) of rice?
(a) 25kg bag -----  (b) 50kg bag ---- (c) 100kg bag --

### 35. What are the constraints faced during the production of rice?
Ranking according to severity 1=Strongly Disagree, 2=Disagree, 3= Agree, 4 =Strongly Agree.

| S/N | Constraints                        | Strongly agree (4) | Agree (3) | Disagree (2) | Strongly disagree (1) |
|-----|------------------------------------|--------------------|-----------|--------------|-----------------------|
| 1   | Herdsmen’s and farmer clashes      |                    |           |              |                       |
| 2   | Inadequate funds                   |                    |           |              |                       |
| 3   | Bureaucracy in accessing credits   |                    |           |              |                       |
| 4   | Inadequate fertilizer              |                    |           |              |                       |
| 5   | Pest and diseases                  |                    |           |              |                       |
| 6   | Poor access to extension agent     |                    |           |              |                       |
| 7   | Distance to the Market             |                    |           |              |                       |
| 8   | High cost of labour                |                    |           |              |                       |
| 9   | High cost of maintenance           |                    |           |              |                       |
|     | **Other Constraints**              |                    |           |              |                       |
| 10  |                                   |                    |           |              |                       |
| 11  |                                   |                    |           |              |                       |
| 12  |                                   |                    |           |              |                       |

### 36. Suggest Solutions to the Problem Stated

i) ........................................................................................................
ii) ........................................................................................................
iii) ........................................................................................................
iv) ........................................................................................................

### 37. Total Loading/ Offloading Cost (₦) ..................................................
38. Total Fees and Commission Paid
(₦)........................................................................................................

SECTION C
39. Production Assets

| S/N | Production Assets | Quantity | Years Purchase | Unit Cost (₦) | Estimated Value |
|-----|-------------------|----------|---------------|---------------|----------------|
| 1   | Plough            |          |               |               |                |
| 2   | Harrow            |          |               |               |                |
| 3   | Tractors          |          |               |               |                |
| 4   | Water Pump        |          |               |               |                |
| 5   | Sprayers          |          |               |               |                |
| 6   | Hoe               |          |               |               |                |
| 7   | Cutlass           |          |               |               |                |
| 8   | Others Specify    |          |               |               |                |

Thank you for your attention.

APPENDIX II
RESULTS

________________________(R)
/__/__/____/__/____/______/____/____/ 14.1 Copyright 1985-2015 StataCorp LP
Statistics/Data Analysis StataCorp
4905 Lakeway Drive
Special Edition College Station, Texas 77845 USA
800-STATA-PC http://www.stata.com
979-696-4600 stata@stata.com
979-696-4601 (fax)

Single-user Stata perpetual license:
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CSUK family

Notes:
1. Unicode is supported; see help unicode_advice.
2. Maximum number of variables is set to 5000; see help set_maxvar.
running c:\ado\personal\profile.do ...

Average interitem covariance: .0397513
Number of items in the scale: 9
Scale reliability coefficient: 0.6077

Determinant of the correlation matrix
Det = 0.076

Bartlett test of sphericity
Chi-square = 864.234
Degrees of freedom = 36
p-value = 0.000
H0: variables are not intercorrelated

Kaiser-Meyer-Olkin Measure of Sampling Adequacy
KMO = 0.605

Principal components/correlation
Number of obs = 341
Number of comp. = 9
Trace = 9
Rotation: (unrotated = principal)
Rho = 1.0000

Component | Eigenvalue | Difference | Proportion | Cumulative |
-----------|------------|------------|------------|------------|
Comp1      | 2.45521    | 0.264601   | 0.2728     | 0.2728     |
Comp2      | 2.19061    | 1.08049    | 0.2434     | 0.5162     |
Comp3      | 1.11012    | 0.181429   | 0.1233     | 0.6395     |
Comp4      | 0.928693   | 0.119789   | 0.1032     | 0.7427     |
Comp5      | 0.808904   | 0.071818   | 0.0899     | 0.8326     |
Comp6      | 0.491301   | 0.0457942  | 0.0546     | 0.8872     |
Comp7      | 0.445507   | 0.103818   | 0.0495     | 0.9367     |
Comp8      | 0.341688   | 0.03723    | 0.0380     | 0.9747     |
Comp9      | 0.227965   |            | 0.0253     | 1.0000     |

Principal components (eigenvectors)

Variable | Comp1 | Comp2 | Comp3 | Comp4 | Comp5 | Comp6 | Comp7 | Comp8 | Comp9 |
Unexplained | | | | | | | | | |
---|---|---|---|---|---|---|---|---|---|
ii | -0.2033 | 0.4707 | 0.2791 | -0.3918 | 0.0769 | -0.2882 | 0.4202 | -0.2123 | -0.4417 | 0 |
iii | -0.1110 | 0.5411 | -0.1152 | 0.0912 | 0.2419 | -0.4772 | -0.4420 | 0.3745 | 0.2271 | 0 |
v | 0.2989 | 0.2831 | 0.4485 | -0.4255 | 0.1180 | 0.5556 | -0.3093 | 0.1033 | 0.1392 | 0 |
v | 0.4728 | 0.2570 | -0.1514 | 0.1093 | -0.0331 | 0.0553 | 0.6605 | 0.4152 | 0.2506 | 0 |
v | 0.2480 | 0.0227 | 0.6082 | 0.3910 | -0.5529 | -0.2695 | -0.1201 | 0.0812 | -0.1261 | 0 |
vii | 0.2466 | 0.4038 | -0.1987 | 0.5525 | 0.2150 | 0.3016 | -0.1127 | -0.3539 | -0.3953 | 0 |
v | 0.4683 | 0.2857 | 0.1914 | 0.2603 | -0.1348 | 0.2006 | 0.1932 | -0.3555 | 0.6104 | 0 |
x | -0.5261 | -0.0299 | 0.1658 | 0.2547 | 0.0887 | 0.3671 | 0.1016 | 0.6067 | -0.3300 | 0 |
x | 0.1229 | -0.3055 | 0.4596 | 0.2332 | 0.7366 | -0.1975 | 0.1464 | -0.0727 | 0.1327 | 0 |
| Variable | Obs  | Mean      | Std. Dev. | Min | Max |
|----------|------|-----------|-----------|-----|-----|
| gender   | 349  | .8452722  | .3621642  | 0   | 1   |
| hhs      | 349  | 12.24355  | 11.41464  | 1   | 50  |
| ms       | 349  | .8825215  | .3797435  | 0   | 2   |
| age      | 349  | 43.53295  | 12.50918  | 0   | 68  |
| hle      | 349  | 1.544413  | 1.109729  | 0   | 3   |
| co       | 349  | .8366762  | .3701916  | 0   | 1   |
| ai       | 349  | 554447    | 259458.8  | 1   | 1000000 |
| lts      | 349  | .9856734  | .1772099  | 0   | 3   |
| cf       | 349  | .0630372  | .2433789  | 0   | 1   |
| exts     | 349  | .6361032  | .4818102  | 0   | 1   |
| fs       | 349  | 1.749284  | .7786525  | .2  | 8.5 |
| laq      | 349  | 1.123209  | .5614585  | 1   | 4   |
| lt       | 349  | 2.297994  | 1.021336  | 1   | 4   |

**GENDER**

|      | Freq. | Percent | Cum. |
|------|-------|---------|------|
| 0    | 54    | 15.47   | 15.47|
| 1    | 295   | 84.53   | 100.00|

**MS**

|      | Freq. | Percent | Cum. |
|------|-------|---------|------|
| 0    | 48    | 13.75   | 13.75|
| 1    | 294   | 84.24   | 97.99|
| 2    | 7     | 2.01    | 100.00|

**CO**

|      | Freq. | Percent | Cum. |
|------|-------|---------|------|
| 0    | 57    | 16.33   | 16.33|
| 1    | 292   | 83.67   | 100.00|

**CF**

|      | Freq. | Percent | Cum. |
|------|-------|---------|------|
| 0    | 327   | 93.70   | 93.70|
| 1    | 22    | 6.30    | 100.00|

**Total** 349 100.00
| EXT S | Freq. | Percent | Cum. |
|-------|-------|---------|------|
| 0     | 127   | 36.39   | 36.39|
| 1     | 222   | 63.61   | 100.00|
| Total | 349   | 100.00  |      |

| LAQ | Freq. | Percent | Cum. |
|-----|-------|---------|------|
| 1   | 330   | 94.56   | 94.56|
| 2   | 7     | 2.01    | 96.56|
| 4   | 12    | 3.44    | 100.00|
| Total | 349 | 100.00 |      |

-> tabulation of lt

| LT | Freq. | Percent | Cum. |
|----|-------|---------|------|
| 1  | 78    | 22.35   | 22.35|
| 2  | 156   | 44.70   | 67.05|
| 3  | 48    | 13.75   | 80.80|
| 4  | 67    | 19.20   | 100.00|
| Total | 349 | 100.00 |      |

| LTS | Freq. | Percent | Cum. |
|-----|-------|---------|------|
| 0   | 7     | 2.01    | 2.01 |
| 1   | 341   | 97.71   | 99.71|
| 3   | 1     | 0.29    | 100.00|
| Total | 349 | 100.00 |      |

| HLE | Freq. | Percent | Cum. |
|-----|-------|---------|------|
| 0   | 88    | 25.21   | 25.21|
| 1   | 66    | 18.91   | 44.13|
| 2   | 112   | 32.09   | 76.22|
| 3   | 83    | 23.78   | 100.00|
| Total | 349 | 100.00 |      |

| agecat | Freq. | Percent | Cum. |
|--------|-------|---------|------|
| 0      | 74    | 21.20   | 21.20|
| 1      | 94    | 26.93   | 48.14|
| 2      | 67    | 19.20   | 67.34|
| Total  | 349   | 100.00  |      |
| | Obs | Mean | Std. Dev. | Min | Max |
|-------------------|-----|------|----------|-----|-----|
| nyf               | 349 | 21.9255 | 11.07525 | 1  | 50  |
| aicat             | 349 | 24.64 | 24.64 | 79.94 | 100.00 |
. sum tfp2

| Variable  | Obs | Mean    | Std. Dev. | Min | Max |
|-----------|-----|---------|-----------|-----|-----|
| tfp2      | 349 | .516361 | .9078899  | 0   | 5.17|
| tfpcat    | Freq. | Percent | Cum.  |
|------------|--------|---------|--------|
| 0          |   217  | 62.18   | 62.18  |
| 1          |     65 | 18.62   | 80.80  |
| 2          |     67 | 19.20   | 100.00 |
| Total      |   349  | 100.00  |        |

Iteration 0:  log likelihood = -221.20777
Iteration 1:  log likelihood = -188.91417
Iteration 2:  log likelihood = -188.20157
Iteration 3:  log likelihood = -188.20074
Iteration 4:  log likelihood = -188.20074

Probit regression  
Number of obs    =     349
LR chi2(11)      =   66.01
Prob > chi2      =     0.0000
Log likelihood   = -188.20074  Pseudo R2    =   0.1492

-------------------------------------------------------------------------------
   rue |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------+----------------------------------------------------------------
 labourmandays |  -.0067473   .0135721    -0.50   0.619    -.0333481    .0198535
     nyf |   .0200982   .0087644     2.29   0.022     .0029204    .0372761
      fs |   .1557524   .1063082     1.47   0.143    -.0526079    .3641127
fertilizerqtt |  -.1529726   .0336044    -4.55   0.000     -.218836   -.0871092
agrochemqty |  -.0164142   .0077782    -2.11   0.035    -.0316592   -.0011691
     co |  -.4131022   .2110933    -1.96   0.050    -.8268374    .0006331
     hle |   .1887574   .0803099     2.35   0.019     .0313529    .3461619
     cf |   .2606337   .3048875     0.85   0.393    -.3369349    .8582022
     lts |   .2038362   .5097497     0.40   0.689    -.7952549    1.202927
     laq |   .3277221   .1369857     2.39   0.017     .0592351    .5962091
     lt |  -.1629695   .0822537    -1.98   0.048    -.3241839   -.0017552
    _cons |  -.2590502    .607053    -0.43   0.670    -1.448852    .9307519
-------------------------------------------------------------------------------

Average marginal effects  
Number of obs    =     349
Model VCE    : OIM

Expression    : Pr(rue), predict()

dy/dx w.r.t. : labourmandays nyf fs fertilizerqtt agrochemqty co hle cf lts laq lt
|                                        | Delta-method |
|----------------------------------------|--------------|
|                                        | dy/dx  Std. Err.  t  P>|t|  [95% Conf. Interval] |
|----------------------------------------|--------------|
| labourmandays | -0.0020725  .0041662  -0.50  0.619  -0.010238  .0060931 |
| nyt | .0061733  .0026462  2.33  0.020  .0009868  .0113598 |
| fs | .0478406  .0323765  1.48  0.140  -.0156161  .1112974 |
| fertilizerqtt | -.0469868  .0095844  -4.90  0.000  -.0657719  -.0282017 |
| agrochemqty | -.0050418  .0023524  -2.14  0.032  -.0096525  -.000431 |
| co | -.1268878  .0637643  -1.99  0.047  -.2518635  -.001921 |
| hle | .0579784  .0241241  2.40  0.016  .010696  .1052608 |
| cf | .0800558  .0392892  2.03  0.043  -.007751  .167862 |
| lts | .06261  .1564218  0.40  0.689  -.243971  .369191 |
| laq | .1006626  .0409939  2.46  0.014  .020316  .1810092 |
| lt | -.0500574  .0248526  -2.01  0.044  -.0987676  -.0013473 |

Iteration 0:  log likelihood = -693.56591  (not concave)
Iteration 1:  log likelihood = -691.11652
Iteration 2:  log likelihood = -688.23069
Iteration 3:  log likelihood = -687.17958
Iteration 4:  log likelihood = -687.08956
Iteration 5:  log likelihood = -687.06877
Iteration 6:  log likelihood = -687.06418
Iteration 7:  log likelihood = -687.06302
Iteration 8:  log likelihood = -687.06245
Iteration 9:  log likelihood = -687.06217
Iteration 10:  log likelihood = -687.06203
Iteration 11:  log likelihood = -687.06196
Iteration 12:  log likelihood = -687.06193
Iteration 13:  log likelihood = -687.06191
Iteration 14:  log likelihood = -687.0619

Stoc. frontier normal/half-normal model  Number of obs = 349
Wald chi2(8) = 57.90
Log likelihood = -687.0619  Prob > chi2 = 0.0000

| y | Coef.  Std. Err.  tP>|t|  [95% Conf. Interval] |
|---|--------------|
| y |             |
| fz | .1585267  .2352921  0.67  0.500  -.3026374  .6196907 |
| labour | -.5255849  .3226124  -1.63  0.103  -.1.157894  .1067238 |
| fertilizerq | -.2809404  .0653758  -4.30  0.000  -.4090747  -.1528062 |
| agrochemq | .1922465  .1734696  1.11  0.268  -.1477497  .5322407 |
| seed | .3186002  .1672761  1.90  0.057  -.0092549  .6464553 |
| _cons | -.3791465  3.793474  -0.10  0.920  -.7.814219  7.055926 |
### Insig2v

|              | Coef.  | Std. Err. | t     | P>|t|  | [95% Conf. Interval] |
|--------------|--------|-----------|-------|------|----------------------|
| _cons        | 1.085234 | .0771119 | 14.07 | 0.000 | .9340979 - 1.236371  |

### Insig2u

|          | Coef.  | Std. Err. | t     | P>|t|  | [95% Conf. Interval] |
|----------|--------|-----------|-------|------|----------------------|
| exts     | -0.747656 | .9186568 | -0.81 | 0.416 | -2.54819 - 1.052878 |
| cf       | -0.4484746 | 1.711237 | -0.26 | 0.793 | -3.802438 - 2.905488 |
| gend     | -0.5210475 | .3672358 | -1.42 | 0.156 | -1.240817 - 0.197215 |
| hle      | -0.0703632 | 0.39928  | -0.72 | 0.471 | -2.97153 - 6.433475 |
| nyf      | 0.730972  | 0.39928  | 1.86  | 0.100 | -0.1592639 - 0.0145376 |
| co       | 1.03889  | 1.545507 | 0.67  | 0.501 | -1.990247 - 4.068028 |
| laq      | -0.205416 | .1501958 | -1.37 | 0.170 | -0.576017 - 0.165186 |
| lt       | 1.870889 | 1.653285 | 1.13  | 0.258 | -1.369491 - 5.111269 |

### sigma_v

|              | Coef.  | Std. Err. | t     | P>|t|  | [95% Conf. Interval] |
|--------------|--------|-----------|-------|------|----------------------|
| _cons        | 1.720504 | .0663356 | 1.59  | 0.113 | 1.59528 - 1.855558  |

---

Iteration 0:  log likelihood = -685.93471
Iteration 1:  log likelihood = -685.93457
Iteration 2:  log likelihood = -685.93373
Iteration 3:  log likelihood = -685.93363
Iteration 4:  log likelihood = -685.93348
Iteration 5:  log likelihood = -685.93345
Iteration 6:  log likelihood = -685.93339
Iteration 7:  log likelihood = -685.93338
Iteration 8:  log likelihood = -685.93338
Iteration 9:  log likelihood = -685.93337
Iteration 10: log likelihood = -685.93337

Stoc. frontier normal/half-normal model Number of obs = 349
Wald chi2(8) = 83.62
Log likelihood = -685.93337 Prob > chi2 = 0.0000

|          | Coef.  | Std. Err. | t     | P>|t|  | [95% Conf. Interval] |
|----------|--------|-----------|-------|------|----------------------|
| fz       | 0.2079927 | .2301585 | 0.90  | 0.366 | -0.2431095 - 0.659095 |
| labourm  | -3.205547 | .3191075 | -1.00 | 0.315 | -9.459939 - 3.048846 |
| fertltyq | -3.5265247 | .055016 | -5.94 | 0.000 | -4.343541 - -2.186952 |
| agroche  | 0.2144232 | .1691221 | 1.27  | 0.205 | -0.11705 - 0.5458964 |
| seedq    | 0.3918486 | .1664039 | 2.35  | 0.019 | 0.0657029 - 0.7179943 |
| _cons    | -3.408017 | 3.727692 | -0.91 | 0.361 | -10.71416 - 3.898126 |

---

/lnsig2v | 1.092963 | .0757202 | 14.43 | 0.000 | 0.9445545 - 1.241372 |
/lnsig2u | -9.313631 | 151.9143 | -0.06 | 0.951 | -307.1165 - 288.4893 |
### Summary Statistics

| Variable | Mean     | Std. Dev. | Min     | Max     |
|----------|----------|-----------|---------|---------|
| `TTe`    | 0.753237 | 0.0018771 | 0.74868 | 0.7571  |

#### Paired t-test for `TTe`

- **Variable**: `TTe`
- **Observations**: 349
- **Mean**: 0.753237
- **Std. Dev.**: 0.0018771
- **Min**: 0.74868
- **Max**: 0.7571

**Hypotheses**:
- **Ho**: mean(diff) = 0
- **Ha**: mean(diff) < 0
- **Ha**: mean(diff) != 0
- **Ha**: mean(diff) > 0

**Test Statistics**:
- **t**: 3.3517
- **degrees of freedom**: 348

**Critical Values**:
- **Pr(T < t)**: 0.9996
- **Pr(|T| > |t|)**: 0.0009
- **Pr(T > t)**: 0.0004

---

### Paired t-test for `lts` and `tfp2`

- **Variable**: `lts`
  - **Observations**: 349
  - **Mean**: 0.9856734
  - **Std. Err.**: 0.0094858
  - **Std. Dev.**: 0.1772099
  - **Min**: 0.9670166
  - **Max**: 1.00433

- **Variable**: `tfp2`
  - **Observations**: 349
  - **Mean**: 0.516361
  - **Std. Err.**: 0.0485982
  - **Std. Dev.**: 0.9078899
  - **Min**: 0.4207778
  - **Max**: 0.6119442

**Hypotheses**:
- **Ho**: mean(diff) = 0
- **Ha**: mean(diff) < 0
- **Ha**: mean(diff) != 0
- **Ha**: mean(diff) > 0

**Test Statistics**:
- **t**: 9.6870
- **degrees of freedom**: 348

**Critical Values**:
- **Pr(T < t)**: 1.0000
- **Pr(|T| > |t|)**: 0.0000
- **Pr(T > t)**: 0.0000

---

### Paired t-test for `constr`s and `tee`

- **Variable**: `constr`s
  - **Observations**: 349
  - **Mean**: 30.44413
  - **Std. Err.**: 0.0995726
  - **Std. Dev.**: 1.86017
  - **Min**: 30.24829
  - **Max**: 30.63997

- **Variable**: `tee`
  - **Observations**: 349
  - **Mean**: 0.7532367
  - **Std. Err.**: 0.0001005
  - **Std. Dev.**: 0.0018775
  - **Min**: 0.753039
  - **Max**: 0.7534343

**Hypotheses**:
- **Ho**: mean(diff) = 0
- **Ha**: mean(diff) < 0
- **Ha**: mean(diff) != 0
- **Ha**: mean(diff) > 0

**Test Statistics**:
- **t**: 1.0000
- **degrees of freedom**: 348

**Critical Values**:
- **Pr(T < t)**: 0.0000
- **Pr(|T| > |t|)**: 0.0000
- **Pr(T > t)**: 0.0000

---

### Paired t-test for `totalrevenue` and `tvc`

- **Variable**: `totalrevenue`
  - **Observations**: 349
  - **Mean**: 689573.3
  - **Std. Err.**: 102762
  - **Std. Dev.**: 1919752
  - **Min**: 487460.6
  - **Max**: 891686

- **Variable**: `tvc`
  - **Observations**: 349
  - **Mean**: 337980.2
  - **Std. Err.**: 27860.93
  - **Std. Dev.**: 520485.1
  - **Min**: 283183.2
  - **Max**: 392777.2

**Hypotheses**:
- **Ho**: mean(diff) = 0
- **Ha**: mean(diff) < 0
- **Ha**: mean(diff) != 0
- **Ha**: mean(diff) > 0

**Test Statistics**:
- **t**: 3.3517
- **degrees of freedom**: 348

**Critical Values**:
- **Pr(T < t)**: 0.9996
- **Pr(|T| > |t|)**: 0.0009
- **Pr(T > t)**: 0.0004

---

### Paired t-test for `lts` and `tfp2`

- **Variable**: `lts`
  - **Observations**: 349
  - **Mean**: 0.9856734
  - **Std. Err.**: 0.0094858
  - **Std. Dev.**: 0.1772099
  - **Min**: 0.9670166
  - **Max**: 1.00433

- **Variable**: `tfp2`
  - **Observations**: 349
  - **Mean**: 0.516361
  - **Std. Err.**: 0.0485982
  - **Std. Dev.**: 0.9078899
  - **Min**: 0.4207778
  - **Max**: 0.6119442

**Hypotheses**:
- **Ho**: mean(diff) = 0
- **Ha**: mean(diff) < 0
- **Ha**: mean(diff) != 0
- **Ha**: mean(diff) > 0

**Test Statistics**:
- **t**: 9.6870
- **degrees of freedom**: 348

**Critical Values**:
- **Pr(T < t)**: 1.0000
- **Pr(|T| > |t|)**: 0.0000
- **Pr(T > t)**: 0.0000

---

### Paired t-test for `constr`s and `tee`

- **Variable**: `constr`s
  - **Observations**: 349
  - **Mean**: 30.44413
  - **Std. Err.**: 0.0995726
  - **Std. Dev.**: 1.86017
  - **Min**: 30.24829
  - **Max**: 30.63997

- **Variable**: `tee`
  - **Observations**: 349
  - **Mean**: 0.7532367
  - **Std. Err.**: 0.0001005
  - **Std. Dev.**: 0.0018775
  - **Min**: 0.753039
  - **Max**: 0.7534343

**Hypotheses**:
- **Ho**: mean(diff) = 0
- **Ha**: mean(diff) < 0
- **Ha**: mean(diff) != 0
- **Ha**: mean(diff) > 0

**Test Statistics**:
- **t**: 1.0000
- **degrees of freedom**: 348

**Critical Values**:
- **Pr(T < t)**: 0.0000
- **Pr(|T| > |t|)**: 0.0000
- **Pr(T > t)**: 0.0000
|     | 349 | 29.69089 | .0995619 | 1.859969 | 29.49507 | 29.88671 |
|-----|-----|--------|---------|---------|---------|---------|
| mean(diff) = mean(constriants - tee) | t = 298.2155 |
| Ho: mean(diff) = 0 | degrees of freedom = 348 |
| Ha: mean(diff) < 0 | Ha: mean(diff) != 0 | Ha: mean(diff) > 0 |
| Pr(T < t) = 1.0000 | Pr(|T| > |t|) = 0.0000 | Pr(T > t) = 0.0000 |

| Source | SS        | df      | MS       | Number of obs = 78 |
|--------|-----------|---------|----------|-------------------|
| Model  | 2.25545174 | 1       | 2.25545174 | Prob > F = 0.0881 |
| Residual | 57.4292633 | 76     | .755648201 | R-squared = 0.0378 |
| Total  | 59.684715  | 77     | .775126169 | Root MSE = .86928 |

| tfp2 | Coef. | Std. Err. | t  | P>|t| | [95% Conf. Interval] |
|------|-------|-----------|----|------|---------------------|
| lt    | .5379133 | .3113546 | 1.73 | 0.088 | -0.0822032 1.15803 |
| _cons | -.0514224 | .3417999 | -0.15 | 0.881 | -.7321759 .6293312 |

| Source | SS        | df      | MS       | Number of obs = 155 |
|--------|-----------|---------|----------|-------------------|
| Model  | 0.508933087 | 1        | 0.508933087 | Prob > F = 0.4594 |
| Residual | 141.570108 | 153     | .92529482 | R-squared = 0.0036 |
| Total  | 142.079041 | 154     | .922591173 | Root MSE = .96192 |

| tfp2 | Coef. | Std. Err. | t  | P>|t| | [95% Conf. Interval] |
|------|-------|-----------|----|------|---------------------|
| lt    | -.2538666 | .3423065 | -0.74 | 0.459 | -0.9301241 .4223909 |
| _cons | 1.098235 | .6977379 | 1.57 | 0.118 | -.2802091 2.476679 |

| Source | SS        | df      | MS       | Number of obs = 47 |
|--------|-----------|---------|----------|-------------------|
| Model  | 2.26552554 | 1        | 2.26552554 | Prob > F = 0.1644 |
| Residual | 51.0183048 | 45      | 1.13374011 | R-squared = 0.0425 |
| Total  | 53.2838304 | 46      | 1.15834414 | Root MSE = 1.0648 |

| tfp2 | Coef. | Std. Err. | t  | P>|t| | [95% Conf. Interval] |
|------|-------|-----------|----|------|---------------------|
| lt    | -1.521439 | 1.076284 | -1.41 | 0.164 | -3.689185 .6463078 |
| _cons | 5.176594 | 3.209711 | 1.61 | 0.114 | -1.288097 11.64128 |
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Authors’ contributions: SS coordinate and supervise the entire research work. He also developed the write up. MM monitored data collection and entry of data. DH analyzed and interpreted the data while AS edited the manuscript and proof reading.

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