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# An Empirical Study of Middle-income Farmers on Millet Production in Kano South Nigeria: A Stochastic Frontier Analysis Approach

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## Abstract

This paper aimed at assessing the technical efficiency of millet farmers in Kano south Nigeria using the stochastic frontier production function from the parametric perspective. The determinants of technical efficiency, such as, education, extension access, access to loans, farm size, labour etc, which played a great role in technical efficiency level, are assessed to measure the level of efficiency of the middle-income farmers. 227 middle income farmers were selected for the study and provide an empirical analysis of the efficiency determinants which aim to find a way of improving the millet production and productivity. The results show that middle income farmers' productivity is very weak ranging from 0.023t/ha to 5.62t/ha, averaging 1.07t/ha. While the technical efficiencies of middle-income farmers range from 0.013 to 0.930 with mean of 0.621. However, the results also indicate that most of the above determinants have negative effect on technical efficiency for the farmers. So, there is need by the government at all levels to review the existing agricultural policy that will favour the reality on the ground which will result in improving the output level of the middle-income farmers with their minimum available input.

**Keywords and Phrases:** Efficiency, Middle income, Frontier, Millet Famers and Productivity.

**AMS Classification:** 62P20.

## 1. Introduction

The measurement of the productive efficiency of a farm relative to other farms or to the "best practice" in an industry has long been of interest to agricultural economists. The technical efficiency of sample individual farmers can be predicted on the basis of cross-sectional or panel data on these farmers. Despite the huge importance and benefits of millet to over 40% of the populace in Kano State Nigeria especially people living in the Kano South, it is unconvincing to apprehend that there are very nominal studies conducted on efficiency of millet in Kano Sate and only few was discovered that used frontier approaches (DEA or SFA). However, with regards to the use of SFA which is the parametric method used for measuring the technical efficiency. The

Stochastic Frontier Analysis – SFA is an analytical approach that utilizes econometric (parametric) techniques whose models of production recognize technical inefficiency and the fact that random shocks beyond producers' control may affect the product. Differently from non-parametric approaches that assume deterministic frontiers, SFA allows for deviations from the frontier, whose error can be decomposed for adequate distinction between technical efficiency and random shocks (e.g. labour or capital performance variations) according to Coelli (1996), the stochastic frontier production function was independently proposed by Meeusen and Broeck (1977) and Aigner, Lovell and Schmidt (1977). The original specification involved production function with composite error terms accounting for random effect as well as technical inefficiency effect both of which could cause production output deviation from frontier. In the agricultural economics literature, the stochastic frontier (econometric) approach has generally been preferred. This is probably associated with a number of factors. There have been many applications of frontier production functions to agricultural industries over the years. Battese (1992) and Bravo Ureta and Pinheiro (1993) provide surveys of applications in agricultural economics, the latter giving particular attention to applications in developing countries. Bravo-Ureta and Pinheiro (1993) also draw attention to those applications which attempt to investigate the relationship between technical efficiencies and various socio-economic variables, such as age and level of education of the farmer, farm size, access to credit and utilisation of extension services. In this Paper we try to apply this technique with intention to measure the Technical efficiency level of the Middle-Income farmers on millet production at the study area.

## 1.1 Millet Production in Nigeria

Millet is a group of small-seeded grasses, which is cultivated throughout the world, for human consumption. It is mainly grown in developing countries, but its ability to grow in relatively harsh, arid, and dry environments makes it a highly versatile crop. And are important crops in Nigeria, India and some other African countries, with 97% of millet production in developing countries. In Nigeria and particularly in the North-Western region, millet is a traditional crop, both in terms of production and consumption and it is very important staple crop for over 40% of the populace. Nigeria has become increasingly important in the production of the crop, accounting for 14% of average annual global production within the period 1992-1994 as compared to only 9% in the 1979-1981 periods. The average annual millet production in Nigeria during 2005 to 2010 was about 6.28 million tons, which ranked the country as the second largest world millet producer after India. However, reports by Food and Agriculture Organization Corporate Statistical Database (FAOSTAT, 2015) indicated that Nigeria lost its position to Niger, China and Mali during 2011 to 2014, by dropping to 5th position in the World with average annual production of 1.21 million tons, representing only 4.9% of the total world production. Despite its importance in terms of food provision and economic gains, millet in Nigeria is still faced with numerous problems which resulted to low productivity, in spite of an expanding production area. The national average yield per hectare declined from 1.5 tons per hectare in 1981-1985 to 0.45 tons in 2011, 0.96 tons in 2012 and 0.88 in 2014 against the potential of 2.0-3.5 tons/ha (FAOSTAT, 2015). In addressing this problem of low productivity of millet, various efforts have been made by different governments and other Agricultural stakeholders. Yet, this problem persists, there is still reported inconsistency in production between the expected average potential yields of 2.0-3.5 tons/ha and the actual average yields of 1.25 tons/ha. This was very much lesser than the expected yield obtainable in other places, which brings down the country's yield in world ranking to 30th in the 1999-2010 and 60th during the period of 2011-2014 (FAOSTAT, 2015).

## 2. Methodology

### 2.1 The Study Area

Kano State is a state located in North-Western Nigeria & Kano State is considered as an agricultural and commercial state, and it is located on 12°37′ N, 9°29′ E, 9°33′ S, and 7°43′ W (Olofin et al., 2008), Furthermore, Kano State like any other state in Nigeria it was subdivided in to three Senatorial Districts namely, Kano Central, Kano North, and Kano South. Kano State has an estimated total land mass of 20,760 Square kilometres, with 1 754 200 hectares of agricultural land and 75 000 hectares of grazing land and forest vegetation. Kano south were research was conducted comprises the following local government, Albasu, Bebeji, Bunkure, Doguwa, Gaya, Kiru, Rano, Takai, Ajingi, Rogo, Kibiya, Tudun Wada, Garko, Wudil, Sumaila with a combine population of approximately 5 million in the region, and the challenges facing the people of the area in terms of meeting their growing needsare great. More than eighty-five percent of the surface land in this area is dedicated to farmland, and the farmers themselves are strongly oriented towards the conservation of land resources.

### 2.2 Data Description

For this research the cross-sectional data collected by the Kano State Agricultural & Rural Development Authority (KNARDA) during the year 2018. Which covers 227 middle-income farmers, the famers were categorized in to three relative groups as, High-income farmer, Middle-income farmer & low-income farmer. As follows: 0.2ha < 1.0ha = low-income farmer, 1.0ha<2.0ha = Middle-income farmer, 2.0ha and above= High-income Farmer, so therefore, for this research the inclusion criteria are that a farmer most fall within the middle-income farmers group for him to be selected or included in the sample.

### 2.3 The Stochastic Frontier Model

In this study we use the SFA approach to estimate the technical efficiency of middle-income millet farmers, the stochastic frontier production function independently proposed by Aigner ert.al; (1977) & Meeusen & Broeck (1977) decomposes the error term in to two-sided random error that captures the random effects outside the control of the farmer & the one-sided inefficiency component. Thus, the stochastic approach allows for statistical noise (Thian *et al.*, 2001). The general stochastic model is given as:

$$Y_i = f(X_i;\ \propto_i)\varepsilon \quad (1)$$

Where: $i = 1,2, \ldots \ldots \ldots . . n$

$Y_i$ is the output of the farmer i, $X_{is}$ are the input variables $\propto_{is}$ are the production coefficients &$\varepsilon$ is the random error term that is composed of two elements that is;
$\varepsilon = V_i - U_i$, the $V_i$is the stochastic error which is assumed to be independently and identically distributed $N(0, \sigma_V^2)$, the second component $U_i$is a one-sided error term which is independent of $V_i$ and is are assumed to be independently and identically distributed non-negative truncations of the $N(0, \sigma_u^2)$ distribution, allowing the actual production to fall below the frontier but without attributing all short falls in input from the frontier in efficiency.

While the $T.E = \frac{Y_i}{Y_i^*} = \frac{E(Y_i/u_i,\ X_i)}{E(Y_i/u_i=0, X_i)} = e^{-[E(U_i/\varepsilon_i)]}$, the value of T.E range between 0 & 1 where the later shows that the farmer is fully efficient.

The Cobb-Douglas production function was also used as the functional form of the stochastic production function to define the relationship between input & outputs due to its simplicity and wide acceptability for production function analysis by many researchers (Battese et. al; 1993).
The two functional forms for the stochastic frontier production function to be estimated are described by

$$LogY_i = \propto_o + \sum_{j=1}^{k} \propto_j LogX_{ji} + (V - U_i) \quad (2)$$

$$LogY_i = \propto_o + \sum_{j=1}^{k} \propto_j LogX_{ji} + \sum \sum_{j=1}^{k} \propto_j (LogX_{ji})(LogX_{ji}) + (V_i - U_i) \quad (3)$$

Where log represent the logarithms in base 10, $Y_i$, $X_1$, $X_2$, $X_3$, $X_4$, $X_5$,&$X_6$ represents the millet production output, and input variables respectively.
And $\beta_j \quad j = 0,1, \dots \dots \dots k$ Are the parameters to be estimated.

$$U_i = \delta_0 + \sum_{j=1}^{l} \delta_j Z_{ji} \quad (4)$$

$Z_{ji}$ *are values of explanatory variables for the technical inefficiency effects for the* $i$th Farmer. $\delta_j$ j= 0,1 …………m are unknown scalar parameters.

## 3. Results and Discussion

The effect of some socio-economic characteristics of middle-income farmers in Kano south on Technical efficiency are described as follows. The result in table 1 indicates that about 93 percent of the respondents are below 60 years of age. The average age of the middle-income farmers was 43 years. The implication of the results is that most of the respondents sampled are in their active productive age. Furthermore, farmers that are less than 50 years of age are 92.1 percent efficient followed by those within the age bracket 31-40 years with the average Technical efficiency of 90.1 percent, the findings also shows that middle-income farmers of age group 51-60 years are less efficient with average technical efficiency of 79.2 percent. This clearly shows that middle-income farmers that in their prime age are more technically efficient. From the table 2 below it shows that farming increase with labor as the middle-income farmers with household size have higher technical efficiency, the result also is consistent with (Aboki et.al, 2013) who also revealed that the technical efficiency increase with labor. Households size ≥10 were found to be 91 percent efficient followed by the household with size 7-9 having 89.5 percent efficient. This means that the technical efficiency increase with the increase in household and it also agrees with the MLE results that indicate that yield increase with increase in labor measured in man-days which will be discuss later. Also as expected the result shows that there is increase in the technical efficiency when a middle-income farmer receive an extension support as indicated in table 3 below which shows that farmers receive extension support were 95.8 percent efficient compared to those who do not receive any extension support. This could attributed to the fact that extension support is very crucial in helping farmers to become more technically efficient as they may have an access to some important advices and information that will benefit them in the increase of their output and productivity. Table 4 shows the frequency distribution of the Technical efficiency estimates of the middle-income millet farmers. The farm specific technical efficiency (T.E) ranges from 0.30 to 0.93 with mean of 0.621, and the results shows that only 38.3 percent of the sampled middle-income millet farmers are technically efficient with more than 90 percent thus, obtained maximum output estimated through the frontier, also 11.5 percent of the sampled farmers were running their farms with technical efficiency level between 81-90 percent. In a short run, there is a scope for increasing millet production by adopting technology and techniques used by the best practice millet farmers. As it shows that a considerable amount of productivity is lost due to inefficiency.

**Table 1:** Summary Distribution of Middle-Income Millet Farmers by Their Age

| Age groups | Frequency | Percentage | Average Technical Efficiency |
|---|---|---|---|
| ≤30 | 40 | 18 | 0.823 |
| 31-40 | 63 | 28 | 0.901 |
| 41-50 | 82 | 36 | 0.921 |
| 51-60 | 26 | 11 | 0.792 |
| >60 | 16 | 07 | 0.810 |
| **Total** | **227** | **100** | |

Source: Authors' Computation based on the data Collected by KNARDA 2018

**Table 2:** Summary Distribution of Middle-Income Millet Farmers by Household size

| House hold size | Frequency | Percentage | Average Technical Efficiency |
|---|---|---|---|
| 1-3 | 15 | 07 | 0.736 |
| 4-6 | 84 | 37 | 0.795 |
| 7-9 | 73 | 32 | 0.895 |
| ≥10 | 55 | 24 | 0.910 |
| **Total** | **227** | **100** | |

Source: Authors' Computation based on the data Collected by KNARDA 2018

**Table 3:** Summary Distribution of Middle-Income Millet Farmers by Extension Support

| Extension Support | Frequency | Percentage | Average Technical Efficiency |
|---|---|---|---|
| Extension Support | 93 | 41 | 0.958 |
| No- Extension Support | 134 | 59 | 0.823 |
| **Total** | **227** | **100** | |

Source: Authors' Computation based on the data Collected by KNARDA 2018

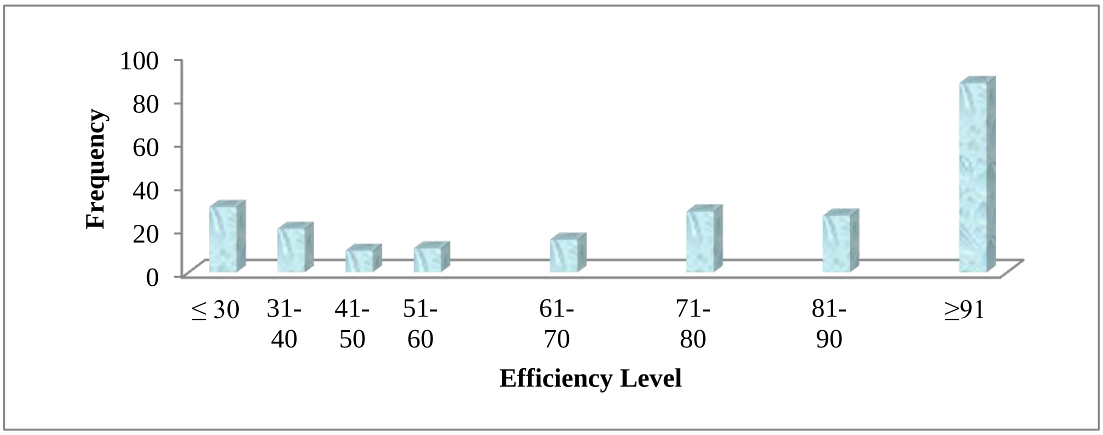


**Figure 1:** Chart Showing the Frequency Distribution of the Technical Efficiency Estimates of millet middle-income farmers in Kano South

**Table 4:** Distribution of Technical Efficiency estimate of Middle-Income Millet Farmers in Kano South

| Efficiency Level | Frequency | Percentage |
|---|---|---|
| ≤ 30 | 30 | 13.2 |
| 31-40 | 20 | 8.8 |
| 41-50 | 10 | 4.4 |
| 51-60 | 11 | 4.8 |
| 61-70 | 15 | 6.6 |
| 71-80 | 28 | 12.3 |
| 81-90 | 26 | 11.5 |
| ≥91 | 87 | 38.3 |
| **Total** | **227** | **100** |

**Mean Efficiency= 0.621**

Source: Authors' Computation based on the data Collected by KNARDA 2018

The maximum likelihood estimates are presented in Table 5 below, in which the results shows the estimated coefficients of the production function and their corresponding levels of statistical significance. Out of the variables in the Cobb-Douglas stochastic frontier model, the parameter estimates of six variables are found to be statistically significant. As the coefficient of both family labor and hired labor were all significant and had a positive sign. This shows the importance of labor in farming activity in the study area, and this findings corresponds with several other studies that have shown the importance of labor in farming (Islam M. & Hossain 2004). And if the labor will be kept at optimal level the farmers will be operating at sub-optimal level hence the increase in productivity.

The coefficient of farm size was also found to be significant at 5% level. Though the link between the farm size and productivity has been a major discussion in literature but some have found no statistical significant correlation between farm size and productivity (Bravo-Ureta & Pinhiero 1994). In contrast, the result in this study as in other studies (Bravo-Ureta & Pinhiero 1997; Aboki et.al, 2013 etc) Supports the notion that large farms have efficiency advantage over other farms in the sample. Land plays a vital role farming with impact on productivity & as one of the most important available resources one can use efficiently. It is interesting to note that only a fraction of the sampled farmers could access extension support, but yet extension support which is a proxy for Technical support in farming activities is also found to be significant at 10% though is negative, but yet it decreases inefficiency, this indicates that the more a farmer receive an extension support the better productivity as it increases technical efficiency. But the significant value of gamma, 0.9670 reveals that there is a considerable level of technical inefficiency among the sampled farmers.

**Table 5:** Maximum likelihood Estimate of the Frontier Production Function of Middle-Income Millet Farmers

| Variables | Parameters | Coefficients | Standard Error | t-Statistics |
|---|---|---|---|---|
| **Stochastic Frontier** | | | | |
| Constant | $\propto_0$ | 0.8093 | 0.9932 | -2.3456*** |
| Farm size | $\propto_1$ | -0.6330 | 0.9632 | -0.6432** |
| Family Labor | $\propto_2$ | 0.3639 | 0.2861 | 0.5820** |
| Seed | $\propto_3$ | 2.7572 | 0.0872 | 30.7651 |
| Fertilizer | $\propto_4$ | 0.9862 | 0.0032 | 315.4521** |
| Haired Labor | $\propto_5$ | 0.4326 | 0.3012 | 2.6893** |
| Educ. Level | $Z_1$ | -0.0932 | 0.8621 | -2.0731 |
| Extension Support | $Z_2$ | -0.0630 | 0.9315 | -0.7361* |
| Farmer's Age | $Z_3$ | -0.2551 | 0.1932 | -0.6638 |
| Years in Farming | $Z_4$ | 0.0730 | 0.1062 | 0.7061 |
| House Hold Size | $Z_5$ | 0.0962 | 0.1608 | 0.6230** |
| **Variance Parameters** | | | | |
| Sigma Squared($\delta^2$) | | 0.8973 | | |
| Gamma($\gamma$) | | 0.9670 | 0.2662 | |
| Log likelihood | | -89.0940 | | |
| LR test | | 9.0081 | | |

*,**,& *** Significant level at 10%, 5% & 1% respectively

Source: Authors' Computation based on the data Collected by KNARDA 2018

## 4. Conclusion and Recommendation

This study aimed at assessing the technical efficiency of millet farmers in Kano south Nigeria, The maximum likelihood estimate of the frontier production clearly shows that farm size, family labour, haired labour, household size and access to extension support are the most important input variables in millet farming. The stochastic frontier function estimated for the 227 middle-income farmers shows that the mean efficiency value was 0.621. And about 38.3 percent are over 91 percent efficient and about 33 percent had TE ranging from 50 percent to 90 percent, based on the use of the above input. This result showed that inputs in millet production need to be efficiently used by all farmers so as to produce more output than ever before. It is therefore likely that agricultural production particularly millet farming in Kano south will need the continuing support from Government at all levels and international agencies for some time to come until the level of efficiency of the middle –income farmer are increased sufficiently through proper enlightenment of the right input combination. And also based on the findings, the study recommends that there is need for introduction of agricultural cooperative societies among the farmers which will help them access the identified important variables.

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