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DETERMINANTS OF TECHNICAL EFFICIENCY IN CROP PRODUCTION AMONG SOME COMMERCIAL CROP FARMERS IN NIGER STATE, NIGERIA

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ABSTRACT
The study was designed to find out the determinants of technical efficiency in production of some commercial crops in Niger State. Primary data was used for the study. Crop production was found to be inelastic with a decreasing return to scale for the farmers. The distribution and level of technical efficiencies for the farmers examined was found to be 74.2%. There was a significant difference in the technical efficiency level obtained. The determinants of technical efficiency observed in the study were age, household size, education level, farming experience and credit access for the farmers. The result showed that there was a statistically significant relationship between the socio-economic factor and technical efficiency in crop production. It further indicated that 3.9% of the total variation in aggregate food crop production by these farmers was due to technical inefficiency. The study concluded that crop farmers are yet to achieve their best, as shown by their low technical efficiency (TE) value and low output levels, thus, calling for critical examination of technical efficiency, as a means of examining the role of higher efficiency level on agricultural output, particularly in the study area.

Keywords: Commercial crops, Crop farmers, Determinants, Output, Technical efficiency.

INTRODUCTION
Technical efficiency measures the relationship between the physical quantities of inputs and output. In other word, technical efficiency determines the maximum possible output using the same input mix or different combination of resources (Ogbanje *et al.*, 2014). In the same vein, Anang *et al*. (2015) defined technical efficiency as the ability of a firm to produce maximum output given a set of inputs and production technology. However, differences may apply in firms' output which may fall below the maximum output known as the production frontier. Technical efficiency implies that natural resources are transformed into goods and services without waste. Invariably, it means that maximum amount of physical production is obtained from the given resource inputs. In essence, production is achieved at the lowest possible opportunity cost. Technical efficiency of a producer is a comparison between observed and optimal values of its outputs and inputs. It refers to the ability to avoid wastage either by producing as much output as the optimal output given the technology and input use allow or by using as little input as required the given technology and output. The technical efficiency ranges between zero and one (Musa *et al.*, 2014). TE values of 1 represents a producer is producing on its production frontier (technically efficient), and 1-TE represents inefficiency (Musa *et al.*, 2014). Technical efficiency is an indicator of the productivity of the farm and the variation in technical efficiency can reflect the productivity difference across farms. Therefore, improvement in technical efficiency of farms is the key for meeting the growing food demand by the ever-increasing population (Anuradha *et al.*, 2010). Measuring efficiency level of farmers benefit the growth of the country since it enables to raise productivity by improving

the neglected source of growth with the existing resource base and available technology (Musa *et al.*, 2014).

However, low productivity still characterizes the agricultural sector in Africa region (FAO, 2004). Apparently, interventions may be significant in increasing the level of outputs in a certain context, but such increments are prone to inefficiency, especially when the available technology is not efficiently utilized. As such, it could be argued that it is quite more cost-effective to exterminate existing inefficiency than to introduce interventions as a means of increasing agricultural households' outputs (Tefaye and Beshir, 2014).

In Nigeria, agriculture is predominantly rural with diverse ecology and it remains the source of livelihood for two-thirds of the populace and contributes 40% to the Gross Domestic Product (IFAD, 2012). Like in most developing countries, agriculture remains the main pathway for pro-poor development (Kassie *et al*. 2013; Dawson *et al.* 2016). As a major contributor to Nigerian Gross Domestic Product, the small-scale farmers play a dominant role in this contribution (Rahji and Fakayode, 2009). It remains the source of food, income, and livelihood for most agricultural households (Dethier and Effenberger, 2012). Therefore, improved output stemming from productivity increase through improvements in efficiency is important to Nigeria's agriculture considering that the scope to enhance farm production by bringing additional land into cultivation is insignificant (Mohammed *et al.,* 2019).

Despite Nigeria's abundant agricultural resources and oil wealth, poverty is still a challenge in the country (IFAD, 2009). Agricultural productivity is very low in Nigeria. This is because about 90 percent of Nigeria's food is produced by small scale farmers who cultivates small plots of land and depend on rainfall rather than on irrigation. Neglect of rural infrastructure affects the profitability of agricultural production. The neglect of rural roads impedes the marketing of agricultural commodities; prevent farmers from selling their produce at reasonable prices and leads to spoilage. Limited accessibility to credits cuts small scale farmers off from sources of inputs, equipment and a few new technologies and this keeps yield low (IFAD, 2009). Efficiency studies are important in that they serve as reliable guidance in formulating policies, especially when it comes to the search for the primary causes of inefficiency and improvement potentials (Ogundari *et al.*, 2011). Efficiency analysis is an issue of interest given that the overall productivity of an economic system is directly related to the efficiency of production of the components within the system. Thus, analysis of technical efficiency could contribute to the identification of production constraints at farm level and there by improves the food security and income sources in the farm sector and the rest of economy (Yohannis, 2020).

In realization of the enormous potentials of these small-scale farmers, few studies have been carried out on the determinant of technical efficiency of farmers in crop production in the state. Thus, for a meaningful planning, it is desirable that a study of this nature be carried out to identify factors militating against the achievement of farmer's objectives which is optimum production in the study area.

In the light of the above, this study tends to answer the following research questions:

i. What are the socioeconomic characteristics of the crop farmers in the study area?
ii. Are the farmers producing within a technically efficient level?
iii. What are the factors determining technical efficiency in crop production in the study area

MATERIALS AND METHODS

The Study Area

The State is located between latitudes 8.2ºN and 11.3ºN and longitudes 3.3ºE and 7.2º E. It is one of the largest States in Nigeria with a landmass of 86,000 km^2 (8.6 million hectares) which represents about 9.3% of the total landmass of Nigeria. Niger state is divided into three political zones, each with a marked climatic pattern and defined agricultural activities. The zones have agriculture as its major traditional occupation. Mixed cropping is major farming practice in the three zones. The most important food crops grown include rice, maize, millet, sorghum, groundnut, cassava and cowpea (Niger State Government, 2009).

Sampling Procedure

A purposive sampling technique (homogeneous sampling) was used in selecting a total of 180 crop farmers that was used for the study. A cross-sectional data from a farm survey of 2015/2016 production year for the crop farmers was used. Primary data were collected by interviewing the selected crop farmers and variables that cause variation in production efficiency like age, education, household size, extension contact, gender and the like. Socio-economic variables such as demographic data as age, educational level, and farm size, amount of credit, crops grown, labour, fertilizer, and years of experience in farming were collected. The Production information collected were output and inputs such as seed, fertilizer, pesticide, herbicides and labour used.

Model specification

This study used the stochastic (or econometric) frontier production function model for cross sectional data. The specific model was explicitly written as:

$$LnY_j = \beta_0 + \beta_1 Ln\,X_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + \beta_6 LnX_6 + ei \qquad \ldots(1)$$

where; Y_j is crop output (kg/₦)

J is 1, 2, 3 ...180 crop farmers;

X_1 = farm size (hectares)
X_2 = labour (man-days)
X_3 = fertilizer (kg/ha)
X_4 = seeds (kg/ha)
X_5 = herbicide (Ltr/ha)
X_6 = capital /access to credit (₦)
β_i = regression coefficients of inputs (input elasticities) and
$e_{i=}v_i - u_i$ = error term.

While an explicit equation for technical, allocative and economic inefficiencies was expressed as:

$$U_{ij} = \delta_0 + \delta_1 Z_{i1} + \delta_2 Z_{i2} + \delta_3 Z_{i3} + \delta_4 Z_{i4} + \delta_5 Z_{i5} + \ldots\ldots\ldots\ldots\ldots\ldots \delta_6 Z \qquad \ldots(2)$$

where;

U_i = technical inefficiency of the ith farmer
Z_1 = Farmer's age (yrs)
Z_2 = Years of farming experience of the ith farmer in crop production
Z_3 = Amount of credit obtained by the ith farmer (₦)
Z_4 = Annual income level (₦)
Z_5 = Years of formal education of the ith farmer
Z_6 = Household size of ith farmer (number of people)

RESULTS AND DISCUSSION

Relationship between Input and Output in Crop Production

The efficiency measures were regressed on set of explanatory variables which included land (hectare), labour (man-day), fertilizer (kilogram), seeds (kilogram), herbicides (litre) and capital input (Naira). The entire variable estimated for food crop production for the crop farmers had positive co-efficient signs with the exception of land and quantity of seeds. Labour was related to production and statistically significant at 5% level. This is in line with the findings of Hazel *et al.* (2007) and also Ojo *et al.* (2020). Fertilizer, herbicide and capital (input) were related to output and statistically significant at 1% level. Though, quantity of seeds and land were significant at 1%, they are not related to output. This implied that increasing this variable input during production will lead to a decrease in the output. The negative co-efficient of seeds is also an indication of excessive use of seeds by the farmers during crop production. The result is shown in Table 1.

Table 1: Relationship between Inputs and Output for the Crop Farmers

Variables	Parameter	Co-efficient	t-ratio
Constant	β_0	4.8064(1.1175)	4.0880***
Land (ha)	β_1	-0.3824(0.1099)	-3.4771***
Labour (man-days)	β_2	0.1251(0.0547)	2.2852**
Fertilizer (kg)	β_3	0.4169(0.1067)	3.9052***
Seeds (kg)	β_4	-0.2269(0.0354)	-6.4094***
Herbicides (litres)	β_5	0.5627(0.1271)	4.4260***
Farm capital (₦)	β_6	0.1039(0.1027)	1.0119
Sigma squared		0.1009(0.0399)	2.5264***
Log likelihood function		-63.2750	

Elasticity of Production and Return to Scale

The elasticities of all inputs employed in food crop production by the farmers showed that labour, fertilizer, herbicides and farm capital were positive, indicating a positive response in output. This also implies that a 1% change in any variable input while keeping the other inputs constant will result in a certain percentage change in the quantity of output equal to the elasticity of the variable input in the same direction as the change of the inputs. The elasticities of production with respect to various inputs indicate that herbicides, fertilizer and farm size (0.56, 0.42 and 0.38, respectively) were the important input to which output was more responsive because of their elasticity values. This was higher than the elasticity of labour (0.13), seeds (0.23) and farm capital (0.10). The sum of elasticities indicates the nature of returns to scale associated with a particular production system. Thus, the behaviour of the output when all the factors of production are changed simultaneously in the same proportion is referred to return to scale.

The results as shown on Table 2 indicate that the sum of elasticities of production for the farmers was 0.60. This implied that there was a decreasing return to scale in crop production, meaning that if all inputs in the model were increased by 1% simultaneously, output will increase 0.60%. It is thus advisable to the farmers to use their recourse based on the marginal value productivity of the individual inputs as a guiding factor so as to maximize total output. It also implied that the food crops farmers are in stage III of production function phase (i.e., irrational stage of production) which is a decreasing return to scale. This was necessitated by the low and negative value of the coefficient of farm size and seeds. This is in consonance

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with Abdul-Rahaman (2016), Khanal *et al.* (2018) and Ojo *et al.* (2020). It therefore implied that food crops farmers in Niger State are subsistent farmers and do not allocate and utilize their variable input optimally.

Table 2: Elasticity of Production and Return to Scale

Variable inputs	**(co-efficient b_1)**
Farm size (X_1)	-0.38
Labour (X_2)	0.13
Fertilizer (X_3)	0.42
Seeds (X_4)	-0.23
Herbicides (X_5)	0.56
Capital input (X_6)	0.10
$\sum b_i$	0.60

Level of Inputs/Output used in Crop Production

The inputs used for crop production in this study by both group of farmers were land, seeds, fertilizer, herbicides and labour. While the output was the total tonne of crop (grain equivalent) obtained per unit area cultivated. Land was one of the most limiting resources for crop production in the study area. An average of 2.52 hectares was cultivated per person, indicating crop production was still at small scale level for the sampled farmers. This finding was in consonance with Adesoji and Farinde (2006). While the average seeds (grain equivalent) used in crop production was 54.09 kg. Majority of the farmers used chemical fertilizer for crop production in the study. An average of 8.28 kg was used.

Table 3: Input/ Output Levels for the Crop Farmers

Inputs variables	**Minimum**	**Maximum**	**Mean**	**Standard dev**
Land (ha)	1	10	2.52	0.301
Labour (man-day)	90	150	120.19	32.71
Fertilizer (kg)	3	22	8.28	4.451
Seeds (kg)	10	105	54.09	30.91
Herbicide (litres)	2	17	6.05	3.088
Farm capital (₦)	8000	250000	112433.33	47461.73
Yield/Output (kg)	2500	38660	9270.93	7403.93
Income (₦)	30000	580000	272555.56	103157.54

Despite a widely accepted view that inorganic fertilizer is necessary for sustained productivity growth, fertilizer use in Africa is estimated to have stagnated at 6-12 kg/ha/year for the last 10 years (The Monpellier Panel, 2013). It was noted that no Africa country was said to have been able to achieve the 50 kg of nutrient per hectare use target set for 2015 at Abuja fertilizer summit (The Monpellier Panel, 2013). The total labour used was made up of both family and hired labour. The family labour was costed and treated as hired labour based on the opportunity cost principles. The average labour used in crop production in the study area was 120.17 man-days. While an average yield of 9270.92 kg (9.27 tones) was obtained by the farmers (Table 3).

Estimation of Technical Efficiency of the Farmers

A significant characteristic of the stochastic frontier production model is its ability to produce farm specific measures of technical efficiency. The distribution of farmers' technical efficiency indices derived from the analysis of stochastic frontier production function was provided in Table 4. The result showed that 59.4% of the farmers had attained between 0.71 and 1.0 efficiency levels, respectively, while 5% of the farmers were below 50% level of efficiency.

The technical efficiency of the sampled farmers is less than 1 (100%) indicating that the farmers are producing below maximum efficiency frontier. A range of technical efficiency was observed across the sample farms where the spread is large. The best farm had a technical efficiency of 0.992 (99.2%), while the worst farm had a technical efficiency of 0.226 (22.6%). This implied that, on the average, the farmers were able to obtain a little over 74.2% of optimal output from a given mix of production inputs.

Table 4: Frequency Distribution of Technical Efficiency Estimates

	Crop farmers	
Efficiency class	**Frequency**	**Percentage**
Less than 0.50	9	5.0
0.50—0.60	14	7.7
0.60—0.70	50	27.8
0.70—0.80	41	22.8
0.80—0.90	35	19.4
0.90—1.0	31	17.2
Total	180	100
Mean	0.7428	
Standard deviation	0.2220	
Minimum	0.2266	
Maximum	0.9922	

The distribution of technical efficiency suggests that potential gains in technical efficiency among the sample farmers are large. With the mean of 74.2%, it implied that in the short run, there is the scope for increasing technical efficiency in food crop production in the study area by 25.8%.

The magnitude of the mean efficiency of the farmers was a reflection of the fact that most of the sampled farmer carry out food crop production under technical condition involving the use of inefficient tools, unimproved seed varieties, under application of fertilizer and so on. The low under application of fertilizer, over usage of seeds and herbicides by majority of the farmers are one of the major factors that had influenced the level of technical efficiency. This result agreed with the findings of Bravo-Ureta and Pinheiro (1997), Amaza *et al.* (2006) and Fasasi (2007).

Determinants of Technical Inefficiency

Age of the farmers had a negative co-efficient and was not statistically significant (Table 5). This implied that as the age of the farmer's increases, the technical efficiency of the farmers reduces. This is in consonance with the findings of Ajibefun and Daramola (2004) and Onyenweaku and Nwaru (2005) but contrary to Bravo-Ureta and Pinheiro (1997) whose results showed age to be positive and significantly related to technical efficiency. The farmers'

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household size was found to be negative and statistically significant at 1% level, implying that the household size is significantly related to technical efficiency. This finding agreed with those of Onyenweaku and Nwaru (2005), and Usman and Olagunju (2019) which showed household size and technical efficiency to be negative and significantly related. While, education was found to be related to technical efficiency because it had a positive contribution to it and was statistically significant at 1% level. It implied that farmers with formal education tend to be more efficient in food crop production, presumably due to their enhanced ability to acquire technical knowledge, which makes them closer to the frontier output. It is very plausible that the farmers with education responds readily to the use of improved technology such as the application of fertilizer, use of pesticides etc, thus producing closer to the frontier. This result was in agreement with findings of Amaza *et al* (2006) and Simonyan *et al.* (2012) but contrarily to the findings of Dessale (2019) who found education to be negatively significant to technical efficiency.

Table 5: Maximum Likelihood Estimates for Crop Farmers

Variables	Parameter	Co-efficient
Constant	b_0	4.806(1.117)***
Land	b_1	-0.382(0.109)***
Labour	b_2	0.125(0.054)**
Fertilizer	b_3	0.416(0.106)***
Seeds	b_4	-0.227(0.035)***
Herbicides	b_5	0.562(0.127)***
Farm capital	b_6	0.104(0.103)
Constant	d_0	1.610(0.748)***
Age	d_1	5.74E-04(9.7E-03)
Farming exp.	d_2	1.01E-04(9.8E-03)
Credit	d_3	-1.38E-05(9.4E-06)
Income	d_4	-0.014(0.029)
Education	d_5	0.025(0.014)**
Household size	d_6	-0.379(0.111)***
Sigma squared		0.101(0.039)***
Gamma		0.039(0.541)
Log Likelihood Function		-63.275
LR Test of one-sided Error		57.858

Farm size had a negative coefficient and highly significant at 1% level of probability. This may be attributed to the ageing number of people who are involved in the production of food crop production in the study area. This finding agreed with Okoye *et al.* (2008) and Ugbagbe *et al.* (2017) but contrasts those of Onyenweaku and Effiong, (2005), Onyenweaku and Nwaru (2005). Credit access is negative and not significantly related to technical efficiency. This result was a confirmation of the fact that the rural areas are still under-banked and the few available ones are reluctant to lend to resource poor farmers. This result is in consonance with the findings of Ezeh, *et al.* (2010), Oyakhilomen *et al.* (2015) and Abdulai and Abdulai (2016). Farming experience was negative and not significantly related to technical efficiency. This result agreed with the finding of Rahman and Umar (2009) but disagrees with that of Onyeweaku and Nwaru (2005) and Ibrahim *et al.* (2015). The estimation of gamma (Table 5), which is the ratio of variance of farm-specific performance of technical efficiency to the total variance of value productivity per hectare was 0.039, implying that 3.9% of the difference between the observed and frontier output is primarily due to the factors which are under the control of farmers.

CONCLUSION AND RECOMMENDATIONS

The levels of input used and output obtained by the farmers showed that the farmers are operating at the last stage of production level. Consequently, crop production was found to be inelastic with a decreasing return to scale. The distribution and level of technical efficiencies for farmers was examined. The mean technical efficiency of farmers in the agricultural production was about 74.2%. The implication is that there is an opportunity to increase output on average by 25.8% through efficient use of inputs given the current input use and technology. The result further shows that there was a significant difference in the technical efficiency level obtained by the farmers. The discrepancy ratio gamma (γ) which measures the relative deviation of output from the frontier due to inefficiency was about 3.9% indicating that about 3.9% of variation in agricultural production among the farmers was attributed to technical inefficiency effects. Thus, it is possible to improve technical efficiency through better use of these factors. The study concluded that there is room to increase crop output from the existing level if farmers are able to use these input variables in an efficient manner. Hence, the State Government and its Agricultural Development Projects (ADPs) should provide necessary supports to the farmers. Such supports as extension trainings, credit, improved seed and timely supply of fertilizer.

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