Effects of Land Fragmentation on Agricultural Productivity in Nigeria

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Abstract The study examined the extent of land fragmentation in Nigeria, where it has become a major agricultural and land reform issue. Data for the study were obtained from the 2013 General Household Survey (GHS). The analysis of the data involved the use of descriptive statistics and stochastic
production function. Among the three different stochastic frontier model specifications, the truncated normal distribution was selected because it gave more robust results than half-normal and exponential models. The model was then used to measure the technical efficiency level. The result revealed that the technical efficiencies for the sampled farmers were less than one indicating that all the sample farmers were operating below production frontiers. The mean technical of farmers was 0 .50. Age, education, fertilizer usage, distance to the household were the significant determinants of land fragmentation in Nigeria The study discovered that there exists a negative and significant relationship between land fragmentation and farmers productivity in Nigeria

Keywords: Productivity, Land fragmentation, technical efficiency, Nigeria

Introduction

Land fragmentation (LF) is defined as a situation where a farm is composed of more than one separate plot of land or a situation that exists when a household operates several owned or rented noncontiguous plots at the same time. Land fragmentation is said to be a constraint to efficient crop production and modernization of agriculture in Nigeria. The prevalence of the problem in several countries, especially in the developing world, has led to diverse land reforms. Land fragmentation used to be closely associated with Europe(European commission ,2016), but in recent time, it has been documented in all part of the world, including Africa. With independence and constitutional governance, land reforms in Ghana are increasingly fashioned through pluralism and consensus-building (Amanor, 2001; Larbi, 2006). For example, since 2004 the Land Administration Project has been used by governments as a platform to elicit public participation in re-engineering the land administration system and to develop a system that is fair, efficient, transparent and cost-effective. It is a comprehensive reform programme that affects the entire continuum of land administration, including policy and legal regimes and institutional reforms i.e .public and customary (Larbi, 2006, 1). Government and its development partners have provided resources to enable traditional authorities to participate in the land reform processes effectively. The review of the literature provides several explanations of land fragmentation that are often divided into two main categories: demand and supply factors. The supply factor treats fragmentation as an exogenous imposition on farmers which have adverse effects on agricultural production while demand factors assume that farmers voluntarily choose the beneficial level of fragmentation (Blarel et al.,1992).

Despite Nigerians enormous resources for agricultural production most especially land, a close look at the agricultural landscape reveals that activities in the food crop sub-sector are continuously dominated by production on several small and scattered holdings (Adegeye *et al* 2015). This study empirically relate land fragmentation to farmers' productivity in Nigeria to provide recent information to policymakers

Most authors consider fragmentation of land holdings as a serious obstacle or "disease" to rational agricultural development because it hinders mechanisation, causes inefficiencies in

production and involves large costs to alleviate its effects

Once a government assess that land fragmentation constitutes a problem for rational agricultural development, there are three strategies to be followed: The first one is to promote such legislation regarding aspects affects land fragmentation (e.g. inheritance, minima parcel size in subdivisions etc.) so as to prevent worsening of the problem. According to Van Dijk (2003, p.47), "this strategy is susceptible for misuse, unwanted side effects and it is hard to assess its effectiveness". The second strategy is to apply specific land management approaches to tackle specific problems in particular agricultural areas (e.g. land consolidation). The third strategy is to apply specific land protection policies/programs to prevent agricultural land in the case is pushed away

Materials and Methods

In order to obtain consistent data from General Household Survey (GHS) the following activities were taken. The farmers were grouped based on geographical proximity to ethnic homogeneity and other political considerations. Various conversions were made to standard units of measurement

The study adopts the stochastic frontier approach developed by Aigner et al. (1977) and Meeusen and Vaan den Broeck (1977). The production function can be expressed as

$$Ly = f(x_{ij}, \beta)^{e(\phi - n_i)}, U = \phi_i - \eta_i and i = 1,2,3...N; j = 1,2...j \quad \ldots\ldots(1)$$

Where Iy denotes the output of the i[th] farm

X_{ij}(i = 1,2,….N; j= 1,2….j) represent a(1 ∗ K)

Vector of inputs and β is (K x I) vector of the unknown parameters to be estimated. Equation (1) is linearized by taking the natural logarithm of both sides and manipulating the relevant terms to give

$$\ln Y = \alpha = \sum_{j=i}^{j} \beta \ln x_j = \phi_i - \eta_{i,} u_i = \phi - \eta_i \quad \ldots\ldots(2)$$

Here ϕ is the systematic random error that accounts for measurement error and other factors that are not under the control of the household and η_i denote the asymmetric non-negative random error component that measures technical inefficiency effects. The systematic random error variable ϕ is assumed to be independently and identically distributed with zero mean and variance σ^2 (Coelli, 1995). The non-negative variable η_i is assumed to be independently and identically distributed with zero mean and truncation (at zero from below) of the N ($\sigma^2\eta_i$) distribution (Coelli, 1995). Moreover, ϕ and η_i are assumed to be independent of each other and also independent of the input, X_j. The variance parameter of the model is parameterized as in (3)

$\sigma^2 = \sigma^2\phi + \sigma^2\eta$, $\gamma = \sigma^2\eta/\sigma^2\mu$ and $0 \leq \gamma \leq 1$

The technical efficiency of farm denote by TE_i

$$TE_i = \frac{R_i}{R_i^*} = \frac{f}{f}\frac{(x_{j,}\beta)^{e(\phi-\eta)}}{(x_{j,}\beta)^{e(\phi_j)}} = e\eta_1 (so\ that$$

$$0 \leq \gamma \leq 1 \ldots\ldots\ldots\ldots\ldots(4)$$

can be estimated as

$$f(u) = \frac{2}{\sqrt{2\pi\sigma_u}} = \exp\left\{-\frac{u^2}{2\sigma_u^2}\right\} u \geq 0.$$

Truncated Normal Distribution in the Cobb-Douglas Stochastic Frontier Model: The half-normal distribution for the inefficient component *Uit* restricts the mode of the distribution to occur at *U*= 0. Stevenson (1980) suggests the use of truncated normal distribution for *Uit* so that the mode need not necessarily be zero. The density function of the truncated standard random variable is:

$$f(u) = \frac{\frac{1}{\sqrt{2\pi\sigma_u}}\exp\left\{-\frac{1}{2}\left(\frac{u-\mu}{\sigma_u}\right)^2\right\}}{\phi\left(\mu/\sigma_u\right)}, \quad u \geq 0$$

.

Where, Φ(.) stands for the standard normal distribution function

The data was extracted from the General Household Survey (GHS, 2013).

The Agricultural post-planting survey wave2 was extracted from the data set. The total sample size of 1381 respondents cut across 36 states in Nigeria, including the Federal capital territory. The National Bureau of Statistic collected this data set on mixed farming.

Results and Discussion

The result in Table 1 shows the distribution of fragmented plots owned by farmers in the study area. More than half of the farmers (55.11%) have one plot, While 2.91% have more than five plots. The summary statistics of farmers, according to their usage of fragmented plots in term of means and standard deviation, is presented in Table 2. The mean age was 42 years; it implies that young and able body men and women constitute the farming population in Nigeria. In the same vein, he average farming experience of the respondents is about 17 years this will enhance specialization in the area of agriculture in Nigeria. Studies have shown that farmers with formal education have a great ability to adopt new technology and innovation. It is expected to have a positive influence on their level of efficiency. Coelli and Battese (1996) have confirmed the positive influence of education on farmer's production efficiency

The survey captured information on the socio-economic demographic characteristics of the respondents such as age(yr), sex, household, education(yr), farming experience (yr), marital status, , factors of production such as labour (man-day), seed(₦), fertilizer(kg), pesticide(₦), farm size(ha), plots numbers and distance of farm to homestead(km) was also extracted

Although a great number of them had attained up to primary school level of education, adopting innovation and thus promote productivity. The average household size among the respondents is 5 this might reduce labour cost. Labour as a factor of production play an important role in agricultural production especially in developing economics where capital intensive equipment are not readily available. ased on gender, it was discovered that the bulk of farmers were found to be females. This complements the findings of several studies that up to 60% of African agricultural workforce comprised of the females. Gabriel (2006) and Sigot (1995) have shown that women in Africa are responsible for an estimated 70% of total foods production throughout the continent. The women undertake mostly subsistence level of production to meet the urgent needs of the family. A good number of farming household who are married operating more than one plots of land, this may not far from the family setting operating in Nigeria.

Table 1: Land holdings by Household

Plot	Frequency	Percentage	Mean
1	701	55.11	1.885
2	330	28.94	
3	108	8.49	
4	90	7.08	
5	6	0.47	
>5	37	2.91	
TOTAL	1272	100.00	

Source: Data Analysis (GHS)

Table 2: Socio-economic characteristic of farmers by plot- fragmentation

Variable	<=1	1-2	2-3	3-4	4-5	>=5	Total
Age	22.24(20.51)	22.58(21.89)	20.80(21.58)	17.76(17.36)	10.83(6.59)	18(9.64)	19.41 (20.03)
Education	1.5(.98)	2.06(1.04)	1.92(1.01)	1.98(.98)	2(1.41)	3.5(2.12)	2.0(1.03)
Sex male	5.98	53.32	19.94	16.44	0.83	3.5	
Female	7.01	54.62	21.79	14.03	0.15	2.35	
Household size	4.00 (1.82)	5.00 (2.518)	5.00 (2.543)	5.011 (2.555)	7.00 (3.777)	6.00 (3.055)	5.00 (2.72361)
FarmingExperience	18.714 (14.106)	26.996 (16.720)	25.303 (17.472)	22.332 (15.777)	10.666 (13.923)	21.666 (16.166)	28.852 (17.036)
Marital status							
Single	7.2	54.85	21.92	14.17	0.22	1.64	
Married	3.9	54.09	16.34	21.41	1.56	2.73	
Divorced	9.87	43.66	23.94	8.45	0.00	14.09	
Widow/widower	0.00	51.85	22.22	7.41	0.00	18.52	

Source: Author computation, 2016

Figure in parentheses and outside parentheses are the standard deviations and means respectively

The result of Maximum Likelihood Estimate (MLE) of the Cobb-Douglas Stochastic frontier is presented in Table 3, together with diagnostic statistics.

Fertilizer was significant at 1% and positively correlated with farm size. The coefficient of 0.516284 indicated that 1% Increase in fertilizer would increase the farm output by 51% in Nigeria. The result was in agreement with Donkoh et al. (2011), who observed a positive relation. The findings concur with those by Everson and Mwabu (1998) that demonstrated a positive and significant relationship between fertilizer use and productivity. Farm size was significant at 1% level and positively related to output. This indicates that the percentage increase in farm size will increase productivity by 0.2874991, that is 28 %.The plot was significant at 1% but negative, this implies that increase in fragmented plot will reduced farm productivity, this also supported by Awotide (2010) he opined that land fragmentation might be detrimental to agricultural by causing physical problems, operation difficulties and forgone investment to individual farmers. The distance of plot to farm plot also plays a vital role in agricultural productivity The most prominent disadvantage is the increase of economic costs because of the time wasted and extra expense involved in the movements of labours, machines etc. since parcels of a holding are scattered in various locations. As a result, agricultural productivity and hence income reduced.

Table 3: Estimated of Cobb-Douglas Stochastic production frontier

Variable	Parameter	Coefficient	Standard error	t- statistics	PZ(Z)
Constant	β_0	6.511116	0.3817753	17.05	0.000***
Fertilizer	β_1	0.516284	0.0363601	13.80	0.000***
Labour (Man/day)	β_2	-0.043835	0.0420167	-1.04	0.297
Farm size (ha)	β_3	0.2874991	0.0256952	11.19	0.000***
Distance(Km)	B_4	.06157767	.0289277	2.27	0.023**
Plot	B_5	-0.0634222	0.3817753	-3.64	0.000***
Observation		792	316.4125		
Log-likelihood - 13545468			0.0060539		
Sigma square 229.0842			280.983		
Gamma 0.9949676					
Sigma square^2 234.77					

Source: author computation

*** are significant level at 1% **=5%

Table 4: Mean Technical Efficiency by Plot

The result of the mean of technical efficiency revealed that those farmers that have between 1-5 scattered plots are striving to attain efficiency score of one. The result also revealed that many farmers also had fragmented plots higher than five(5), this will be associated with a high level of inefficient resource allocation and resultant increase in Agricultural Production(Shuhao 2005)

Table4: Technical Efficiency mean scores of plot fragmentation by different frontier distribution

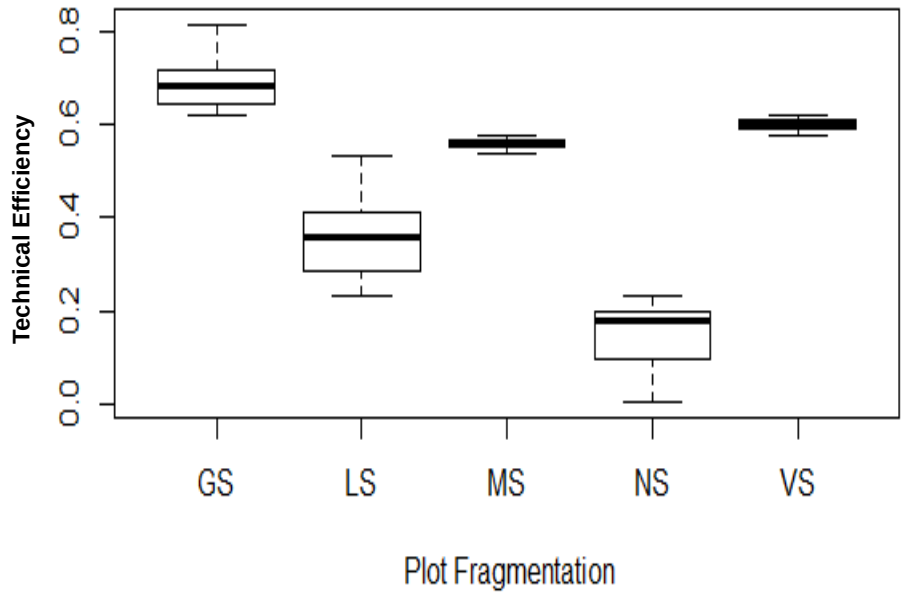
Plot	Truncated Normal distribution	Half Normal Distribution	Exponential Normal Distribution
1	.578	.416	.578
2	.551	.384	.549
3	.552	.388	.550
4	.558	.396	.556
5	.536	.430	.536
>5	.491	.327	.489
Total	.565	.401	.564

Source: Author Computation, 2016

Summary of different level of plot fragmentation

The result of ANOVA shows that more significant than five (GS) of plot fragmented are technically efficient. Also, farmers operating under one plot are less technically efficient. This support the Marginalist theory which postulates plots that large is more efficient than smallholding plots. The plot fragmentations are all significant at 5% level.

Graph 1



LEGEND
GS=>5plots (Great severe)
VS= 5plots (Very severe)
NS=1plot(Not Severe)
LS=2plots (Less Severe)
MS=4plots (Mid Severe)

Summary of technical efficiency of different types of fragmentation

Table 5: ANOVA post estimate for different fragmentation levels in Nigeria

Levels	Difference	lower	upper
LS-GS	-0.310	-0.325	-0.295
MS-GS	-0.126	-0.143	-0.109
NS-GS	-0.535	-0.565	-0.506
VS-GS	-0.085	-0.100	-0.069
MS-LS	0.183	0.164	0.203
NS-LS	-0.225	-0.25	-0.193
VS-LS	0.225	0.207	0.243
NS-MS	-0.408	-0.441	-0.376
VS-MS	0.041	0.022	0.060
VS-NS	0.450	0.418	0.482

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
frgcat	4	13.155	3.289	1211	<2e-16 ***
Residuals	678	1.841	0.003		

Significant at 5% Level

Source : Author computation,2016

Conclusion

Land fragmentation presents in many areas throughout the world from the past until nowadays. Bentley opined that " land fragmentation is a universal trait of all agricultural systems". He also stated that "to his knowledge no one has documented a society where there is no land fragmentation". FAO, realizing the potential impacts of the problem to many aspects of the development of a country began dealing with this around late 40's..

. However, it is known that land fragmentation may significantly differ from these figures from region to region of a country The study is aimed at capturing the effect of land fragmentation on the technical efficiency of the farmers in Nigeria. Apriori expectation on land fragmentation is made with the argument that the more plots the farmer has, the more distant they are from the residence, the less productive is the farm operation, the distant the average time the farmer must travel from the residence to the plots. The socio-demographic statistic was discussed, such as age, education, marital status, single household size, sex. Also these inefficient variables were used to determined the extent of fragmentation in the study area The study concludes that excessive fragmentation will adversely affect productivity likewise the distance of plot to homestead which also found to be significant at 1% level and the plot was negative and significant at 1% level. Therefore, it is expected that land availability will enhance productivity in Nigeria.

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