Impact of Land Fragmentation on Technical Efficiency: The Case of Maize Farmers in the Transitional Zone Of Ghana

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***Abstract*— *This paper seeks to study the impact of land fragmentation on technical efficiency of 461 maize farmers selected through the multi-stage sampling technique from the transitional zone of Ghana. The study used the stochastic production frontier model to analysis data from 2017/2018 farming season. The findings showed that, most of the farmers were in their youthful age with few of them over the age of 60 therefore, an average age of 44.8. The study revealed that; quantity of labour used , quantity of seed used, and farm size are the factors that determine the technical efficiency of farmers in the study area since it has a significant relationship with technical efficiency. On the other hand, land fragmentation and distance between farms was identified to be the only significant source of technical inefficiency of maize farmers in the study area. It is suggested that resource allocation and land policies should target the improvement of production efficiency of maize farmers in the study area.*

***Keywords:* land fragmentation, technical efficiency, maize farmers, transitional zone.**

I. INTRODUCTION

In African, maize is graded as the first cereal grain of greatest economic importance, at the expense of wheat and rice, which ranking second and third respectively (Thobatsi, 2009). Maize was identified as the solution to Africa food insecurity problem which can reduce poverty. In a summit held in Abuja by Head of States and Government from Africa in December 2006, the African Union Commission (AUC), the New Partnership for Africa's Development (NEPAD) as well as regional economic communities (RECs) were admonished to support the campaign of maize production on the continent so as to achieve self-sufficiency by the year 2015 (Union, 2006). In order to boost maize production in the continent, the summit recognized the significance of accepting the variations in maize production on the continent. Hence, an investigation into the factors affecting the changing patterns in maize production was highly recommended and welcomed so as to improve production and market of maize in the continent.

Although the natural conditions in Ghana are suitable for agricultural production, it's realized that local supply are still lagging behind demand, making the country food insecure (Wolter, 2009). According to the report of the Ministry of Food and Agricultural, Ghana's production in agricultural product supply meets just 50% of domestic meat and cereal needs and 60% of domestic fish intake (MoFA, 2011). Although Ghana is attaining self-sufficiency in starchy staples like plantain, yam and cassava, production of maize is nowhere near demand (Wolter, 2009). With a larger section of maize supply going into food consumption in Ghana, a rise in its productivity is unquestionably vital for achieving food security in the country. As maize also been a key component of livestock and poultry feed, the productivity and development of the poultry and livestock industries depend on the maize value chain. In the medium term, the demand for maize in Ghana was expected to grow at an annual rate of 2.6% (Akramov & Malek, 2012). Unfortunately, Ghana as at now is self-insufficient in the production of this very important commodity. Therefore, there is an urgent need for actions to be taken to improve productivity and aggregate production of maize so as to tackle Ghana's endless demand for maize and food security in general would be improved (MiDA, 2010).

Land fragmentation, also known as pulverization, parcellization or scattering (Bentley, 1987), is defined in the literature as the situation in which a single farm consists of numerous spatially separated parcels (Bentley, 1987; Binns & Binns, 1950; King & Burton, 1982; McPherson, 1982) (McPherson, 1982). According to (Demetriou, 2014), defined Land fragmentation can also be defined as a state where a household owns several non-contiguous land plots, often scattered over a wide area. It is characterized as a fundamental rural spatial problem concerned with farms which are poorly organized at locations across space (King & Burton, 1982). It implies a defective land tenure structure that often leads to major problem at various spatial scales which may hinder effective agricultural production and sustainable rural development. Land fragmentation among others has been identified as the root cause of the low productivity of maize in the transitional zone of Ghana and the nation as a whole.

Four types of land fragmentation are well-known in the literature: they are; fragmentation of land ownership; land use; within a farm (or internal fragmentation); and separation of ownership and use (Van Dijk, 2003). Fragmentation of land ownership refers to the number of landowners who use a given piece of land. Fragmentation of land use refers to the number of users that are also tenants of the land. Internal fragmentation emphasizes the number of parcels exploited by each user and considers parcel size, shape and distance as the main issues. Separation of ownership and use involves the situation where there is a discrepancy between ownership and use.

There exist an argument concerning whether land fragmentation is a problem or not (Nguyen, Cheng, & Findlay, 1996; P. Sklenicka, Janovska, Salek, Vlasak, & Molnarova, 2014; P. J. L. U. P. Sklenicka, 2016; Wu, Liu, & Davis, 2005). Some scholars are of a viewpoint that land fragmentation is a foundation of ineffective agriculture (Apata, 2016; Bentley, 1987; del Corral, Perez, & Roibás, 2011; Di Falco, Penov, Aleksiev, & Van Rensburg, 2010; Latruffe & Piet, 2014; Rahman & Rahman, 2009; P. Sklenicka et al., 2014). These people see land fragmentation as a main hindrance to efficient production system owing to the fact that continuous subdivision of farms would lead to small sized land holdings that may be difficult to economically operate. According to them, land fragmentation is said to impairment to productivity in different ways for example, fragmented land holdings can escalate transport costs. Also if the plots are located far from home, and far from each other, it will result in waste of time for the workers spent on travelling in between the plots and home. Management, supervision and securing of scattered plots can also be more difficult, time consuming, and costly. Land fragmentation have a possibility of increase the tendency of disputes between neighbor farmers (Mwebaza & Gaynor, 2002). Small fragmented land holdings can also result in difficulties to grow certain crops, and stop farmers from moving to high profit crops. More profitable crops, like fruit crops, needs larger plot areas, therefore if the farmers only owns small and fragmented plots they may be pushed to grow only less profitable crops (The World Bank, 2005). Other costs associated cost of land fragmentation include the hindering of economies of scale and farm mechanization. Small and scattered plots hinder the use of machinery and other large scale agricultural practices. In small fields operating machines and moving them from one field to another can cause problems. Small land holdings might also discourage the development of infrastructure like transportation, communication, irrigation, and drainage (Mwebaza & Gaynor, 2002). Also, it is observed that, financial institutions are sometimes reluctant to take small and scattered land holdings as collateral, which prevents farmers from procuring credit to make investments. With these disadvantages, land fragmentation is considered as defective and this has in turn caused several countries to implement land consolidation programs (Shao et al., 2006; Talyzin, Andersson, Sundqvist, Kurnosov, & Dubrovinsky, 2007).

Other scholars on a contrary viewpoint sees land fragmentation as a positive situation where farmers can cultivate many environmental zones, minimize production risk and optimize the schedule for cropping activities (Bentley, 1987). The known advantages of land fragmentation in this viewpoint are mostly related to the demand-side causes of fragmentation. Among the benefits linked with land fragmentation is the variety of soil and growing conditions that decrease the risk of total crop failure by offering the farmer a variety of soil and growing conditions. They are of the view that many different plots allow farmers access to land of different qualities in terms soil, slope, microclimatic variations etc. Another advantage of land fragmentation is the use of multiple eco zones. Holding different plots enable farmers to cultivate a wider mix of crops. Since crops ripe at different times when the plots are in different altitudes, spreading out the agriculture work like harvest and sawing during a longer period of time helps farmers to avoid household labour bottlenecks. Farmers may also desire fragmented land holdings in situations like diseconomies of scale with respect to the size of the parcels.

Previous studies and ample literature have studied the connection between land fragmentation and land productivity, or efficiency at farm level, (Blarel, Hazell, Place, & Quiggin, 1992; Thomas & Economics, 2006; Van Hung, MacAulay, Marsh, & economics, 2007; Wu et al., 2005) (Chen, Huffman, & Rozelle, 2009; Rahman & Rahman, 2009; Thomas & Economics, 2006). The focus of this paper is to examine the impact of land fragmentation on technical efficiency (TE) of maize farmers in the transitional zone of Ghana. As far as we know, no research has empirically estimated the impact of land fragmentation on maize production output in the transitional zone of Ghana, which justifies the need for this study. The specific objectives were to:

i. know the pattern of land holdings in the study area and

ii. Investigate the determinants of technical efficiency of maize farmers in the study area.

1.1 Conceptual framework and literature review

Agricultural land fragmentation is well-known in the world and it is usually attributed to numerous factors such as inheritance laws, political system, historical antecedence and consolidation processes, and transaction costs in land markets, urban development policies, and personal valuation of land ownership (Balogun & Akinyemi, 2017). Land fragmentation is often believed to be one of the main problems prevailing in rural land management, especially in developing countries (Rusu, Florian, Popa, Marin, & Pamfil, 2002; Wan & Cheng, 2001). Numerous studies have contended that the adverse effects of land fragmentation overshadow its possible benefits, mostly because it expands economic costs and decreases agricultural efficiency (Wan & Cheng, 2001). Specifically, it is viewed as a hindrance to adoption of modern agricultural technologies, to construction and maintenance of rural infrastructure and thus as an impediment to agricultural modernization.

There is inadequate proof available in the literature on the output and labour allocation influence of land fragmentation. With the use of the Cobb-Douglas production function, Fleisher and Liu (1992) estimated that land fragmentation leads to inefficiency in agricultural production. This result was reaffirmed by Nguyen, Cheng, and Findlay (1996), who also in their studies established a positive relationship between plot size and output for major grain crops in China. Whereas (Chen et al., 2009) established that fragmented farm structures links to higher labour costs; it is not completely clear why this implies that land consolidation does release rural labour, as the authors do not investigate the actual mechanisms of labour allocation any further.

1.1.1 Concept and measurement of land fragmentation

Land fragmentation is said to exist when a household have controls on a number of owned or rented noncontiguous lands at the same time. Numerous factors are accountable for agricultural land fragmentation, among the main factors that contribute to subdivision and fragmentation are, traditional system of inheritance of land (inheritance laws, which divide a family's land among all the remaining sons, which means as the population increases, not only does the size of holdings fall, but fragmentation also increase into small plots, scattered over a wide area), (Gebeyehu, 1995). Agricultural land fragmentation in the world has become rampant in the world and it is usually credited to numerous factors such as inheritance laws, political system, historical antecedence and consolidation processes, and transaction costs in land markets, urban development policies, and personal valuation of land ownership (Blarel et al., 1992; King & Burton, 1982). It is believed that Land fragmentation is one of the main problems existing in rural land management, most especially when it comes to developing countries (Wan & Cheng, 2001). Numerous studies are in support of the argument that, the adverse effects of land fragmentation dominate its likely benefits, mostly because it expands economic costs and decreases agricultural efficiency (Wan & Cheng, 2001). Land fragmentation is viewed as a hindrance to adoption and implementation of modern agricultural technologies, to construction and maintenance of rural infrastructure and therefore as an impediment to agricultural modernization. There is inadequate evidence presented in the literature on the output and labour allocation impacts on land fragmentation. Fleisher and Liu (1992) estimated that land fragmentation led to inefficiency in agricultural production by the use of Cobb-Douglas production function. Nguyen, Cheng, and Findlay (1996), also confirm the above result by establishing a positive relationship between plot size and output for major grain crops in China.

Land fragmentation can be measured with two different approaches namely: single dimension indicators and integrated indicators. Under the single dimension, one indicator is used to measure the extent of land fragmentation, indicators such as, farm size, total number of plots in the farm, average plot size, distribution of plot sizes, spatial distribution of plots, and the shape of plots are commonly used in the literature (Bentley, 1987). Farm size is used to measure the total holding of a farm but among the remaining parameters, size and spatial distribution (i.e. distance) are often considered to be most significant (Shuhao, 2005). The integrated indicators capture the information from several single indicators into one index. The most commonly used index is the Simpson index (Blarel et al., 1992). The Simpson index (SI) measures the degree of land fragmentation in the following way:

$$SI = 1 - \frac{\sum ap^2}{(\sum ap)^2} \tag{1}$$

where ap is the area of each plot. The Simpson index is positioned between 0 and 1. Differently to the Jawanski Index (JI), a higher SI value matches with a higher degree of land fragmentation. The value of the Simpson index is also determined by the number of plots, average plot size and the plot size distribution. Also, farm size, distance and plot shape are no taken into account.

1.1.2 Factors that influence Agricultural Productivity

Factors influencing the output of farmers can be categorized into three, firstly, the physical inputs engaged (capital, land and labour), secondly, the characteristics of farmers and farm, and lastly, factors that are external to the farmer such as climatic conditions, government and institutional policies (Wiebe et al, 2001). Capital inputs employed comprises of herbicide, fertilizer, seed, pesticide as well as farm tools and implements. The second category which is the characteristics of the farm and farmer covers factors such as topography and size of land cultivated, distance of farm from input and output markets, level of education, age, gender, family size etc. Soil conditions and weather as external factors including temperature, rainfall and humidity (Michele, 2001). Shamsudeen et al (2013), Sienso et al (2013), Oppong (2013) and Bempomaa and Acquah (2014) have testified to significant positive impacts of size of land cultivated on the productivity of maize production in Ghana. Sienso et al (2013), Oppong (2013) and Bempomaa and Acquah (2014) for example discovered 5.3%, 0.201% and 1.29% respectively rises in maize outputs for the respective above-mentioned studies in Ghana. Fan and Chan-Kang (2005), studies into farm size, productivity, and poverty in Asian agriculture in addition to that of Goni et al (2007) analysis of resource-use efficiency in rice production in Nigeria also exposed positive correlations between farm size and agricultural productivity. Nevertheless, Pender et al (2004), Okoye et al (2008), Stifel and Minten (2008), Masterson (2007) as well as Byiringiro and Reardon (1996) reported that, there is a negative relationship between area for crop production and productivity. Farmer's resources are limited and may not be able to meet the requirements of large farm lands that they cultivate. Farmers are consequently incapable to provide for and apply key production inputs such as fertilizers, herbicides, pesticides, improve seeds, etc. thereby resulting in low productivity.

1.1.3 Technical Efficiency among Smallholder Farmers

Technical efficiency as an element of economic efficiency reveals the farmers ability to maximize productivity from a given level of inputs (e.g. output-orientation).Theoretical developments in assessing technical efficiency can be traced back to the works of Debreu (1959). There has been numerous literature on the technical efficiency of smallholder agricultural outstanding among them are the works of, Basnayake and Gunaratne (2002), Barnes (2008), Duvel et al (2003), Shapiro and Muller (1977) and Seyoum et al (1998). Large number of studies have associated farmers` age, farmers` educational level, access to extension, access to credit, land holding size, number of plots owned, farmers` family size, gender, tenancy, market access, and farmers` access to improved technologies such as fertilizer, agro-chemicals, tractor and improved seeds with technical efficiency. The works of the following, Amos, 2007; Ahmad et al, 2002; Tchale and Sauer, 2007; Basnayake and Gunaratne, 2002, reported that, farmers` age and education, access to extension, access to credit, family size and tenancy as well as farmers access to fertilizer, agrochemicals, tractors and improved seeds have positive effect on technical efficiency of maize production. The impact of educational level on the efficiency and productivity of cereals was also scrutinized by Weir (1999). Weir and Knight (2000) also studied the impact of education externalities on the productivity and technical efficiency of crop producers and found that education externalities resulted from use and dissemination of innovations that shifted out the production frontier. Notwithstanding the outcomes there is one identified shortcoming of the Weir (1999) and Weir and Knight (2000a) work that is, it only investigate formal education as the only source of variations in technical efficiency of smallholder farmers. Amos (2007), Raghbendra et al (2005) and Barnes (2008) holds the view that there is a relationship between land holding size and technical efficiency to be positive. However, impact of the number of plots on technical efficiency has been reported by Raghbendra et al (2005) to be negative, that is land fragmentation (as measured by number of plots) has a negative impact on productivity. There has been disagreeing results on the impact of socio-economic variables such as gender on technical efficiency. While some studies by (Kuwornu et al, 2013; Bempomaa and Acquah, 2014) reported that gender of the farmer has no significant influence on technical efficiency, other studies (Sienso et al, 2013; Shamsudeen et al, 2013; Oppong, 2013) are on a contrary view that gender plays an important role on Technical efficiency. Addai (2011) also studied the Technical Efficiency of Maize Producers in three Agro Ecological Zones of Ghana and reported a mean technical efficiency of 64.1 % for maize producers in te chosen agro ecological zones. The study again identifies the determinants of technical efficiency of maize producers across the selected agro ecological zones to be contact with extension agents, mono cropping, gender, age, land ownership and access to credit.

II. MATERIAL AND METHOD

This study used primary data which was collected through a questionnaire from smallholder maize farmers. The multi-stage sampling technique was adopted in the selection process. In the first stage of the sampling process, two (2) districts were purposively selected from the transitional zone; the selected districts were Nkoranza and Ejura Sekyerdumasi. In the next selection process, five and four farming communities/villages were randomly selected from each of the district selected above respectively, Dotobiri, Koforidua, Abountem, Banofour, Donkro Nkwanta (Nkoranza District) and Durobo, Asuogya, Ejura, Sekyeredumase (Ejura Sekyerdumasi District).

The study makes use of the (Bartlett, DeMasi, Quinn, Moxham, & Rousseau, 2001)'s sample size determination formula to determine the sample size. That is

$$n = \frac{t^2(z)(h)}{d^2}$$

$$n = \frac{1.96^2 \times 0.513 \times 0.585}{0.05^2} = 461$$

where

n = sample

t = the value for selected alpha level of 0.025 in each tail = 1.96 (the alpha level of 0.05 represent the level of risk.

z = proportion of population engaged in maize production activities.

h = proportion of population who do not engage in maize production activities.

d = acceptable margin of error for proportion being estimated = 0.05 which the researcher is willing to take.

The study employed analytical techniques like descriptive statistics and stochastic frontier production. Descriptive statistics such as frequency tables, percentages means and standard deviations were used to analyze farmers' socio-economic characteristics, land fragmentation. The original models of stochastic frontier production model by (Aigner, Lovell, & Schmidt, 1977); and proposed by (Battese & Coelli, 1995), was applied to cross-sectional data to determine the efficiency of the maize farmers in the study area. The model was employed because it is capable of capturing measurement error and other statistical noise influencing the shape and position of the production frontier.

2.1 Model Specification

As employed by (Ajibefun, Battese, & Daramola, 2002) this study used the stochastic frontier production function. According to (Battese & Coelli, 1995) this model has advantage over other models because it allows simultaneous estimation of individual technical efficiency of respondents and also determines the technical efficiency. The stochastic frontier approach, contrary to other parametric frontier measures, give room for stochastic errors which may arise from statistical noise or measurement errors. With our objectives in mind we apply a Cobb-Douglas production function and the stochastic frontier which is expressed as:

The model of the stochastic frontier production for the estimation of technical efficiency is therefore specified.

$$\ln(y_i) = f(x_{ij}, \beta) + \varepsilon_j$$

$$\varepsilon_i = v_j - u_j$$

Where y is the level of output of the *j*th plot, *x* is the value of input used on the *j* plot, β is a vector of parameters to be estimated, $\varepsilon_i = v_j - u_j$ that is the error term, where $v_j - N(0, \sigma\ )$ and u_j is the one-sided error term, v_j and u_j is the two- side-sided error term and assumed to be independently distributed. The term v_j is the symmetric component and allows random variation of the production function across farms and also capture factors outside the control of the farmer. The one-sided element (u_j >0) reveals technical efficiency relative to the stochastic frontier. Output is said to lie on the stochastic frontier when u_j = 0 on the other hand there is inefficiency when u_j > 0.

The error term is presumed to follow one of the three likely distributions (Bauer, 1990)

i. Half-normal as U/N $(0, \sigma u^2)$

ii. Exponential as exp $(\mu u, \sigma u^2)$

iii. Truncated normal at zero $N \square \mu u, \sigma u^2$

$$\sigma^2 = \sigma_{v^2} + \sigma_{u^2} \tag{2}$$

Where $\sigma = (\sigma_{v^2} + \sigma_{u^2})1/2$

The technical efficiency (TE) of each an individual farmer is calculated as the projected values of v_j conditional on $\varepsilon_j = v - u$ with reference to (Jondrow, Lovell, Materov, & Schmidt, 1982).

That is

$$\text{E=}\ (u_j / \varepsilon_j) = \frac{\sigma_x - \sigma_y}{\sigma}[\frac{f(\varepsilon_j^2/\sigma)}{1-F(\varepsilon_j^2/\sigma)} - \frac{\varepsilon_j^2}{\sigma}] \tag{3}$$

Where E is the expectation of the farmer, F* is the values of the standard normal density and f* is the distribution function. Therefore Technical Efficiency (TE) is calculated as

Where 0 ≤TE ≤ 1.

$$\text{TE} = \exp(-Eu_j / \varepsilon_j);\ j = 1 \tag{4}$$

$$\text{Technical Efficiency (TE)} = \exp(-Eu_j / \varepsilon_j); i = 1 \tag{5}$$

The stochastic production frontier model is stated as follows

$$\ln Y_1 = \beta_0 + \beta_1 \ln S_1 + \beta_2 \ln S_2 + \beta_3 \ln S_3 + \beta_4 \ln S_4 + \beta_5 \ln S_5 + \beta_6 \ln S_6 + V_j - U_j \tag{6}$$

where Y is the productivity or output of farmer in kg; β 's is the parameters to be estimated; ln's is natural logarithms; V_j is the symmetric component that considers random errors associated with random factor under the control of maize farmers; U_j is the asymmetric error component that represent deviation from the frontier production (inefficiencies); S_1 represent the quantity of labour employed on a man-day; S_2 represent the quantity of seed (kg) used; S_3 represent the quantity of fertilizer (kg) applied; S_4 represent the quantity of herbicides (litre) applied; S_5 represent farm size (ha) and S_6 represents quantity of pesticides applied.

Empirically, the stochastic frontier translog production function was estimated as

$$\begin{aligned}
&\ln OUTPUT_i = \beta_0 + \beta_1 \ln LAB_i + \beta_2 \ln SED_i + \beta_3 \ln FET_i + \beta_4 \ln HEB_i \\
&+\beta_5 \ln LAD_i + \beta_6 \ln PET_i + \beta_7 \ln(LAB)_i^2 + \beta_8 \ln(SED)_i^2 + \beta_9 \ln(FET)_i^2 \\
&+\beta_{10} \ln(HEB)_i^2 + \beta_{11} \ln(LAD)_i^2 + \beta_{12} (PET)_i^2 + \beta_{13} (\ln LAB \times \ln SED)_i \\
&+\beta_{14} (\ln LAB \times \ln FET)_i + \beta_{15} (\ln LAB \times \ln HEB)_i + \beta_{16} (\ln LAB \times \ln LAD)_i \\
&+\beta_{17} (\ln LAB \times \ln PET)_i + \beta_{18} (\ln SED \times \ln FET)_i + \beta_{19} (\ln SED \times \ln HEB)_i \\
&+\beta_{20} (\ln SED \times \ln LAD)_i + \beta_{21} (\ln SED \times \ln PET)_i + \beta_{22} (\ln FET \times \ln HEB)_i \\
&+\beta_{23} (\ln FET \times \ln LAD)_i + \beta_{24} (\ln FET \times \ln PET)_i + \beta_{25} (\ln HEB \times \ln LAD)_i \\
&+\beta_{26} (\ln HEB \times \ln PET)_i + \beta_{27} (\ln LAD \times \ln PET)_i + v_i - u_i
\end{aligned}$$

The inefficiency model is specified as;

$$T_1 = \sigma_0 + \sigma_1 B_1 + \sigma_2 B_2 + \sigma_3 B_3 + \sigma_4 B_4 + \sigma_5 B_5 + \sigma_6 B_6 + \sigma_7 B_7 \tag{7}$$

Where T_1 represent the technical efficiency of maize farmers; σ 's represent the parameters estimated; B_1 represent the age of farmers (years); B_2 represent the sex of farmers (Male=1 and Female=2); B_3 represent the marital status of the farmers (Married=1 and Otherwise=0); B_4 represents the Household size; B_5 is the number of the years spent in school (years); B_6 represent the fragmentation index; B_7 represents the distance between plots (kilometer).Also, the empirical inefficiency model was estimated as;

$$u_i = \delta_0 + \delta_1 AGE_i + \delta_2 GENDER_i + \delta_3 MARST_i + \delta_4 HOSIZ_i + \delta_5 EDU_i$$
$$+\delta_6 FRAIND_i + \delta_7 FRADIS_i$$

III. RESULTS AND DISCUSSION

The tables below present the socioeconomic characteristics of maize farmer in the study area. It was realized from the result that, as high as 192 farmers representing 41 % were in the age group of 41-50 years, followed by farmers in the age group of 31-40 with 157 farmers representing 34.1% farmers in the age range of 20-30 and 51-60 recorded percentages of 8.7% and 11.1% respectively. Farmers with age above 60 years recorded the least number with a percentage of 4.6% The average age of the farmers in the study area recorded 42.7 years with a Standard Deviation (SD) of 11.7, which testified that majority of the farmers are still within their youthful active productive age. The result has consequence on availability of labour and productivity because age has a direct bearing on the availability of labour and the adoption of new and improved agricultural practices. This result is in agreement with the work of Rauf (2010) who also identified that age of farmers has direct implication on labour productivity and improved agricultural practices. However some literatures consider age to have an ambiguous effect on productivity (Tan, 2005).

The result revealed that, as many as 320 farmers representing 69.4% in the study area were males, with 141 farmers representing 30.6% been females, this indicates active involvement of males in maize production in the study area than females. The result agrees with the work of Sdiq et al (2013) which revealed 67% of maize farmers were males and 33% were females in their study of Profitability and Production Efficiency of Small-Scale Maize Production in Niger state. It is also in agreement with the study results of (Oladejo & Adetunji, 2012) Economic Analysis of Maize (Zea mays L.) Production in Oyo State of Nigeria, which also found out that majority (70.9%) of the farmers were males with minority (29.1%) been females.

TABLE 1
SOCIOECONOMIC CHARACTERISTICS OF THE FARMERS

Age (Years)	Frequency	Percentage %
20 – 30	40	8.7
31 – 40	157	34.1
41 – 50	192	41.6
51 – 60	51	11.1
More than 60	21	4.6
Total	461	100
Mean = 42.7		
SD = 8.8		
Min. = 20, Max. = 77		
Sex		
Male	320	69.4
Female	141	30.6
Total	461	100
Marital Status		
Married	331	71.8
Otherwise	130	28.2
Total	461	100
Educational Level		
No formal education	58	12.6
Primary education	118	25.6
Middle School Education	93	20.2

Secondary education	132	28.6
Tertiary Education	60	13.0
Total	461	100
Mean = 13.1		
SD. = 1.21		
Min. = 0 Max. = 19		
Household Size		
1 – 4	100	21.7
5– 8	255	55.3
More than 8	106	23.0
Total	461	100
Mean = 7.1		
SD. = 3.2		
Min. = 1 Max. = 19		

Source: Survey 2018.

The results of educational level from the table above revealed that, 58 farmers representing 12.6% of the farmers interviewed were illiterates with no formal education at all. Farmer with secondary school education recorded the highest percentage of 28.6% representing 132 farmers, second to them was farmers with primary education with a percentage of 25.6 representing 118 farmers, whilst 20.2% and 13.0% were the percentages of farmers with middle school education and tertiary education respectively. The results proves majority of the farmers interviewed were literates within various levels of education that is 87.4% of the farmers were literates with formal education. According to the works of Huffman, (1977); Lockheed, Jamison & Lou, (1980) and Osman, Binici,& Zulauf, (2009) education partly determines farmers stock of human capital and positively influenced the level of technical efficiency of farmers and hence, the greater the stock of human capital, the better a farmer's ability to organize the factors of production for maximum efficiency. The result agrees with that of the work of Oladejo and Adetunji (2012) which revealed that 82.3% of maize farmers in Oyo state of Nigeria were literates.

The household size ranges from 1 to 19 with a mean of 7.1 and a Standard Deviation (SD) of 3.2 for maize farmers in the study area. The mean household is large enough to influence land fragmentation in the study area since per the custom of the people in the study area, land holding of the demise farmer must be divided among the children in the family.

TABLE 2
NUMBER OF PLOTS OWNED AND MEAN LAND SIZE BY FARMERS IN THE STUDY AREA.

Number of Plots	Frequency	Percentage %	Average Plot size (hectares)
1	93	20.2	0.58
2	180	39.0	0.90
3	119	25.8	1.29
4	51	11.1	1.81
5	18	3.9	2.41
Total	461	100	Mean= 1.09 ± 0.3

Source: Survey 2018.

The table above shows the number of land plots owned by maize farmers in the study area, from the table it was realized that farmers with two (2) pieces of land located at different arears recoded the highest percentage of 39.0 representing 180 farmers. Next to them were farmers with three pieces of land also located at different areas separated by distance from each other with a percentage of 25.8 representing 119 farmers? The others recorded 20.2%, 11.1% and 3.9% for farmer owning one, four and five different plots of lands respectively. The mean plot owned by farmers in the study area was 1.09 ± 0.3. Some researchers are of the view that, the number of plots can has positive effects on technical efficiency among them are, (Shuhao, 2005; Marara and Takeuchi, 2003). The work of (Raghbendra 2005) revealed that, the higher the number of plots the lower the technical efficiency lever of the farmer.

TABLE 3
THE AVERAGE TECHNICAL EFFICIENCY SCORE FOR MAIZE FARMERS.

Technical efficiency range	Frequency	Percentage
0.61-0.70	21	4.6
0.71-0.80	150	32.5
0.81-0.90	282	61.2
0.91-100	8	1.7
Total	461	100
Min	61.1	
Max	91.6	

Source: Survey 2018

The table above presents the minimum, maximum and mean of the technical efficiency of maize farmers in the study area. The table shows that, efficiency of maize farmers in the transitional zone of Ghana ranges between 61.1 % and 91.6% with a mean of 81.0%. This implies farmers in the transitional zone are operating at a high efficient level given all the available production technologies. However, farmer still have room of about 19.9% to improve by adopting and practicing the best farming practices.

TABLE 4
RESULTS OF THE STOCHASTIC FRONTIER SCALE OF EFFICIENCY FUNCTION OF MAIZE FARMERS.

Variable		Coefficient	Standard error	T-Value
Constant	β_0	4.5267***	0.22672	19.95
Quantity of labour (Man-day)	β_1	-0.01317***	0.003949	-2.89
Quantity of Seed (kg)	β_2	-0.783844***	0.010051	-1.83
Land Size (Ha)	β_3	-0.01183928*	0.280894	-2.79
Quantity of fertilizer (kg)	β_4	0.0004087	0.008709	0.05
Quantity Herbicides (litre)	β_5	0.010099	0.008663	1.17
Cost of farm implement	β_6	-0.0662485	0.0428042	1.54
Inefficiency				
Constant	B_0	0.1376273	0.243386	0.56
Age (year)	B_1	-0.0011641	0.001171	-0.68
Sex	B_2	0.0400865	0.040874	1.18
Marital Status	B_3	0.0031164	0.035340	0.89
Household Size	B_4	0.00391	0.0029525	1.34
Education (Years)	B_5	0.0006845	0.001992	0.34
Fragmentation index	B_6	0.1490806***	0.060665	2.46
Farm distance	B_7	0.010808**	0.004872	2.22
Sigma-squared (σ^2)		0.0139141***	0.4174042E+01	3.33
Gamma (γ)		0.99999	0.11558621E-03	
Log-likelihood function	0.54256121E+02			
LR-test of one sided error	0.17580149E+03			
Mean efficiency	0.828			

Source: Survey 2018 Note: * is significant at 10%, ** is significant at 5% *** is significant at 1%

The results of the maximum likelihood estimate of the Cobb-Douglas function revealed that the Lambda and the Gamma were both significant at 1% with values of 0.0139141 and 0.99999 respectively. For the fact that the values are significantly different from zero, it implies there is a good fit of the model and the distribution assumptions are correct. The results revealed that, quantity of labour (man-day) used, farm size and quantity of seed used, are very important inputs factor for the production of maize in the study area, because they all have a significant relationship with technical efficiency. Quantity of labour used in the farm which is measured in man-days has a negative relationship with technical efficiency but significant at 1%. This implies that, as the number of labour used in the farm increases by a unity the technical efficiency of the farmer will also decrease by 0.13%. This results in consistent with work of (Byiringiro & Reardon, 1996) who found out that land and labour had positive significant effects on production. Land size with coefficient of (0.01183928) also has a negative relationship and significant at 10% with technical efficiency. The implication of this result is that, a 10% increase in the area of land allocated of the cultivation of maize will reduce the technical efficiency of the farmer by 0.12%. With an increase in farm size, farmers' resource endowment will be proportionate to their scale of production. The results of the current study confirm existing knowledge about the effect of land holding on the technical efficiency of farmers. Even though Raghbendra et al (2005), Amos (2007) and Barnes (2008) reported a positive correlation between farm size and technical efficiency. This result is in agreement with the work of Msuya et al. (2008) who found out that land, expenditure on materials (including maize seed) and family labour positively affect maize productivity in Tanzania. Moreover, the cost of farm implements has significant relationship with technical efficiency and a negative coefficient value which is inelastic. This means a 10% increase in farm implement will cause a 7.8% decrease in technical efficiency of the farmer. Although, quantity of seed was significant it had a negative relationship with technical efficiency on the other hand quantity of herbicides was not significant and also had a negative relationship. This means as quantity of seed is increased by one kilogram (kg) the technical efficiency of the farmer will decrease by 0.10%, in the same way as the quantity of herbicides is increased by one litre the technical efficiency of the farmer will decrease by 0.36%. Both quantity of herbicides and pesticides were insignificant but herbicides had a negative relationship whiles pesticides had a positive relationship with technical efficiency.

In the case of the inefficiency variables, land fragmentation index and distance between farms were all significant at 10%, and 5% respectively with all the factors having a positive relationship with technical efficiency. The positive coefficient of land fragmentation means a unit increase in the fragmentation index will affect the technical efficiency of maize farmer in the study area. The positive effect of the fragmentation index on technical efficiency of farmers confirms the results of Sherlund, Barrett, and Adesina (2002) and Tan et al. (2010) whose studies revealed that technical efficiency is higher for farmers who cultivate few plots than more plots. The positive relationship of the land fragmentation of this study disagrees with the study of Dao (2013) who claimed that there is a positive relationship between farm size and technical efficiency and a negative relationship between land fragmentation and technical efficiency. In the case distance between farms plots a positive relationship significance was recorded which means a unity increase in distance between farm plots will result in an increase of output of maize farmer in the study area. These results confirm the results of Sherlund et al. (2002) and Tan et al. (2010). Who claims there is a positive effect of the number of plots on technical efficiency? Both age and sex of the farmers were not significant with age having a negative relationship with technical efficiency and sex having positive relationship. The age of the farmer though was not significant but had a positive relation with technical efficiency, however some literature consider age to have ambiguous effect on technical efficiency (shuhao, 2005). The effect of education on technical efficiency was positive and insignificant for maize farmers in the study area. The results show that educated farmers produced maize more efficiently than illiterate farmers. This is true since human capital represented by educational level, enhances the managerial and technical skills of farmers. According to (Battese & Coelli, 1995), education is hypothesized to increase the farmers' ability to utilize existing technologies and attain higher efficiency levels. This result was consistent with the work of by (Bizimana, Nieuwoudt, & Ferrer, 2004) in Rwanda. However Owour and Shem (2009) are of the view that educational level is negatively correlated to technical efficiency of farmers. They explanation that, scientific skills in agriculture, for example in developing economies are more affected by practical training in modern agricultural methods than just formal education. Household size on technical efficiency by maize farmers in the study area was significant and had the expected positive signs. This result is in agreement with Chukwuji et al (2007) work that revealed that large families enable farm activities to be completed on time in Nigeria. This on the other hand contradicts the work of Addai (2011) and Coelli et al (2002) that concluded that larger families are clearly a cause of lower efficiencies in the less labour intensive season, when surplus labour is a problem.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

This study was concentrated on the effects of land fragmentation on technical efficiency of maize farmers in the transitional zone of Ghana. The findings showed that most of the farmers were in their youthful age with few of them over the age of 60 years therefore, an average age of 44.8 years. The age of the farmers has direct bearing on the technical efficiency of the farmers because productivity tends to decrease with increase in age. With the system of land tenure in the study area, the large mean of household size which is about 8 members per household would have a serious impact on land fragmentation since the land must be shared among all children in the family after the demise of the farmer. The revealed quantity of labour used, quantity of seed used, quantity of fertilizer, and farm size as the factors that determines technical efficiency of farmers in the study area. On the other hand, household size, land fragmentation and distance between farms were identified as the source of technical inefficiency of maize farmers in the study area. The results in this study show a positive relation between land fragmentation and productivity. We draw the following key lessons from the study of land fragmentation. (a) Land fragmentation should not be considered as undesirable; (b) it should also not be viewed as purely originating from, and/or made persistent by the influences of only a single type of factor (e.g. population density – a supply side factor) but a result of interaction between both the supply – and demand – driven factors. Which type dominates the other will depend on the farming environment prevailing in a specific area. The study recommends that there should be proper resource allocation and also, attention should be paid to the most efficient resources in order to make farmers more efficient. Technical efficiency determinants should also be taken into consideration to help in forming policies on land use.

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