Agricultural production inefficiency in Nigeria: the contribution of farming households' ill-health disability

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With the predominantly manual nature of most agricultural production activities in Nigeria, health becomes a key determinant of household agricultural labour capacity, the efficiency of household labour and other inputs utilised in agriculture. Hence, this study examined how ill-health disability affects agricultural household production through the dual pathway of reduction in household labour capacity as well as the efficiency of agricultural inputs used in production. We used datasets obtained from the first two completed panel waves of the ongoing Nigerian Living Standard Measurement Study, Integrated Survey on Agriculture (LSMS-ISA). From the health information in the LSMS-ISA panel datasets, household ill-health disability experience and ill-health disability days were constructed and used as ill-health disability measures. Data were analysed using descriptive statistics, t-test and the panel data time-varying stochastic frontier production model. The results revealed that agricultural household experience of ill-health disability significantly lowers the value of agricultural output produced and increases the inefficiency of agricultural production. The efficiency of agricultural production could be improved beyond the current level by about 41% through agricultural household members' health improvement, encouragement of participation of male heads and more members of the households in production and increasing the number of cultivated agricultural plots. Therefore, agricultural and welfare-related policy efforts should be focused on the improvement in the health and wellbeing of the agricultural workforce to boost the production efficiency and productivity growth of the agricultural sector in Nigeria.

Keywords: Agricultural production, inefficiency, farming households, ill-health disability, Nigeria

Health as a form of human capital is required for developing individual work capacity and maximising earning potentials in life. This makes health central to productivity growth and the overall economic development of any nation. Thus, improving productivity growth and overall welfare relies to a large extent on health improvements. The framework developed by Hawkes and Ruel (2006) established that health and agricultural production activities impact each other. Good health enhances physical and mental capacities, hence translating to better production organisation, efficient utilisation of production resources, improved output and overall economic wellbeing of the producers. In contrast, ill-health lowers labour strength, the effective labour time and the ability to adapt, invest in and operationalise productivity-enhancing innovations. All these consequently result in declining agricultural productivity and output, farm income and an overall depletion of agricultural household economic resources. On the other hand, agriculture importantly provides food and other basic human needs as well as a livelihood source for the agricultural labour force. However, agriculture is likely to impair human health, arising especially from occupational-related stress and injuries, foodborne diseases and agrochemicals poisoning.

The majority of the agricultural production activities in Nigeria lie in the hands of small-scale farm families, who rely heavily on labour-intensive production techniques. To boost the agricultural sector's contribution to local food supplies and economic growth in Nigeria, there is a need for significant improvement in the agricultural sector's productivity growth. For this to happen, these smallholder farm families must be fully efficient in the use of agricultural resources,

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especially labour inputs committed to output production given their current form of labour-intensive production technology. However, the labour-intensive nature of agricultural production in the country makes the country's agricultural labour force highly vulnerable to illness and injury shocks. The vulnerability to ill-health shock is compounded by poverty prevalence and the poor state of infrastructural development in most agricultural communities of the country.

Empirical evidence has demonstrated that agricultural households in Nigeria lose a significant number of productive days to ill-health disability, especially from some preventable common illnesses like malaria, typhoid, body pain, respiratory tract infections, diarrhoea, tuberculosis and HIV/AIDS (Eboh and Okeibunor 2005; Asenso-Okyere et al. 2011; Onuche et al. 2014). These households apart from their low socio-economic position and high poverty status, bear a significant burden of ill-health shocks in terms of lost labour time and output productivity, high health care costs and reduced household income (Ajani and Ugwu 2008; Onuche et al. 2014).

Therefore, the established critical linkage between health and agriculture and the central role of labour in agricultural production activities in Nigeria warrants the empirical study of the effects of ill-health disability on agricultural production activities using a countrywide panel dataset. This study is motivated by the proposition of the model by Grossman (1972, 2000), that health, as a type of human capital determines the quantity and quality of healthy time available for individuals to commit to their market and non-market production activities. Ill-health disability is expected to affect agricultural output and technical efficiency of agricultural production through the reduction in physical strength and mental acuity usually associated with ill-health, thus causing a reduction in household labour capacity.

Previous studies have assessed the effects of ill-health either on the output of agricultural production or on the efficiency of agricultural production. The studies (Onuche et al. 2014; Osei-Akoto et al. 2013) that have analysed how ill-health affects agricultural production used the conventional production function in which a measure of ill-health is included as an extra covariate. Inefficiency is assumed inexistent in the production function, thus, variation in agricultural output produced is assumed to be due to variation in inputs used and ill-health disability plus random shocks which are outside the control of the farm. On the other hand, methodological pieces of evidence on the use of ill-health effects on the efficiency of agricultural production have been assessed with the stochastic frontier methodology (Kussa 2012; Ulimwengu 2009a and 2009b; Ajani and Ugwu 2008). Unlike these previous studies, this study jointly examines the effects of household ill-health disability experience and household members total illness disability days on the average value of output produced and production inputs used per hectare of cultivated land, the inefficiency of agricultural production and value of agricultural output produced. Ill-health disability experience, as used in this study, is constructed as a binary variable indicating the report of any form of illness and or injury experienced for at least one day which imposes inability on the affected individual to carry out his or her usual daily activities over the four week recall period considered by the panel survey. Similarly, ill-health disability days denote the number of days of illness and or injury disability experienced by each of the ill-health affected household members. The results of this study will therefore provide a comprehensive overview of the relationship between ill-health disability and agricultural production activities in Nigeria. The conclusions drawn from the findings of this study are useful as a guide for priority setting in formulating policies targeted at agricultural household health and agricultural productivity improvement in the country.

Data source and management

The data utilised for this study were drawn from the first two completed waves of the Nigerian Living Standard Measurement Study, Integrated Study on Agriculture (LSMS-ISA) panel datasets (2010 to 2013)[1]. The study units were the panel sampled agricultural households who reported the cultivation and harvesting of crops during this period. The agricultural input and output dataset, utilised in the stochastic frontier analysis, was examined and cleaned. The first stage of the data cleaning process involved the dropping of observations with missing and zero values for the cultivated agricultural plot size. This is because land is an indispensable input in agricultural production, without which agricultural output cannot be produced. Thereafter, observations with cultivated agricultural plot sizes less than 0.01 ha and greater than 40 ha were also dropped from the dataset. Dropping of observations with cultivated agricultural plot area less than 0.01 ha was because their corresponding reported value of output produced was too high to be obtained for the reported plot size cultivated. This may be due to data entry error during the LSMS-ISA panel survey. Similarly, the reported values of cultivated agricultural plot area above 40 ha were in hundreds, and these values did not appear as realistic cultivable agricultural land size at the household level within the Nigerian context. This data cleaning exercise resulted in an agricultural input and output dataset with cultivated land size ranging between 0.0104 - 40 ha, and an average value of 2.87 ha per household.

Methods of data analysis

The stochastic frontier production model with one step estimation was used to examine the effects of household ill-health disability measures on the value of agricultural output and inefficiency of agricultural production. Crop production in Nigeria, especially small scale, usually involves the cultivation of multiple crops on the same agricultural plot. Due to the complexities that could arise in aggregating the physical quantities of the numerous crop inputs and outputs, the value of planting materials and that of agricultural outputs produced were used in place of physical quantities in the stochastic frontier production model. This is based on the assumptions that the agricultural households take the prices of inputs and outputs as given, and that they produce intending to maximise profit.

Agricultural household members ill-health disability is hypothesised in this study to impact agricultural production activities through its effect on the quantity of output produced and the efficiency in which production inputs are utilised and combined to generate output, that is, the efficiency of agricultural production. The effect on output production can be viewed through reduced households labour capacity devoted to agricultural production activities due to ill-health disability. Production inefficiency may set in from reduced physical strength and economic ability to either try out improved production practices and or investment in high yielding inputs that could enhance production level.

Given the panel nature of the datasets used for empirical analysis and the need to account for the possible temporal behaviour of efficiency of agricultural production in the country over the two considered panel waves, we employed the Battese and Coelli (1992) time varying stochastic frontier production model with distribution assumptions made on the error terms. Under this model, agricultural production inefficiency is assumed to be

[1] Each wave was carried out in two visits (post-planting and postharvest visits) to the panel households. For the first wave, post-planting visit occurred in August to October 2010 and postharvest visit in February to April 2011. The second wave of the GHS-Panel post-planting visit was in September to November 2012, while the postharvest visit was in February to April 2013.

household specific and jointly time varying for all households. The specification of this model and its underlying assumptions are as follows:

$$y_{it} = \boldsymbol{x}'_{it}\boldsymbol{\beta} + v_{it} - u_{it} \quad \ldots\ldots\ldots.(1)$$
$$v_{it} \sim N\,(0, \sigma_v^2);\; u_i \sim N^+\,(\mu, \sigma_u^2); u_{it} = G\,(t)\,u_i$$

v_{it} capture random shocks beyond the control of the agricultural households, it is a two-sided normally distributed error term identically and independent of u_i and explanatory variables with a mean of zero and variance of σ_v^2 $[v_{it} \sim i.i.d.N(0,\ \sigma_v^2)]$. u_i is a positive random variable associated with the inefficiency in agricultural production; $u_i \sim i.i.d.N^+(\mu,\ \sigma_u^2)$ assumed to be truncated normally distributed identically and independent of v_{it} and explanatory variables with a mean of μ and variance of σ_u^2. μ is not constant, but a linear function of exogenous variables hypothesised to influence technical inefficiency of production. The inefficiency component u_{it} is made up of the non-stochastic time component, $G(t)$ similar for all households and the stochastic household specific component, u_i.

The Battese and Coelli (1992) model assumes that $G(t) = \exp\ [-\eta(t - T)]$, with t referring to any panel time period; while T is known to be the last panel time period. η denotes the time-varying feature of the inefficiency component. The level of statistical significance of η importantly indicates whether or not inefficiency is time varying in the model. According to Kumbhakar et al. (2015), if η is not significantly different from zero, this model (Battese and Coelli, 1992) falls back to the random effects time invariant panel stochastic frontier model of Pitt and Lee (1981). The sign of η points to whether or not inefficiency jointly increases or decreases over time, $\eta > 0$ implies that technical inefficiency jointly decreases over time amongst the agricultural households, and vice versa if $\eta < 0$. Also, since u_i is non-negative, u_{it} is as well non-negative by making sure the time component, $G(t)$ is non-negative.

To examine the influence of ill-health on the level of agricultural production, household ill-health disability measures (ID) are included as covariates in the household production function.

$$y_{it} = \boldsymbol{x}'_{it}\boldsymbol{\beta} + \psi ID_{it} + v_{it} - u_{it} \quad \ldots\ldots\ (2)$$

The ill-health disability measures are household ill-health disability experience and the total number of days lost by household members to ill-health disability over the four week recall period considered by the panel survey. $\boldsymbol{\beta}$ and ψ are the parameters to be estimated; y_{it} is the log of value of agricultural output produced by each household at time t; $\boldsymbol{x_{it}}$ represents vectors of production inputs in their log forms. The production inputs included: cultivated agricultural plot size; household labour hours; hired labour days; the cost of planting materials used; the quantity of fertiliser used by each household on their plots; the number of days of work animals used on the plots; the number of hours of farm machinery used in the production process.

On the other hand, to capture factors influencing technical inefficiency in agricultural household production, u_{it} is expressed as a function of household level exogenous covariates including ill-health disability measures as:

$$u_{it} = \boldsymbol{z}'_{it}\boldsymbol{\delta} + \psi ID_{it} + \epsilon_{it} \quad .\ldots\ldots..\ldots\ldots\ (3)$$

$\boldsymbol{\delta}$ and ψ are the parameters to be estimated; z_{it} denotes household level exogenous covariates believed to be capable of determining technical inefficiency in agricultural production. These are household head age, years of formal education and gender, households size, number of adult equivalent households members, panel time period, households ill-health disability measures (ID), number of agricultural plots cultivated, household major occupation and geo-political zone. The time variable in the inefficiency effect model was included to account for the rate of change in the inefficiency of production over time. ϵ_{it} is a random error term, which is independently distributed and follows a truncated normal distribution with zero mean and variance of σ^2. This assumption is consistent with u_{it} being a non-negative truncation that is,

$$[\epsilon_{it} \geq -(\boldsymbol{z}'_{it}\boldsymbol{\delta} + \psi ID_{it})].$$

The parameters of the stochastic frontier production function (Equation 2) and those of the inefficiency model (Equation 3) are estimated jointly using a one-step maximum likelihood estimation procedure. Thereafter, the inefficiency of agricultural production for each sampled household is estimated according to Jondrow et al. (1982) from the expected value of the conditional mean of u_i given $\epsilon_{i,}$, that is, the $[\ E(u_i \mid \varepsilon_i)]$. Where ε_i is the composed error term $(v_{it} - u_{it}\ )$. While the efficiency score of each agricultural production unit is predicted following the method of Battese and Coelli (1988), which is based on $[\ E[exp(-u_i\ |\varepsilon_i)]]$.

Results

This study found that ill-health affected agricultural household members who lost an average of eight days of productivity to ill-health disability over the four week recall period considered by the panel survey (Table 1). This result is similar to estimates by Onuche et al. (2014) in their study on ill-health and agricultural production activities in Komi State, Nigeria.

Description of agricultural inputs and outputs by household ill-health disability experience

Based on the statistics on agricultural inputs utilisation and value of output produced per hectare, it was found that agricultural households whose members experienced ill-health disability cultivated about 0.45 ha less agricultural land than their counterparts without ill-health disability experience (Table 2). Agricultural households without ill-health disability experience generated a higher value of agricultural output per hectare on average than their counterparts whose household members experienced ill-health disability. This finding goes parallel to the empirical evidence from Osei-Akoto et al. (2013) and Ulimwengu, (2009a and 2009b) that days lost to ill-health disability have significant negative effects on the value of agricultural production, especially during the crop harvesting phase. This result provides evidence that agricultural households without the experience of ill-health disability have higher agricultural productivity compared to those households whose members were affected by ill-health disability.

Table 1: Descriptive statistics of household members average days lost to ill-health disability per agricultural household

	Number of households	Average ill-health disability days	Standard deviation
Wave One	994	8.59	10.35
Wave Two	975	7.70	9.41
Pooled sample	1969	8.15	9.91

Waves One and Two are the first two panel time periods of data collection during the Nigerian LSMS-ISA panel survey

Table 2: Descriptive statistics of average agricultural inputs used and the output produced per hectare by households ill-health experience

	Households without ill-health disability experience (0)		***Households with ill-health disability experience (1)***		***Difference***		***Full sample***	
Average cultivated plot size (ha)	2.74		3.19		0.45		2.87	
	Mean	*Standard error*	*Mean*	*Standard error*	*Mean (0) – mean (1)*	*t value*	*Mean*	*Standard error*
Value of output naira/ha	216,510	9,105	182,535	12,899	33,975**	2.15	206,895	7,482
Planting materials cost/ha	6,921	553	7,812	945	-891	-0.81	7,172	478
Fertiliser used kg/ha	4.46	1.14	2.86	0.87	1.60	1.11	4.00	0.85
Hired labour used in hours/ha	5,673	5,393	344	64	5,330	0.99	4,167	3,869
Household labour used in hours/ha	4,216	233	4,956	1,351	-740	-0.54	4,425	417

**Statistically significant at $P \leq 0.05$

Household ill-health disability and agricultural production

The household ill-health disability measures considered in this analysis are household ill-health disability experience and illness disability days. These ill-health measures are hypothesised to jointly impact agricultural output and efficiency of agricultural production. Household ill-health disability measures could affect the quantity of agricultural output produced, hence, the value of agricultural production through the reduction in household labour capacity available for agricultural work. While on the other hand, it can be argued that agricultural household ill-health disability measures could influence the efficiency of agricultural inputs used during output production.

The joint influence of household ill-health disability measures on the value of agricultural output and inefficiency of agricultural production was assessed using Battese and Coelli (1995) time varying one step stochastic frontier production and inefficiency effect model. This model was estimated under the assumption that the inefficiency component of the agricultural production function is household specific, and time varying over the two considered panel waves. In this model, the distribution of the inefficiency effects in production is obtained by truncation at zero of the normal distribution of the exogenous inefficiency determinants. The maximum likelihood estimates arising from these models are presented in Table 3. Blocks 1 and 2 of Table 3 represent the model with household ill-health disability experience and total household members illness disability days included both as agricultural production input and inefficiency determinant respectively.

From the results estimates (Panel A of Table 3), all the agricultural production inputs included as part of the model covariates have a positive significant relationship with the log of value of output produced. The elasticities of the value of agricultural outputs to the production inputs are positive and significant, implying the percentage change in the value of agricultural output due to a 1% change in each of the production inputs. Since the coefficient of the estimated Cobb-Douglas functions are direct elasticities, a percentage increase in fertiliser quantity (kg), planting materials cost and cultivated plot size (ha) will increase the value of agricultural outputs produced by 0.087%, 0.111%, and 0.202% respectively. Likewise, a percentage increase in household labour hours, hired labour hours, animal days and machinery hours used in production will cause the value of agricultural outputs produced to increase by 0.022%, 0.163%, 0.120% and 0.171% respectively. The elasticity of the value of agricultural output for cultivated land size, machinery and hired labour hours are the highest, indicating the vital role of land, labour and machinery in agricultural output production in Nigeria. Hence, any agricultural policy and or intervention that will target the improvement of productivity of land and the agricultural labour force will be important in enhancing agricultural production efficiency in the country.

The result estimates from the joint influence of household ill-health disability measures on the value of agricultural output and inefficiency of agricultural production indicated that the effect of ill-health disability measures is significant only as an inefficiency determinant, but it is not significantly affecting household labour capacity, hence, the value of agricultural production. From the estimates of the one step panel stochastic frontier production and inefficiency effect model (Table 3), ill-health disability measures significantly impact household agricultural production activities only through the reduction in the efficiency of agricultural production. This is such that agricultural households without ill-health disability experience are approximately 9% more efficient than their counterparts whose members were affected by ill-health disability. This result corroborates previous findings (Adekunle et al. 2016; Kussa 2012; Ulimwengu 2009a and 2009b; Ajani and Ugwu 2008; Eboh and Okeibunor 2005) that productive days lost to ill-health disability by farmers and their household members will cause a significant reduction in the efficiency of agricultural production.

Table 3: Maximum likelihood estimates of stochastic frontier production model and inefficiency effects

	Battese and Coelli (1995) Time varying Inefficiency Model			
Dependent variable: log of the value of agricultural output produced	*Block 1*		*Block 2*	
Panel A	*Model with IE both as production input and as inefficiency determinant*		*Model with IDD both as production input and as inefficiency determinant*	
Agricultural production inputs	*Coefficient*	*z value*	*Coefficient*	*z value*
Log of fertiliser quantity	0.087*** (0.009)	8.96	0.087*** (0.009)	8.97
Log of planting materials cost	0.111*** (0.009)	11.73	0.111*** (0.009)	11.74
Log of cultivated plot area	0.202*** (0.011)	17.73	0.202*** (0.011)	17.71
Log of household labour hours	0.022*** (0.009)	2.38	0.022*** (0.009)	2.40
Log of hired labour hours	0.163*** (0.012)	14.06	0.163*** (0.012)	14.06
Log of animal days	0.120*** (0.019)	6.38	0.120*** (0.019)	6.40
Log of machinery hours	0.171*** (0.016)	10.90	0.172*** (0.016)	10.95
Log of illness disability days	---	---	-0.002 (0.022)	-0.07
Household ill-health experience	-0.001 (0.048)	-0.02	---	---
Constant	9.647*** (0.125)	77.26	9.643*** (0.125)	76.99

Table 3: Maximum likelihood estimates of stochastic frontier production model and inefficiency effects continued…

	Battese and Coelli (1995) Time varying Inefficiency Model			
Dependent variable: log of the value of agricultural output produced	*Block 1*		*Block 2*	
Panel B				
Exogenous inefficiency determinants	*Average marginal effect*	*z value*	*Average marginal effect*	*z value*
Household head age	-0.0003	-0.54	-0.0003	-0.59
Household head formal education (years)	0.015**	2.22	0.015**	2.21
Household head gender *(Base category: female)*				
Male	-0.110***	-2.89	-0.112***	-2.91
Household size	-0.008*	-1.78	-0.008*	-1.65
Households ill-health experience	0.086*	1.88	---	---
Log of ill-health disability days	---	---	0.030	1.51
Number of cultivated plots	-0.042***	-2.68	-0.040***	-2.61
Household major occupation *(Base category: non-agriculture)*				
Agriculture	-0.068*	-1.75	-0.068*	-1.76
Geo-political zone *(Base category: north-central)*				
North-east	0.350***	2.86	0.347***	2.84
North-west	0.126	1.56	0.125	1.56
South-east	0.576***	3.41	0.575***	3.37
South-south	0.536***	3.25	0.533***	3.22
South-west	0.196*	1.70	0.191*	1.67
Panel periods	0.064	1.61	0.065	1.63
Time varying inefficiency parameter				
Eta	-0.169** (0.081)	-2.09	-0.168** (0.081)	-2.07
Variance parameters for the error terms				
U-sigma				
Constant	0.376 (0.243)	1.55	0.388 (0.245)	1.58
V-sigma				
Constant	-0.434*** (0.048)	-8.98	-0.435*** (0.049)	-8.97
Sigma_u	1.207*** (0.147)	8.24	1.214*** (0.149)	8.16
Sigma_v	0.805*** (0.019)	41.35	0.804*** (0.019)	41.24
Lambda	1.499*** (0.144)	10.44	1.509*** (0.146)	10.36
Model descriptive				
Log likelihood	-7777.302		-7779.427	
Wald chi-squared	1898.92		1900.87	
Probability > chi-squared	0.0000		0.0000	
[a] *Likelihood Ratio test of inefficiency*	1989.964		1988.808	
Overall Mean Efficiency in % (based on Battese and Coelli, 1988 measure)	59.28		59.26	
Sample size	3014		3014	
Panel periods	2		2	

Values in parenthesis are bootstrap standard errors

*** Statistically significant $P \leq 0.01$; **statistically significant at $P \leq 0.05$; * statistically significant at $P \leq 0.1$

IE – household ill-health disability experience; IDD – household illness disability days

[a] The critical value from the mixed chi-squared distribution is 24.049 (at $P \leq 0.01$, degrees of freedom = 11) taken from Kodde and Palm (1986).

The positive relationship between ill-health disability and inefficiency of agricultural production could occur through the reduction in physical strength and mental acuity caused by ill-health shock. This result points out the vital role of household labour acquired farming skills and knowledge in resource use efficiency and overall production organisation in agriculture. Ulimwengu (2009a and 2009b) added that household members acquired farming skills might not be easy to replace by hiring labour to work on the farm in times of ill-health disability shocks of especially highly experienced agricultural household labour.

In addition to household ill-health disability measures, the exogenous factors increasing inefficiency in agricultural production include years of formal education of the household head and the household geopolitical zone of residency. On the other hand, the negative factors determining inefficiency are male household head status, household size, number of cultivated agricultural plots and household type of major occupation. These results imply that better educated household heads are less efficient in their agricultural production activities than the less educated ones. Evidence from previous findings (Wadud and White, 2002; Ajani and Ugwu, 2008; Ogunniyi and Ajao, 2011) indicated that increased years of formal education of the household head will increase inefficiency in agricultural production. Perhaps better educated household heads may not take agricultural production activities as their major occupation, thus, they may be less efficient in their agricultural production activities. This contradicts the finding of Ajibefun (2002) that an increase in the years of formal education increased the efficiency of agricultural production amongst smallholder crop farmers in Ondo State Nigeria. Educational attainment may have enhanced productivity through higher ability, better access to and quicker adoption of productivity enhancing information. The inconsistency with our result may be explained partly by the differences in the socio-economic features of each study sample as well as the changes that might have occurred over time in the socio-cultural and political settings of the country since the time of Ajibefun (2002) and that of this study.

The results also showed that regional variations in the geopolitical zone of production significantly affect the efficiency of agricultural production in the country. Sampled agricultural households in the north-central zone appear to be significantly more efficient in their production activities compared to their counterparts from all other zones except the north-west zone. This finding might be due to differences in soil types, climate characteristics and agricultural production methods of the geopolitical zones in the country. The coefficient of household head gender indicated that male household heads are more efficient in agricultural production activities than female household heads.

Household size was found to contribute positively and significantly to the efficiency of agricultural production. The implication of this is that larger agricultural households could benefit from higher household labour capacity and or from the timeliness of labour provision during periods of scarcity of hired labour, thus resulting in increased efficiency of agricultural production. This finding corroborated with Rahman and Rahman (2008), that large agricultural households will find it easy to substitute hired labour with their members during periods of scarce hired labour and in the peak production season. However, the positive relationship between household size and technical efficiency of agricultural production contradicts the findings of Ajibefun (2002), Oni et al. (2009) that larger household sizes with high dependency ratio may lower the household efficiency of agricultural production.

Similar to the findings of Chiona et al. (2010), Tippi et al. (2010) and Rahman and Rahman (2008), practising agricultural production as the household major occupation seems to have a significant negative effect on agricultural production inefficiency. It was found that households whose major occupation is agricultural production tend to be more efficient than households whose major occupation and source of income are non-agricultural. It is expected that households whose major source of livelihood is agriculture are likely to commit more of their time and resources to their production activities compared to part-time agricultural households. In the same way, agricultural households whose major income source is non-agriculture related, will commit a large share of their household labour time to non-farm activities, relative to farm production. This could have negative implications on their farm production activities and the efficiency of agricultural production.

The number of plots cultivated had a significantly negative effect on the inefficiency of agricultural production, implying that the efficiency of agricultural production will increase as more agricultural plots are cultivated. This corroborates previous findings (Tan et al. 2010; Sherlund et al. 2002), but negates the submissions of Rahman and Rahman, (2008) and Tippi et al. (2010) that the cultivation of many agricultural plots lowers the technical efficiency of agricultural production. From the review of studies on the relationship between land fragmentation and technical efficiency of agricultural production, it was deduced that the number of farmed plots could influence agricultural production efficiency both positively and negatively. Tan et al. (2010) attributed the positive effect to what they called the 'variation effect' and the negative effect to 'management effect' of the number of plots cultivated on agricultural production efficiency.

Tan et al. (2010) argued that the cultivation of more agricultural plots allows the farmers to benefit from variations in soil quality and agro-climatic conditions across the different cultivated agricultural plots. Also, farming on several different plots could guide the effective allocation of production inputs, particularly labour in ways that will suit the production needs of the different cultivated plots. All these variation effects across the cultivated plots could result in increased efficiency of agricultural production. On the other hand, the reduction in inefficiency by farming on many different agricultural plots could be attributed to the difficulty in managing the production activities on the plots, especially if the plots are far apart (Tippi et al. 2010). Rahman and Rahman (2008) added that fragmented agricultural landholdings could discourage farmers from investing in productivity enhancing innovations and the use of modern implements which could increase agricultural productivity.

The time varying characteristic of the model's inefficiency component (eta) was found to be negative and significantly different from zero, thereby justifying the use of the time varying inefficiency model in the model estimations. The significantly negative coefficient of eta indicates that inefficiency in agricultural production is jointly increasing over the panel wave periods across all the sampled agricultural households. The implication of this is that the level of agricultural production amongst the sampled households is moving away from the frontier over time due to inefficiency. The average increase in inefficiency over the panel wave periods across the sampled agricultural households was approximately 17% for both of the two models estimated. A likelihood ratio test for the presence of inefficiency in the estimated models was done under the null hypothesis (H_0): sigma (u-squared) equals zero; indicating the absence of inefficiency in the models. This null hypothesis was tested against the alternative hypothesis (H_1) that sigma (u-squared) is not equal to zero implying the preference of the stochastic frontier production model to the ordinary least square model. From this test, the likelihood ratio test statistics obtained are 1990.0[2] and 1988.8[3] from the estimated stochastic frontier models with ill-health disability experience and illness disability days respectively. Each of these likelihood ratio test statistics values is greater than the critical value of the mixed chi-square distribution obtained from Kodde and Palm (1986) at $P < 0.01$. With these results, the null hypothesis of the absence of inefficiency in the estimated stochastic frontier production models is rejected.

[2] Chi-square = -2* (log-likelihood ordinary least square – log-likelihood stochastic frontier) = 1990.0 ~ mixed $_{\chi}^{2}$ (11).

[3] Chi-square = -2* (log-likelihood ordinary least square – log-likelihood stochastic frontier) = 1988.8~ mixed $_{\chi}^{2}$ (11).

Description of mean efficiency scores by ill-health disability experience, sector of residence and cultivated plot size

The distribution of agricultural production efficiency scores, given by $E\ [\exp(-u_i \mid \epsilon_i)]$) is presented in Table 4. The average estimated production efficiency of smallholder farming households in the country is 59%. This points to the existence of a high level of inefficiency in agricultural production, as 41% of potential agricultural output is lost due to inefficiency by smallholder farming households. Table 5 shows that households whose members did not experience ill-health disability were significantly more efficient in agricultural production activities than those households whose members experienced ill-health disability. This finding corroborates that of Kussa (2012) on the existence of technical efficiency differential between farmers affected by illness and those not affected by illness. Kussa (2012) found that average technical efficiency scores were 33.5% and 48.9% for farmers affected and not affected by illness disability respectively.

The description of efficiency scores by sector and geo-political zones of residence (Table 5) is important in identifying the suitability of the different locations of the country for agricultural production. Findings showed that rural sampled agricultural households have a significantly higher average efficiency of production compared to their urban counterparts. This implies that given the current level of agricultural production technology, rural agricultural households are more efficient in their resource utilisation to generate agricultural outputs than urban households. Thus, there is a need for sustained productivity improvements amongst the rural smallholder agricultural households, if agricultural productivity growth is to be attained and sustained in Nigeria. This is particularly important because most of the agricultural production activities and the bulk of the locally produced food items supplied in Nigeria are handled by the rural smallholder farm families.

Table 6 shows that the level of efficiency in agricultural production in the country varies from one geo-political zone to another. The north-central and north-west geo-political zones are the most efficient. This is followed by the south-west zone, then by the north-east zone, south-south zone, while the south-east zone is the least efficient in agricultural production. This implies that there is a need for agricultural productivity-enhancing interventions in the south-south and south-east zones.

Table 4: Distribution of agricultural production efficiency scores

	Model with households' ill-health disability experience both as production input and as inefficiency determinant	
Efficiency categories (%)	*Frequency*	*Percentage*
0 - 29	371	6.6
30 - 49	955	17.1
50 - 69	2,525	45.1
70 - 89	1,749	31.2
90 - 100	0	0.0
Total	5600	100.0
Mean (%)	59.3	
Minimum (%)	3	
Maximum (%)	89	

Table 5: Descriptive statistics of average efficiency estimates by households ill-health disability experience

Ill-health disability experienced							
Households without ill-health disability experience (0)		Households with ill-health disability experience (1)		Difference		Full sample	
Mean efficiency score (%)	Standard error	Mean efficiency scores (%)	Standard error	Mean (0) – mean (1)	t value	Mean efficiency scores (%)	Standard error
60.1	0.25	57.2	0.43	2.9***	5.77	59.3	0.22
Sector of residence							
Rural (0)		Urban (1)		Difference		Full sample	
Mean efficiency scores (%)	Standard error	Mean efficiency scores (%)	Standard error	Mean (0) – mean (1)	t value	Mean efficiency score (%)	Standard error
0 59.5	0.23	57.8	0.66	1.7***	2.40	59.3	0.22

***Statistically significant at $P \leq 0.01$

Table 6: Descriptive statistics of average efficiency estimates by geo-political zone of residence

	Mean efficiency score (%)	*Standard deviation*
Geo-political zones		
North-central	70.3	10.3
North-east	59.7	12.8
North-west	65.8	9.6
South-east	45.6	16.5
South-south	49.2	17.7
South-west	65.2	15.1

Conclusion

An assessment of agricultural household ill-health disability effects on their production activities is important to ensuring agricultural labour force welfare improvements, the productivity growth of the sector, as well as overall economic development of the nation. It is in view of this that this study empirically examined the effects of ill-health disability measures on agricultural production activities in Nigeria. Out of the agricultural households sampled for this study, about 28% reported having experienced at least 1 day of ill-health disability from at least one household member during the four week recall period considered by the panel survey. An average of eight days of production was reported lost to illness and or injuries per sampled agricultural household over the four week survey recall period by households whose members were affected by ill-health.

Furthermore, this study established that the reduction in household labour capacity for agricultural activities caused by ill-health disability has implications on the level of agricultural production in the country. This effect occurs through the reduction in efficiency of inputs used in agricultural production. Ill-health disability lowers the average efficiency of agricultural inputs used and the value of output produced per hectare of cultivated agricultural land. This implies that households without the experience of ill-health disability performed better in their agricultural production relative to their counterparts whose members were affected by ill-health.

The results of this study revealed that the sampled agricultural households were producing at a very inefficient level. Efficiency gain of about 41% beyond the current level is possible given the current level of resource use and production technology by Nigeria's smallholder farming households. This indicates that there is significant potential for agricultural productivity and income enhancing opportunities in the country's agricultural production activities. This could be brought about by putting into consideration important agricultural household specific predictors of efficiency while setting policies targeted at improving agricultural productivity in the country. These efficiency predictors include encouragement of better participation of household members in agricultural production; and increasing the number of cultivated agricultural plots. And most importantly, the improvement in the health and welfare of agricultural households is critical to the enhancement of agricultural production efficiency and the attainment of productivity growth in the country.

The findings of this study indicate that the production efficiency of smallholder farming households in Nigeria could be increased by enhancing agricultural households access to cultivable agricultural land. It is therefore suggested that the government and appropriate stakeholders should put in place measures and policies that will improve access to agricultural land by the smallholder agricultural households, particularly the rural ones. This is based on the finding of this study that the rural sampled agricultural households are more efficient than their urban counterparts. Apart from this, the rural agricultural households in Nigeria are known to depend solely on agricultural activities as their major source of livelihood. Hence, any effort that will cause improvement in their efficiency of production and agricultural productivity will go a long way in improving their welfare. The study results showed that agricultural household members ill-health disability experience is a significant contributor to agricultural production inefficiency in Nigeria. This is such that the experience of ill-health disability will cause a reduction in affected households production efficiency by about 9%, when compared with agricultural households whose members were not affected by ill-health. Hence, any effort that will cause improvement in the health of agricultural household members will boost the efficiency of agricultural production, and this will go a long way in improving the welfare of the Nigerian agricultural workforce.

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