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Assessment of Tractor Use Efficiency among Smallholder Farmers in Nigeria

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ABSTRACT Smallholder tractor use is being promoted, which is necessary. However, the efficiency of smallholder tractor users and the pull factor that could stagnate or impact the smallholder tractor user's efficiency are left uninvestgated. This study investigates the efficiency of the tractor users, the contribution of tractor service providers to smallholder farmers' efficiency, the determinant of smallholder tractor users' efficiency, and the challenges smallholders face when accessing tractor service in Benue and Delta States of Nigeria. Multistage sampling technique was used to collect data from 280 smallholders. Descriptive statistics and one-step stochastic frontier model (SFM) of truncated normal distribution were employed to analyse the results. Fewer smallholders (78 out of 280 sampled smallholders) used tractors. On average, smallholder tractor users operate twenty-eight percent below their maximum technical efficiency portfolio and production frontier level, but their income was double that of non-tractor users. Tractor user output shows decreasing return to scale, with an elasticity of production that is less than one. Involvement of the smallholders in other occupations, marital status, long-distance travel to access tractor service providers, and the type of tractor service providers used by the smallholders significantly influence their efficiency. Smallholders who used private tractor service providers were fourteen percent more efficient than those who used government tractor services. Entrepreneurial attributes displayed to smallholders by SME tractor service providers could be why smallholders who use SME tractors are more efficient. Smallholder tractor users' challenges in accessing tractor services include delayed service delivery, lack of professionalism, and limited tractor service providers. Stakeholders should promote market-driven hire tractor service that is constantly available.

INTRODUCTION

Smallholder farmers occupy an essential segment of the global agricultural sector. They provide up to eighty percent of domestically produced food in sub-Saharan Africa (Kienzle 2015). However, the economic viability of smallholder farmers, especially those in Africa and other developing nations is threatened by competitive pressure from globalisation and large-scale commercial farmers who have access to wide varieties of tractor services and implements. According to research, the fate of African smallholders is either to disappear or be purely subsistence producers who depend on primitive farming methods (Mudhara 2010).

Most smallholders struggle with rudimentary hand tools and sometimes have little or no access to farm power (Guadagni and Fileccia 2009; Kienzle 2015). According to Sims and Kienzle (2016), there is poor tractor usage in sub-Saharan Africa because agricultural mechanisation for smallholder farmers in the region has for long been neglected. However, some governments in sub-Saharan Africa have sought to address the issue of smallholders' poor access to tractor services, with the most common approach being government-provided or government-sponsored tractor hire services, and another approach involved the government purchasing tractors for individual emerging commercial farmers (Alabadan and Yusuf 2013; Mutabazi et al. 2013; Zhou 2016). For example, in Nigeria, both the federal and some state governments, including Delta State, built tractor hire centres to provide services for smallholders (Alabadan and Yusuf 2013; AgroBusiness Times 2015). Nevertheless, most smallholder farmers' tractor use challenges remain unabated (Onomu and Aliber 2020). Takeshima et al. (2013) state that in Nigeria, tractors are used for only about eight percent of the total cultivated area by both large-scale and smallholder farmers. The indication is that Nigeria's government tractor services are in a state of collapse (Akinola 1987; Bishop-Sambrook 2005). Apart from the fact that these services are typically too few, government-operated tractor services tend to be riddled with corruption (Akinola 1987; Hittersay 2013; Onomu et al. 2020).

Research suggests that the answer to a smallholder's tractor-use challenges is rather to promote private tractor hire services as an alternative to government-run or funded tractor services (Mudhara 2010). However, the availability of private tractor services and the efficiency of smallholder farmers linked to hiring tractor service providers are uninvestigated in many parts of Nigeria. Moreover, existing private tractor services are faced with numerous challenges, such as competing with heavily subsidised government-operated tractor hire services (Alabadan and Yusuf 2013; Onomu et al. 2020). Though tractor services are faced with several challenges, they have been recognised as pivotal for enabling farm mechanisation. Mrema et al. (2008) submit that farm mechanisation cannot be realised among smallholders without access to effective tractor services, whereby usually small-scale farmers hire people who own tractors and equipment to perform specific farming operations for them.

Tractor services facilitate development and may even trigger youth involvement in agriculture (Achora 2015). In a report written for FAO on mechanisation in sub-Saharan Africa, Singha et al. (2012) state that tractors are a crucial tool in any farm mechanisation system that aims to increase the area under cultivation, facilitate the accomplishment of tasks that are difficult to perform with hands, reduce pressure on human labour, improve the quality of work and products, and thus promote labour efficiency and increase in productivity.

Experience with tractor services in some developing countries of Asia and Latin America shows that smallholder agriculture could be transformed into progressive commercial farming through adequate and appropriate application of an effective model for tractor mechanisation. For example, evidence showed that the constant availability of tractors and associated equipment in countries such as India, Brazil, China and Turkey have contributed to smallholders' production intensification, thus improving their incomes and quality of life (Alam and Singh 2004; OCED 2004; Rada and Valdes 2012). The success of tractor services is also evidenced in a rapid expansion of farm machinery demand. Ironically, in Nigeria and other parts of Africa, smallholders' access to tractor services remains very poor, and the efficiency of the smallholders associated with tractor service provider sources remains unknown.

While several empirical studies have been conducted on smallholders' mechanisation (tractor services), including extant research by Mrema et al. (2008), Singha et al. (2012), Alabadan and Yusuf (2013), Takeshima et al. (2013) and Onomu et al. (2020), no study has investigated smallholder tractor user efficiency. A recent study by Onomu and Aliber (2020) investigated the smallholder tractor use concerning willingness to pay for tractor services in Nigeria. Still, their research did not determine smallholder tractor users' efficiency.

Technical efficiency relates to the variability between actual and potential yield outcomes for a specific input resource level, including technology used (Spacey 2017). The study of technical efficiency explains the input resources that achieve the best result. For example, a study in Tanzania found that the technical efficiency of smallholders who employed the hoe for cultivation was higher than their counterparts who either employed an ox plough or tractor. The same study revealed that smallholders who did not apply chemicals to their farms were more efficient than those who applied agrochemicals (Msuya et al. 2008). This shows that production efficiency varies according to the resources and technologies applied. Technical efficiency comes in two fundamental forms, that is, input and output-oriented technical efficiency (Ray 2008).

Conversely, input-oriented technical efficiency establishes how it can change input level, holding output constant. In other words, it tries to quantify the extent to which inputs can be reduced (capital and labour) without changes in output level (Färe and Ca 1978). On the other hand, output-oriented technical efficiency seeks to increase output without necessarily changing inputs. In output-oriented technical efficiency, inputs are held constant while determining how to increase output (Färe et al. 1984).

Technical efficiency ensures that maximum satisfaction is achieved in production from specific resources (Coelli et al. 2005). Though technically efficient smallholder farmers aim to achieve high production and productivity using the least available inputs, most smallholder farmers' production and productivity remain low due to inefficiency in inputs application (Ajibefun et al. 2006). Inefficiency could also be attributed to the inability to maximise farming practice and the technology applied. Technical inefficiency comes about when a farmer fails to achieve the desired result from production despite the availability of necessary inputs, and this owes to various factors (Kadapatti and Bagalkoti 2014).

Investigating the technical efficiency of the Turkish automotive industry from 1992-2012 using the stochastic frontier approach, Çalmasur (2016) found that firm size, foreign capital ratio and export intensity positively influenced technical efficiency while firm age had a negative relationship with technical efficiency. Comparing the technical efficiency of urban and rural smallholder farmers in the Ondo State of Nigeria using stochastic frontier, Ajibefun et al. (2006) revealed that rural smallholder farmers were more technically efficient than their urban counterparts, with mean technical efficiency of 0.66 and 0.57 for rural and urban smallholder farmers, respectively. Using transcendental logarithmic (translog) to investigate the smallholder rice farmers' efficiency in Ghana, Al-hassan (2012) established that the mean technical efficiency for irrigated and non-irrigated rice farmers was forty-eight and forty-five percent, respectively. This shows that technology adoption did not significantly contribute to smallholder efficiency. Al-hassan (2012) also reported that non-farm employment, family size and credit availability significantly influenced the smallholders' efficiency. In Ethiopia, Tenaye's (2020) findings who used panel data from 1994-2009 showed that land quality, land fragmentation, farm size, family size, education level of the household head, extension service, credit use, and off-farm employment were determinants of smallholder farmers' technical efficiency.

Shortfalls in efficiency could result in low production despite increased use of inputs and technologies. This suggests that more efficient use of existing inputs, resources or technology is justified. Hence, empirical measure of efficiency is imperative to ensure better performance of a given technology while promoting policy and programmes that could improve efficiency since technical efficiency investigation cannot be undermined because it varies according to technology, resources, sources, organisation and enterprise. Therefore, this study investigates the efficiency of smallholder tractor users in the study area.

Objective of this Study

Specifically, the study investigates factors affecting smallholder tractor users' efficiency. It determines the contribution of tractor service providers (tractor sources) to smallholder efficiency. It also determines the contribution of factors of production (tractor) to the efficiency of the smallholder tractor users. In addition, it compares the output of smallholder tractor and non-tractor users. This study also contributes to literature by describing the level of tractor used by the smallholder farmers in the study area.

METHODOLOGY

The study was done in the Delta and Benue States of Nigeria. Nigeria is divided into two main geographical zones, that is, northern and southern Nigeria. Delta State is located in southern Nigeria and Benue State is in northern Nigeria. Nigeria is an agrarian country, and agriculture employs two-thirds of Nigeria's labour force (FAO 2018). According to Omorogiuwa et al. (2014), Nigeria has rich agricultural land and as much as seventy-five percent of its land is suitable for agriculture.

A semi-structured questionnaire was used to collect data from the respondents. Multistage sampling techniques that covered four stages were employed for the data collection. The first stage involved the purposive selection of the two states (Benue and Delta). The second stage was a simple random selection of two senatorial districts (Benue North and Benue South) from the three senatorial districts in Benue State. The random selection in Benue State was done because all three senatorial districts of Benue State are actively involved in crop farming. In Delta State, two senatorial districts, Delta North and Centre, were purposively selected from the state's three senatorial districts. Delta South senatorial district was excluded because most of those involved in agriculture in that district are into fish farming. More so, the major commercial area of the state (Warri) is located in Delta South. In the third stage, one local government area was randomly selected from each senatorial district. Therefore, four local government areas were selected. In the fourth stage, seven communities were randomly selected from each local government area, and ten farmers were selected from each of these communities. This gave a total sample of 280 smallholders. Seventy-eight out of the 280 sampled smallholders used tractors. Therefore, 78 respondents were used for the analysis.

Model Specification

Frontier efficiency estimation is generally evaluated using a parametric and non-parametric methodology (Simar 1992). Free Disposal Hull and Data Envelopment Analysis (DEA) are examples of non-parametric methodology, with Distribution Free Approach (DFA), Thick Frontier Approach (TFA) and Stochastic Frontier Analysis (SFA) being examples of parametric methodology (Kumbhakar and Lovell 2003; Coelli et al. 2005; Cornwell and Schmidt 2008). However, SFA and DEA are the most used frontier models. DEA can analyse multiple inputs and outputs simultaneously. No input-output measurement restricts it. However, the DEA cannot distinguish statistical noise, resulting in a bias in the efficiency estimation. The shortcoming of the Data Envelopment Analysis could result in loss of discriminating information (Thiam et al. 2001; Lertworasirikul et al. 2003; Jahanshahloo et al. 2005; Mérel et al. 2006).

The determination to provide a less biased frontier model that better explains inefficiency led to further research, and as a result, the Stochastic Frontier Analysis (SFA), which produces less biased results, was simultaneously introduced (Aigner et al. 1977; Meeusen and van Den Broeck 1977). The distinct processes in agriculture production, including the farming system and hazard challenges such as weather, diseases, pest, insect and physical damage, are ills that make the SFA more suitable for the analysis of crop farmers' technical efficiency (Cornwell and Schmidt 2008). The SFA factors in the various ills associated with the production process while simultaneously reporting the random error and inefficiency of parameters peculiar to crop farming. More so, the individual farmer's technical and allocative efficiency assessment is possible through SFA (Battese and Coelli 1995). SFA is performed in two broad ways, namely one-step and two-step approaches. The two-step approach involves two stages in which the frontier model is first regressed to generate the level of technical inefficiency. It estimates the parameter by maximising the log-likelihood function in the first stage. In the second stage, the factors that affect technical efficiency or inefficiency are regressed through the mean conditional distribution. In the one-step approach, the frontier model and the technical inefficiency factors are simultaneously generated. Unlike the two-step approach, the one-step process has more consistent results and allows the estimation of truncated normal distribution (Chakraborty et al. 1999; Thiam et al. 2001; Ghorbani et al. 2010).

Farming system and the specific characteristic that influences the smallholder farmers' technical efficiency propelled the use of the stochastic frontier production model. The functional form specification of the SFA model, which has its foundation in production function that was concurrently presented by Aigner et al. (1977) and Meeusen and van Den Broeck (1977), can be derived from the presentation summed as:

$Y_r = \beta_0 + \beta_{x^1}$,

Where,

Y_r stands for the farm firm's output level

β_0 for the constant term

β an unknown parameter that explains how affects the production frontier,

x being a vector of an explanatory variable of r^{th} farm firm

Thus, as an extension of the conventional production function, the SFA model of the r^{th} farm firm without the error term (random component) is presented as:

$Y_r = \beta_0 + \beta_x{}^1{}_r, TE$,

Where,

TE_r is technical efficiency of r^{th} farm firm

In this condition, the r^{th} farm firm could be efficient if the highest possible output is obtained when $TE_r \geq 1$.

In other words, if TE_r is < 1, the r^{th} farm firm has experienced shortfall or inefficiency in production. The variation in efficiency resulting in different output levels in production could be attributed to different factors, including random chock. Thus, any deviation from the production possibility frontier is also due to random chock. Therefore, factoring in the influence of random chock, the SFA is further written as:

$Y_r = \beta_0 + \beta_x{}^1{}_r, TE_r - \varepsilon_r$

Where,

ε_r represents random chock, which is also known as a composite error term. Because it is composite, the deviation from the production possibility frontier comprises two elements, which could be expressed as ($n_r - u_r$), where v_r is $N(0, \sigma_v{}^2)$, which stands for independently and identically normal disturbance random errors term with zero mean and unknown variance. Then u is a non-negative technical inefficiency score, which follows the distribution f. Therefore, the effect of the individual random chock on r^{th} farm firm outcome could be denoted as exp (v_r) and as exp $(-u_r)$ respectively, with 'exp' representing exponential. Thus, the frontier model could be expressed as:

$Y_r = \beta_0 + \beta_{xr}, TE_r - (v_r)$

Therefore, the exponential of the two composite elements (chock) could be written as:

$Y_r = \beta_0 + \beta_{xr}, TE_r - (v_r) (-u_r)$

Assuming that the production function takes a Cobb-Douglas linear log form, the SFA model is expressed as:

$$InY_r = \beta_0 + \sum_{r=1}^{n} \beta_n \; Inx_{nr} + v_r - u_r$$

Where, In is the natural logarithm with r = 1,…..n.

Factors responsible for technical inefficiency of the r^{th} farm firm are considered to have identical and independent distribution in the observations, and distribution is determined by truncation at the zero point in the normal distribution of the non-negative shock as expressed below:

$u_r = \delta_0 + \delta_r x_r + \varepsilon_r$

Again, r = 1,…..n, u = non-negative of the inefficiency, x is an explanatory variable associated with inefficiency, δ is estimated unknown parameter, and ε is an unobserved random variable. Drawing from Battese and Coelli (1995), the r^{th} farm firm technical efficiency is presented as:

$TE_r = \exp(-u)$

Where, the value of TE_r ranges between zero and one ($0 \leq TE_i \leq 1$).

Analytical Framework

Despite being recognised as one of the best models in efficiency analysis, it was recommended that a diagnostic test of the SFM be done for a particular data set to ascertain the relevance of its application with that data. Basically, there are two broadly diagnostic tests for checking the relevance of the SFA to validate if the stochastic frontier model is the right model for its implementation. One way of doing this is to consider the inefficiency component's variance and the random noise's variance to generate total error term variance. Then the value of the technical inefficiency component ratio to the total variance of the error term component is taken. This value produces statistics that range between zero and one, which account for the proportion of output responsible for the technical inefficiency or the random noise. If the value of the outcome is close to one, it simply means that more variation is accounted for by technical inefficiency and, therefore, the SFA is appropriate. But if close to zero, it simply means that very little variation is accounted for by technical inefficiency, so it will not be reasonable to use the SFA model because more variation is coming from random variation, which means that the entire SFA has been collapsed into conventional production function model. The second way of diagnosing the appropriateness of the SFA was suggested by Battese et al. (2004) and Kumbhakar et al. (2015). They stated that the above approach was not the best way to diagnose the appropriateness of SFA. Hence, they suggested the likelihood ratio check be done, and that the outcome of the likelihood ratio test be compared with the critical values under the degree of freedom in the calculated Kodde and Palm (1986) table. Therefore, it was hypothesised that the SFA is not appropriate for this analysis. Post estimation heteroscedasticity test was conducted using a Breusch-Pagan model to identify the presence of heteroscedasticity.

Variable Measurement

The variables used for the study were income output, labour, capital expenditure, material (land), gender of the respondent, age of the farmer, marital status, educational status, access to extension information, involvement of the farmer in other occupations, using tractor services or not, source of tractor services (type of the tractor service provider) and distance to location of tractor service provider.

Output (income output) was measured in naira gross income generated from all produces sold. Labour is measured as the number of household members used. Capital was measured in naira expenditure. Capital has different dimensions, but it represents expenditures on all fixed assets, buildings, machinery, hand tool implements and the liquid form of money in this study. Land size cultivated was measured in hectare and used as material. The gender of the farmers was measured as a dummy (male = 1, otherwise = 0). Age was measured as the number of years. Marital status is measured as a dummy. Educational status was measure as dummy (formal education = 1, otherwise = 0). Access to information from extension officer is measured as dummy. The farmer involvement in other occupations was measured as dummy, distance to the tractor service provider's location was measured as a continuous variable in km and using tractor service was measured as dummy variable.

A list of tractor service provider options, namely private tractor service provider, Government tractor service provider, Self-owned tractor service, free tractor service provider from a friend were provided as a the follow-up question for farmers who used tractors. They were provided in follow-up question as SME/Cooperative tractor service provider = 1, Government tractor service provider = 2, Self-owned tractor service = 3, a free tractor service provider from friend = 4, and other sources of tractor service specify = 5. However, government and private service providers (SME/Cooperative tractor service providers) were the only tractor service sources to the smallholder tractor users in the study area. None of the smallholders indicated that they engaged the services of both tractor service providers concurrently. Therefore, the tractor service provider was coded as a dummy (private = 1, government = 0). The tractor service provider was included in the SFA, which was hypothesised to influence the smallholder tractor users' technical efficiency.

RESULTS AND DISCUSSION

This section presents and discusses the results of the study. It discusses tractor-use occurrence of the smallholder farmers and the distribution of tractor service providers to the smallholders. It elaborates and evaluates the results of data obtained in detail as applicable to the objectives of the study. The smallholder tractor users' efficiency and the tractor service provider's role in the smallholders' efficiency are also discussed in this section.

Tractor Use Distribution by the Respondents

Despite stakeholders' efforts, including government efforts in providing tractor services for smallholder farmers, few smallholder farmers used tractors for their agribusiness farming activities. As shown in Table 1, most (72%) of the smallholder farmers in the fourth industrial revolution era did not use a tractor in the study area. This result is similar to Daum and Birner (2017) findings, which state that seventy percent of smallholders in Africa do not use tractors. This implies a severe challenge of technology adoption and application among the smallholder farmers. This result indicates dependency of majority of smallholders on household labour. Therefore, seeing that a small proportion of smallholders used a tractor, it is necessary to have a holistic overhauling of the mechanisation policy since federal and state governments' investment efforts in recent times to promote smallholder farmers' tractor use in Nigeria have not been achieved.

Table 1: Distribution of tractor users in the area

Variables	*Both states*		*Delta State*		*Benue State*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
Use tractor services	79	28	27	19	52	37
Do not use tractor services	201	72	113	81	88	63
Total	280	100	140	100	140	100

The number of non-tractor users outweighs tractor users in both states. However, the number of farmers not using tractor services was higher in Delta State than in Benue State. This result shows that the farmer's location has the likelihood of influencing the adoption of mechanisation. This result corresponds with the findings by Pingali (2007) who observes that the smallholder farmers' mechanisation adoption varies across developing countries, with smallholders in Asian countries adopting mechanisation farm practices better than their counterparts in African countries.

The Smallholders' Tractor Service Providers

The respondents who used tractors were asked to identify their tractor service providers. Recall that the only tractor service providers identified by the farmers are SMEs and the government. None of the smallholders had access to free tractor services, and none owned a tractor. As shown in Table 2, out of the 79 smallholders who used tractor services in the study area, eighty-one percent used SME tractor services while nineteen percent used government tractor services. The result could imply that SME tractor services dominate the study area. The result could also imply that SME tractor services are more business-oriented than government tractor services. It could also be that SME tractor services are more numerous and available to the smallholder farmers in both states than government tractor service providers.

Determination of Factor Affecting the Efficiency of Tractor Users

The null hypothesis that the SFM is not appropriate for this analysis was explained before discussing the smallholder tractor users' efficiency and factors affecting it, including tractor service providers' role in the smallholder tractor users' efficiency. The calculated likelihood ratio result is 26.96771, which is greater than the tabulated critical value of 2.705 at a five percent level of significance. The value of the tabulated critical value was derived from Kodde and Palm (1986). This result shows that SFM is appropriate for the analysis, as it explains the technical inefficiency among the smallholder tractor users. Therefore, the null hypothesis that the one-step stochastic frontier model is inappropriate in this analysis is rejected. The lambda coefficient value of 2.00, which was statistically significant as shown in Table 3, reveals the proportion of the technical inefficiency in the total error variance. This indicates that technical inefficiency plays a vital role in the model relative to noise. Since lambda is greater than one, the variance mode is in inefficiency rather than noise. Therefore, the lambda result indicates that the smallholder farmers' tractor service provider plays a major role in contributing to inefficiency.

Using the Breusch-Pagan model to conduct post estimation heteroscedasticity test, the presence of heteroscedasticity was not predicted, with F-statistics value being 0.8745. The F-statistics P-value was close to one, which was not significant in predicting the square residual. Therefore, the analysis was homoscedastic, and the explanatory variables did not affect the variance of the error term, with the standard deviation being constant.

The Prob chi2 = 0.001, which means that the entire model is significant. The log of labour, capital and material (factors of production) in the frontier regression model are in line with economic theory. They are positive and significant at a one percent level. However, the coefficient of the log of labour is negative. This indicates that the sole dependency of tractor users on household labour may reduce smallholders' production.

Note that being a one-step approach; the stochastic frontier model produces results for

Table 2: Tractor service sources

Service providers	*Both states*		*Delta State*		*Benue State*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
SME	64	81	23	86	41	79
Government	15	19	4	14	11	21
Total	79	100	27	100	52	100

Table 3: Maximum likelihood estimate frontier for the smallholder' tractor use and determinant

Log income	*Coef*	*Std. Err*	*Z*	*P>|z|*
Production Function				
Ln labour	-.034	0.000	-3586.32	0.000***
Ln capital	.032	0.000	1.00	0.000***
Ln material (land)	1.461	.000	1.00	0.000***
Cons	8.515	.000	2.00	0.000
Inefficiency Variables Effect (Mu)				
Tractor service provider	-.033	.007	-4.63	0.000***
Gender	-.295	.200	-1.48	0.140
Age	.001	.008	0.11	0.915
Educational status	-.054	.039	-1.38	0.168
Marital status	-.350	.198	-1.77	0.077*
Other occupation involvement	854	.413	2.07	0.038***
Distance to tractor service provider	.035	.006	5.70	0.000***
Information	-.113	.366	-0.31	0.757
Cons	1.130	.903	1.25	0.211
Usigma cons	-.604	.185	-3.27	0.001
Vsigma cons	-34.476	352.207	-0.10	0.922
Sigma U	.739	.068	10.82	0.000
SigmaV	0.001	0.001	0.01	0.995
Lambda	2.000	.068	3.00	0.000***

Number of observations = 79, Wald chi2(3) = 1.42e+10, Prob > chi2 = 0.001, Log likelihood = -67.4664
*Significant at 10% level, **Significant at 5% level and ***Significant at 1% level, respectively.

the Cobb-Douglas production function and the inefficiency term. A negative coefficient of the inefficiency variables stands for positive efficiency. The tractor service provider significantly influences the smallholder tractor user's technical efficiency. The mu result shows that smallholders' tractor service provider reduces the farmers' technical inefficiency at a one percent significance level. Therefore, tractor service source plays a pivoted role in ensuring that the tractor users operate in the production frontier. However, SME tractor service provider promotes smallholders' efficiency more than government tractor service providers. The smallholder farmer who depended on government tractor service providers was less technically efficient than those who depended on SME tractor services. The coefficient of the result of tractor service provider shows that smallholders who used SME tractor service provider were three percent more efficient than smallholders who used a government tractor service provider. This result could be attributed to the SME tractor service providers' commitment to their business as entrepreneurs. The less efficiency of the government tractor service could also be ascribed to weaknesses such as delay in rendering of hire tractor services that are more associated with government tractor service providers' and poor management in the government tractor service as observed by Onomu et al. (2020). This could be the reason Sims and Kienzle (2016) suggest that the government's role in promoting smallholder access to mechanisation services should be limited to instituting enabling policies that ensure demand acceleration and promote technical and business management skills. Other factors that have a significant relationship with the smallholder tractor users' efficiency include marital status, involvement of the farmer in other occupations, and a distance to get a tractor service provider.

The smallholder who is married and uses hired tractor services has a higher tendency of being more efficient than the unmarried smallholder tractor user. Being married improves the efficiency of the smallholder farmer who uses a tractor, which could be due to assistance provided by a spouse, sharing of ideas with a spouse, and the farmers' determination to provide for the family.

The involvement of the smallholder tractor user in other occupations is statistically significant at a five percent level in association with inefficiency. Contrary to expectation, the coefficient of the tractor user variable of smallholders' involvement in other occupations shows that it negatively relates to the farmers' efficiency. In other words, the smallholder tractor user involvement in other occupations promotes inefficiency. The smallholder tractor user engagement in other occupations stimulates inefficiency because the smallholders' involvement in other occupations distracts their attention from fully concentrating on their farming activity. It could also divide the time they would have devoted to their farming activity.

A longer distance travelled by the smallholder tractor user to access tractor service providers reduces the farmers' efficiency. The stochastic frontier result shows that the farther away from the tractor service provider is from the smallholder tractor user, the less efficient the farmer will be. This could be attributed to different reasons. For example, the tractor service provider could charge the farmer a higher price to compensate for extra gas consumption if the farmer is very far from his location. The higher price charged resulting from long-distance travelled could make the farmer incur additional costs that would have ordinarily been channelled for other farming costs that could also enhance their efficiency. The further the tractor service provider is away from the farmer, could also delay and prolong the service of the tractor service provider. This means that there is the need to overcome the challenge that prevents some smallholders from using tractor services, and some of the smallholder tractor users also need to overcome the challenge of travelling a long distance to get the service of hire tractor operators for them to be efficient.

Technical Efficiency Distributions of Tractor Users

The mean distribution of the tractor users' technical efficiency is presented in Table 4. The maximum value of the smallholder tractor users' technical efficiency was 0.94. This shows that some of the smallholder tractor users were ninety-four percent technically efficient, indicating that some of the smallholders were operating close to the production frontier. Furthermore, the result suggests that though some smallholders' farming operations might be small, they use modern technology efficiently. This indicates a reduced x-inefficiency level among some smallholder farmers, particularly those with access to modern technology and mechanisation services such as the tractor. This result opposes the findings by Selejio et al. (2018) in Tanzania, which indicate that though the smallholders who used modern technologies were more efficient than non-users, none were ninety percent efficient.

The mean value of the tractor users' technical efficiency was 0.722, indicating that they were on average 72.2 percent technically efficient. Therefore, the smallholder tractor user was operating twenty-eight percent below their maximum output on average. Thus, tractor use needs to be complemented by good farming practices, including the use of improved seeds, irrigation and herbicides for the smallholder farmer to operate in the production frontier efficiently. The result also shows that the mean value of the smallholders who used SME tractor services was higher than those who used government tractor services, with SME tractor service provider users operating at a thirty-seven percent level of efficiency more than the government tractor service users. This further corroborates the result in Table 3, showing that service providers in the farming system play a crucial role in improving farmers' efficiency.

Distribution of Smallholder Farmers' Technical Efficiency by Frequency

The frequency distribution of the smallholder tractor users' technical efficiency is presented in Table 5. Although the average technical efficiency of the smallholder tractor users is high, about fifteen percent of these had technical effi-

Table 4: Mean technical efficiency of the smallholder tractor users

Efficiency	*Obs*	*Mean*	*Std. Dev*	*Min*	*Max*
All tractor users	79	.72	.18	.21	.94
SME tractor users	64	.79	.11	.24	.94
Government tractor users	15	.42	.12	.21	.61

ciency that is equal to or less than 0.50. It, however, shows that a tiny fraction of the smallholder tractor users were operating below fifty percent efficiency level.

Table 5: Technical efficiency frequency distribution of the smallholder tractor users

Distribution	*Frequency*	*Percentage*
≤?0.50	12	15.19
0.51/0.60	6	7.59
0.61/0.70	4	5.06
0.71/0.94	57	72.15
Total	79	100.00

About seventy-two percent of the smallholder tractor users had technical efficiency above 0.70. This indicates that most smallholder tractor users are operating not too far from the production frontier. With a little additional development and access to efficient mechanisation services (tractor services), these smallholder farmers will be operating at the efficiency frontier.

Differences between Mean Income of Tractor and Non-tractor Users

The difference between the mean income of tractor and non-tractor users is presented in Table 6. The mean income of tractor users was doubled that of the non-tractor user. The result shows that tractor use could contribute to the smallholder farmer welfare gain since tractor user income generated outweighs that of a non-user.

Table 6: The mean income of tractor and non-tractor users

Variable	*Obs.*	*Mean (Naira)*	*Std. Deviation*
Do not use tractor	201	16688.56	34427.3
Use tractor	79	288897.8	127203.7
Total	280	93490.5	142950.1

Irrespective of the smallholder tractor users' farming inefficiency, their income exceeds that of non-tractor users. Therefore, smallholder farmers' use of the tractor is vital to their efficiency and income generation.

Challenges Faced by Smallholder Tractor Users in Accessing Tractor Services

The smallholder tractor users stated that they faced one challenge or the other when accessing tractor services. The challenges identified by the tractor users include limited tractor service providers, delay in the rendering of tractor services by the tractor service providers, corruption among government tractor service providers, long-distance travelled to contact tractor service providers, high bureaucracy in securing government tractor, lack of professionalism from the tractor service provider and limited finances to pay for the different kinds of operation of the tractor service providers.

CONCLUSION

SME hired tractor service providers are more efficient than government hired tractor service providers. On average, the smallholder tractor user is twenty-eight percent inefficient, showing that the smallholder tractor user does not operate at production frontier dues to different reasons. Despite the smallholder not operating at the production frontier, tractor service significantly influences smallholders' efficiency. The mean income of tractor users doubles that of non-tractor users. Ironically, the percentage of smallholders not using the tractor still outweighs those using tractor. Other factors that play an essential role in influencing the smallholder tractor users' efficiency include marital status, involvement of the smallholder in other occupations, and a long distance between the farmers to the hired tractor service provider. This study shows that no smallholder farmer owned a tractor, probably because a smallholder farmer lacks the capability to purchase tractors. Therefore, the smallholder tractor users depend on tractor hiring service providers, especially the government and private SMEs. Since a smallholder user relies on hiring tractor services, the tractor hire service provider needs to be effective for the smallholder user to be more efficient. Thus, it becomes more crucial to address the pitfalls of tractor service providers since it influences the smallholder tractor users' efficiency.

RECOMMENDATIONS

Since the number of non-tractor users still outweighs that of users, it is recommended that efforts should be intensified to stimulate more smallholders into using tractor services. This can be done by revamping the campaign to benefit tractor use. Mechanisation policies should motivate and strengthen tractor service providers that promote smallholder tractor users' efficiency. Market-driven tractor services should be encouraged, especially SME tractor services, since SME services reduce the smallholder tractor users' inefficiency. All challenges contributing to the smallholder inefficiency, including delay in rendering services to the smallholder farmers by government tractor service providers should be addressed. Tractor service provider centres should be located close to the smallholder farmers.

IMPLICATIONS OF THE FINDINGS FOR AGRIBUSINESS

This research contributes to knowledge on the smallholder farmers' tractor-use benefits, and information on how some smallholder farmers are gradually transforming their agribusiness.

It also contributes to raising awareness that dependency of the smallholder on tractor-use only is not sufficient in achieving the agribusiness aim of operating in the production frontier. This means that all stakeholders working in smallholder agriculture should provide holistic support, effort and programs to ensure the transformation of the smallholders' agribusiness aim. Government's mechanisation support to smallholder farmers will be more efficient if it supports market-driven policies that allow individual small-scale entrepreneurs to provide mechanisation services to the smallholder at affordable prices.

ETHICS APPROVAL AND CONSENT

The researcher obtained ethics approval from the University of Fort Hare. The researcher used the ethical template of the University of Fort Hare. The ethical template contains a form presented to each respondent to indicate their willingness to participate in the research. All research ethics were fully observed. Participants were not forced or influenced by the researcher.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and analysed during the study are available from the corresponding author and Professor Michael Aliber (supervisor) on a reasonable request.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this paper.

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Consent for Publication

The researcher, Onomu Achoja Roland as the sole author of the paper, gives his consent for publication of this manuscript in the Journal of Human Ecology.

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