TRANSACTION COSTS, INEFFICIENCY AND PRODUCTIVITY OF ACHA (*Digitaria exilis*) FARMERS IN KADUNA STATE, NIGERIA

Duniya, K.P., Haruna, O.E. and Damisa, M.A.

Department of Agricultural Economics and Rural SociologyAhmadu Bello University, Zaria
Email: kalatduniya@yahoo.com

Abstract
This paper analyses the role which barriers to acha production in the form of high transaction costs have on farmers' production efficiency. Particular attention is paid to the effects of transaction cost on acha farmers' output and total production cost. An empirical application is presented on a sample of 200 households randomly selected from Kaduna State. The stochastic translog production and cost functions were used to analyse the data. The results revealed that although acha farmers are small scale producers with an average land productivity of 498kg/ha, they are 81% technically efficient, 85% allocative efficient and 76% economically efficient. The results also confirm the contribution of transaction costs to inefficiency and their role in orienting households towards making decision to produce as they affect output, increase cost of production and hence, increase inefficiency in production. Although these transaction costs effects are not large, they do significantly affect ($P<0.05$) the output and total cost of production. Policy makers therefore need to focus on providing institutional support to producers which is necessary for technical and managerial skills and for reducing cost inefficiencies in production.

Keywords: Transaction costs, inefficiency, acha farmers, stochastic frontier, productivity

Introduction

With the increasing concern with regards to reducing poverty in the world, lowering transaction costs within the agricultural value chain is one of the key elements to ensuring growth in agriculture which will in turn have a significant impact in reducing poverty. One factor explaining the inverse relationship between productivity and transaction costs runs through the effect they have on the choice of the crop mix (Stifel *et al.,* 2003). An aspect that is conceivable, but has not yet received attention in the productivity literature is the role of transaction costs on production decisions. Models of household behavior with respect to transaction costs generally exclude the production side by assuming that households face unique exogenous prices in each market, prices at which they can buy and sell. This assumption simplifies the analysis because production decisions can be affected by transaction costs. While most of the studies on transaction costs focused on marketing behavior of farmers (for instance Key *et al.,* 2000; Bellemare and Barrett, 2006; Ouma *et al*., 2010; Alene *et al.,* 2008), only little studies looked at transaction cost with respect to production behavior (Dorosh *et al.,* 2010). Even in this case, their study focused only on road connectivity with crop production.

The choice of acha *(Digitaria exilis)* for this study lies in the fact that it is a crop which has been neglected in the past by research and scientists. Also known as Hungry rice as coined by the Europeans, it is an orphan crop which is said to be one of the oldest cereals grown and originated from West Africa. Due to its increasing awareness of high nutritional value, it has of recent, started receiving attention by researchers (such as Jideani and Podgorski, 2009; Musa *et al., 2008;* Morales-Payan, 2003; Cuz, 2004). Recent studies (Jideani, 2012; Jideani and Jideani, 2011) have also shown an increasing importance of the crop amidst growing utilization as food; hence there is the need to increase the literature and production level of the grain by conducting more research.

The key goal in this article therefore is to examine how transaction costs affect farm household efficiency, that is, production behaviour. In achieving this, focus is made exclusively in estimating the determinants of efficiency in terms of transaction costs and their contribution to inefficiency. The knowledge of this study will enable researchers and analysts to meaningfully derive a workable framework for addressing production and transaction costs.

Methodology

The Study Area: The study was conducted in Kaduna State, Nigeria (between latitude 09^0 02' and 11^0 32'N of the equator, 06^0 15'and 80^0 50'E of prime meridian).

Sampling: Multi-stage technique was used to sample acha farmers across three Local Government Areas (Jaba, Kachia and Kagarko) which were purposively selected on the basis of being the prominent acha producing areas of the State. Simple random sampling was then employed in selecting 200 acha farmers for enumeration.

Data Collection: The key information collected by the study team related to the major components of transaction costs that farmers have to bear alongside inputs and output information. The questionnaire contained questions covering all costs (direct and transaction) incurred during the farming season in 2012 and interviews were conducted mostly at the homes of farmers by trained enumerators.

Analytical Tools: The empirical stochastic frontier production model that was used in this study is specified in a translog production function.

Theoretical Framework and Model Specification

Singh (2008) captures the essence of the complexity of the problem of transaction costs stating that there is no standard definition of the term while proposing that transaction costs is broadly interpreted as costs associated with market exchange. While there are many definitions of transaction costs, North (1990) divided the total costs incurred by farmers into; (1) *transformation (production) costs*: the costs that are unavoidable and directly associated with the farming process, e.g., cost of inputs of land, fertilizer, labour, seeds, capital and agrochemicals involved in transforming the physical attributes of a good, and (2) *transaction costs* which are the costs of facilitating transactions, e.g. cost of packaging and transporting produce to market. Key *et al.* (2000) also defined transactions costs as fixed and proportional (or variable) transactions costs, where fixed transactions costs include the original search, negotiation and enforcement costs that are invariant to the volume of input as well as output. From yet a different perspective, Hockmann *et al.* (2012) defined transaction costs as internal and external transaction costs. Internal transaction costs determine the degree to which producers are able to exploit production possibilities which results in technical inefficiency, while external transaction costs result in allocative inefficiency and find their expression in the variation of prices among agricultural enterprises. In this context, transaction costs are viewed at the production-based levels (or internal transaction costs, according to Hockmann *et al.,* 2012) which encompass the money that farmers spend as far as harvest and post harvest operation is concerned. Thus, efficiency and productivity of farmers can as well be a function of transaction costs.

Frontier efficiency model has been used extensively in measuring the level of inefficiency/ efficiency in farms. Considering the works of Battese and Coelli (1995), the stochastic frontier translog production and cost functions as used by some authors (such as Kibaara, 2005) were employed in the analysis for this study. The stochastic frontier production function was independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). The stochastic frontier production function can be written as:

$$Y_i = f(X_i \beta) e^{(v_i - \mu_i)} \quad i = 1, 2, 3, ..., N \quad \text{.............................} (1)$$

Where Y = output of the i^{th} farm, X_i = vector of inputs, β = vector of parameters, v_i = random error term, and u_i = inefficiency term.

The term v_i is the symmetric component which accounts for random variation in output due to factors outside the farmer's control such as measurement errors, weather condition, drought, strikes, luck, etc. It is assumed to be independently and identically distributed normal random variables with constant variance, independent of μ_i. On the other hand, μ_i is assumed to be non-negative exponential or half-normal truncated (at zero) $N \sim (\mu_i, \sigma^2)$ random variable associated with farm-specific factors, which leads to the i^{th} firm not attaining maximum efficiency of production; μ_i is associated with technical inefficiency of the farmer (Coelli *et al*., 1998; Battese and Rao, 2002). N represents the number of farms involved in the cross sectional survey. Technical efficiency of an individual farm is defined in terms of the ratio of the observed output to the corresponding frontier output, conditioned on the level of inputs used by the farm. Technical inefficiency (TI) is therefore, defined as the amount by which the level of production for the firm is less than the frontier output.

$$\text{TE} = \frac{Y_i}{Y_i^*} = \frac{f(X_i \beta) e^{(v_i - \mu_i)}}{f(X_i \beta) e^{v_t}} = e^{-\mu} \quad \text{.............................} (2)$$

$$\text{TI} = 1 - \text{TE}$$

Where, $0 \leq \text{TE} \leq 1$ with 1 defining a technically efficient farm, Y_i is the observed output and Y_i^* the frontier output. Technically efficient farms are those that operate on the production frontier and the level by which a farm lies below its production frontier is regarded as the measure of technical inefficiency; if μ_i equals zero, then TE equals one and production is said to be technically efficient. Technical efficiency of the i^{th} farm is therefore a relative measure of its output as a proportion of the corresponding frontier output. A farm is technically efficient if its output level is on the frontier, which implies that Y_i / Y_i^* equals one in value. Several studies specified a Cobb-Douglas production function to represent the frontier function. The Cobb-Douglas function however, restricts the production elasticities to be constant and the elasticities of input substitution to unity (Wilson, *et al*., 1998). Also, there are times when the marginal effect of a variable depends on another variable, hence the need to choose functional forms that include interaction terms (Asteriou, 2011). This study therefore employed the stochastic frontier production function using the translog functional form. The trans log model is specified as

$$\ln Y_t = \beta_0 + \sum \beta_k \ln X_{ki} + \frac{1}{2} \sum \sum \beta_{kj} \ln X_{ki} \ln X_{ji} + (v_i - \mu_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Hence, the parameters, variables and the interactions that were included in the production function model are shown below:

$$\begin{aligned} \text{In } Y = {} & \text{In } \beta_0 + \beta_1 \text{In } X_1 + \beta_2 \text{In } X_2 + \beta_3 \text{In } X_3 + \beta_4 \text{In } X_4 + \beta_5 \text{ In } X_5 + \beta_6 \text{In } (X_1)^2 + \beta_7 (X_2)^2 \\ & + \beta_8 \text{ In } (X_3)^2 + \beta_9 \text{ In } (X_4)^2 + \beta_{10} \text{ In } (X_5)^2 + \beta_{11} \text{ In } (X_1 {*} X_2) + \beta_{12} \text{ In } (X_1 {*} X_3) \\ & + \beta_{13} \text{ In } (X_1 {*} X_4) + \beta_{14} \text{ In } (X_1 {*} X_5) + \beta_{15} \text{ In } (X_2 {*} X_3) + \beta_{16} \text{ In } (X_2 {*} X_4) \\ & + \beta_{17} \text{ In } (X_2 {*} X_5) + \beta_{18} \text{ In } (X_3 {*} X_4) + \beta_{19} \text{ In } (X_3 {*} X_5) + \beta_{20} \text{ In } (X_4 {*} X_5) + V\text{-}U \end{aligned}$$

Where,

ln = natural logarithm to base e

Y_i = output of acha (kilogrammes)

X_1 = farm size (hectares)

X_2 = labour used in crop production (man days)

X_3 = quantity of seeds used (kilogrammes)

X_4 = quantity of fertilizer used (kilogrammes)

X_5 = quantity of agrochemicals used (litres)

β_0 = intercept

β_{1-20} are the coefficients of the variables

v_i = assumed independently distributed random error or random stocks which are outside the farmer's control

u_i = technical inefficiency effects which captures deviation from the frontier.

The inefficiency model is estimated from the equation:

$$\mu_t = \delta_0 + \sum \delta_m Z_i \text{ ....,,,,,,. } (4)$$

$$u_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + W$$

The variables Z_i are the inefficiency variables considered to be transaction costs. Hence:

Z_1 =harvesting cost, Z_2 = threshing cost, Z_3 = storage cost, Z_4 = transportation cost of the ith farmer in acha production.

The corresponding cost frontier of Cobb-Douglas functional form is specified as follows:

$$C_i = f(P_i, \beta) e^{(v_i + \mu_i)} \qquad i = 1, 2, 3, ..., N \text{ .... } (5)$$

The translog cost functional form is given by:

$$\ln C_t = \beta_0 + \sum \beta_k \ln P_{ki} + \frac{1}{2} \sum \sum \beta_{kj} \ln P_{ki} \ln P_{ji} + (v_i + \mu_i)$$

Where C_i represents the total input cost of the i^{th} farms; f is a suitable function such as the Cobb-Douglas function; P_i represents cost of inputs employed by the i^{th} farm in food crop production measured in naira; β is the parameter to be estimated, v_i and μ_i are the random errors and assumed to be independent and identically distributed truncations (at zero) of the $N \sim (\mu_i, \sigma^2)$ distribution as earlier defined. These were obtained using the computer programme, frontier version 4.1 (Coelli, 1994). The *a priori* expectation is that the estimated coefficients of the inefficiency function provide some explanation for the relative efficiency levels among individual farms.

Results and Discussion

Descriptive Statistics of Variables:

Descriptive statistics of the variables employed in the study are presented in Table 1. The yield averages 486 kg per hectare. The large variability in the total yield of the farmers as indicated by the standard deviation (6,821) implies that the farmers operated at different levels of input use, which affected their output levels. This average yield is obtained by using averages of 61 man-days labour, 39 kg of seed, 60 kg of fertilizer and 0.3 litres of herbicide.

The variability in land size, labour, seed, fertilizer and herbicide are revealed by the standard deviations (0.42, 18.77, 46.67, 65.36 and 0.91 respectively). This large variability recorded could be due to changes in hectarage of available farmland at the farmers' disposal in the production season, also an indication that acha production in the study area is labour intensive. The mean total cost of production/hectare is ₦39, 299.23 with a standard deviation of ₦23,113.72. The large variability recorded in the cost of production implies that the farmers operated at different levels of farm sizes which tend to affect their cost of production. In addition, the costs of labour, seeds, fertilizer, agrochemical, harvesting, threshing, storage, transportation and farm distance showed variability in terms of their standard deviations (8,750.45, 11,417.87, 2,698.78, 284.67, 2265.130, 2,157.72, 300.83, 1,101.91, and 1.22 respectively).

Production Analysis:

The estimates of the parameters of stochastic frontier production function of acha farmers in the study area are presented in table 2. Most of the variables and their interactions are statistically significant. This implies that the output of acha increases by the value of each coefficient as the quantity of each variable is increased by one, *ceteris paribus*. The study shows that output has the highest responsiveness to land, followed by seed, then fertilizer. However, gamma (98%) is statistically significant (P<0.01). This is evidence that there are measurable inefficiencies in acha production probably caused by differences in transaction costs of the households which were captured in the model. Of the transaction cost variables, only storage and transportation cost proved to be statistically significant (P<0.01). This finding agrees with that of Stifel and Minten (2008) , that farmers in isolated areas are affected by high transportation costs and that of Dorosh *et al*. (2010) which show a significant effect of road infrastructure on agricultural output and input adoption using a more aggregated cross-sectional spatial approach for Sub-Saharan Africa. Although the magnitudes of the coefficients are not large, it is important to note that the direction of the coefficients implies that a unit increase in the costs of these variables increases inefficiency in production, hence, output is reduced by the magnitude of the coefficient.

Cost Analysis:
The estimates of stochastic frontier cost function of acha farmers in the study area are shown in table 3. Most of the variables included in the model and their interactions have direct (positive) relationship with the total cost of production. This means that the total cost of acha production increases by the value of each coefficient as the quantity of each variable is increased by one, *cetris paribus*. Most of the cost variables were significant to the total cost of production ($P<0.05$). However, the total cost of production has the highest response to seed cost, followed by labour cost, then fertilizer cost. Gamma (91%) is statistically significant ($P<0.01$), implying that transaction costs contribute immensely to cost inefficiency, hence, have effect on total production cost. Although only two of the transaction cost variables (threshing cost and transportation cost) are significant, the coefficients of the variables are negatively signed, implying that total cost of production is increased by the magnitude of each variable as the quantity of each variable is increased by a unit.

Efficiency Estimates of Acha Farmers:
Table 4 shows the technical, allocative and economic efficiency indices of the acha farmers. The result shows that there is a wide variation in the efficiencies of acha farmers especially their allocative efficiencies. The mean technical, allocative and economic efficiencies were obtained as 81%, 85% and 76% respectively. This indicates that if the average farmer was to reach the economic efficiency level of its most efficient farmer, then the average farmer will require a cost saving of 69% $[1 - (45/91)]$. This average economic efficiency (76%) also means that, in the short-run, there is the possibility of increasing efficiency in acha production in the study area by 24% if the farmers would and production techniques currently used by the most efficient farmer. It is also evident from this result that transactions costs contribute to production inefficiency and hence, productivity in general.

Conclusion

The results of this study stress that producers experience high transaction costs at the production/ processing stages which are relatively significant. The results also provide evidence of the importance of transaction costs in the study area. The asymmetric effect of transaction costs on farmers' efficiency shows that policies able to reduce these costs can promote unexploited productivity gains. Although these transaction costs are not large, they do significantly affect output and the total cost of production. This leads to the, not unexpected, conclusion that the small expense incurred by farmers to ensure increased productivity has a positive multiplier effect on farm output. However, the study also shows that as transaction costs rise, they give ever decreasing returns.

Since acha production is a small-scale farming and farmers are efficient in production, large/ commercial farming should be encouraged as this will improve the productivity of small-scale producers. Farmers should also be encouraged to increase the production of such orphan crops as a means of attaining food security. Most small-scale producers do not have adequate skills in how to produce certain crops of their choice; thus this makes it hard for them to meet the stringent food safety quality standards of the global market. Policy makers need to focus on providing support to producers. One option would be the provision of credit to farmers. Our results show that this would reduce the costs associated with harvesting, threshing, storage and transportation. Institutional support is also necessary for technical and managerial skills and for reducing cost inefficiencies in production. Beyond a threshold, reduced transaction costs alone will not lead to higher productivity; good and motorable roads are needed to ease transportation.

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Table 1: Descriptive statistics of production variables

Variables	Measurement	Mean	Min	Max	SD
Yield	Kg/hectare	486.37	100	2800	299.46
Land	Hectare	0.95	0.30	2.50	0.42
Labour	Man days/hectare	61.64	12.0	450	18.77
Seed	Kg/hectare	39.20	7.00	152	46.67
Fertilizer	Kg/hectare	60.70	0.00	400	65.39
Agrochemicals	Litre/hectare	0.42	0.00	6.0	0.91
Labour cost	Naira/hectare	18,492.24	1,800	19000	8,750.45
Seed cost	Naira/hectare	8,075.14	1,000	15000	11,417.87
Fertilizer cost	Naira/hectare	6,168.79	0.00	8,500	2,698.78
Cost of agrochem.	Naira/hectare	348.36	0.00	1,300	284.67
Harvesting cost	Naira/hectare	4314.95	800	9000	2265.130
Threshing cost	Naira/hectare	3,224.31	680	9,760	2,157.72
Storage cost	Naira/hectare	589.43	200	1500	300.83
Transportation cost	Naira/hectare	1310.31	300	5000	1101.91
Farm distance	Kilometres	0.498	1.25	2.25	1.22

Source: Field Survey, 2011

Table 2: Estimates of the Stochastic Frontier Production Function Model

Variable	**Parameter**	**Coefficient**	**SE**
Constant	β_0	3.981	1.011**
Lnland	β_1	-3.091	1.018**
Lnlab	β_2	0.232	0.342
Lnseed	β_3	1.142	0.079 **
Lnfert	β_4	0.018	0.056
Lnagrochem	β_5	0.812	0.741
$(\text{lnland})^2$	β_6	0.242	0.322
$(\text{lnlab})^2$	β_7	0.127	0.061*
$(\text{lnseed})^2$	β_8	0.021	0.033
$(\text{lnfert})^2$	β_9	0.007	0.003*
$(\text{lnagrochem})^2$	β_{10}	0.297	0.065**
lnland*Inlab	β_{11}	-1.198	0.741
lnland*Infert	β_{12}	-0.134	0.225
lnland*lnagrochem	β_{13}	-0.078	0.100
lnland*Inseed	β_{14}	-1.823	0.515**
lnlab*Infert	β_{15}	-0.122	0.065*
lnlab* lnagrochem	β_{16}	-0.022	0.012*
lnlab* lnseed	β_{17}	-0.215	0.100*
lnfert*lnagrochem	β_{18}	0.002	0.007
lnfert* lnseed	β_{19}	0.036	0.065
Inagrochem*Inseed	β_{20}	0.025	0.027
Inefficiency Model			
Constant	δ_0	-7.495	1.362**
harvesting	δ_1	-0.732	1.381
Threshing	δ_2	-0.603	2.019
Storage	δ_3	0.004	0.001**
Transportation	δ_4	0.005	0.001**
Diagnostic Statistics			
Sigma Square	σ^2	1.905	0.318**
Gamma,	γ	98.399	38.305**
Log Likelihood Function	LLF	-5.629	
Mean TE (%)		81.156	

**p<0.05, **P<0.01*

Table 3: Estimates of the Stochastic Frontier Cost Model

Variable	Parameter	Coefficient	SE
Cost Model			
Constant	β_0	0.144	0.112**
Lnseedcost	β_1	0.626	0.014**
Lnlabourcost	β_2	0.279	0.012**
Lnfertilizercost	β_3	0.033	0.002**
Lnagrochemcost	β_4	0.009	0.002**
$(\text{lnseedcost})^2$	β_5	0.031	0.001**
$(\text{lnlabourcost})^2$	β_6	0.016	0.001**
$(\text{lnfertilizercost})^2$	β_7	0.004	0.0001**
$(\text{lnagrochemcost})^2$	β_8	0.001	0.0001**
lnlabcost*lnfertcost	β_9	0.008	0.002**
lnlabcost* lnagrochemcost	β_{10}	0.011	0.010
lnlabcost* lnseedcost	β_{11}	0.046	0.003**
lnfertcost* lnagrochemcost	β_{12}	0.016	0.012
lnfertcost* lnseedcost	β_{13}	0.021	0.011*
lnagrochemcost*lnseedcost	β_{14}	0.063	0.026**
Inefficiency effects			
Constant	δ_0	-1.679	0.0001**
Harvesting	δ_1	0.0001	0.0001
Threshing	δ_2	-0.0001	0.00001**
Storage	δ_3	0.0002	0.002
Transportation	δ_4	-0.0015	0.0002**
Diagnostic Statistics			
Sigma Square	σ^2	0.612*	
Gamma	γ	0.912**	
Log Likelihood Function	LLF	185.041	
Mean Cost Efficiency		0.891**	

**P<0.05, **P<0.01*

Table 4: Estimates of Technical, Allocative and Economic Efficiencies of Acha Farmers

EfficiencyLevel	Technical Efficiency		Allocative Efficiency		Economic Efficiency	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
<0.40	1	0.5	-	-	-	-
0.40-0.49	3	1.50	-	-	-	-
0.50-0.59	9	4.50	2	1.00	32	16.00
0.60-0.69	10	5.00	30	15.00	52	26.00
0.70-0.79	11	5.50	61	30.50	42	21.00
0.80-0.89	102	51.00	85	42.50	71	35.50
0.90-0.99	64	32.00	22	11.00	3	1.50
Total	**200**	**100**	**200**	**100**	**200**	**100**
Minimum		**0.47**		**0.55**		**0.45**
Maximum		**0.91**		**0.98**		**0.91**
Mean		**81**		**85**		**76**