

Analysis of the Technical Inefficiency of Rubber Tapping in Rubber Research Institute of Nigeria, Benin City, Nigeria

D.Y. Giroh* and E.F. Adebayo**

*Rubber Research Institute of Nigeria, P.M.B 1049, Benin City, Nigeria
E-mail: girohydengle@yahoo.com

**Agricultural Economics and Extension Department, Federal University of Technology,
P.M.B 2076, Yola, Nigeria

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ABSTRACT The study was conducted to analyze the technical inefficiency of rubber tapping in Rubber Research Institute of Nigeria Benin City, Edo State. Time series data of 129 tappers were analyzed using stochastic frontier analysis. The tappers were sampled using simple random sampling technique. The result of the stochastic frontier production function revealed that the variance of parameters (gamma and sigma squared) of the frontier production function were both significant at $p < 0.01$. There were substantial variations in estimated efficiencies ranging from 0.38 for the least practiced tapper and 0.99 for the best tapper with a mean technical efficiency of 0.72. However, the inefficiency model revealed that education, training and gender were found to have significant effect on tappers efficiency at one percent probability level. It was however recommended that addressing the tappers specific factors would reduce inefficiency in rubber tapping.

INTRODUCTION

Natural rubber (*Hevea brasiliensis* Muell Arg) production statistics show that Nigeria has a total of 247,100 of land under rubber cultivation. Of this figure, small scale farmers own 200,100 while the remaining 47,000 by estates (Kpolo 1999; Aigbekaen et al. 2000, Delabare and Serier 2000; Uraih 1980) The Nigerian rubber industry has enormous potentials for sustainable growth and development. Rubber yield has been enhanced by the introduction of clone rubber trees instead of traditional seedlings with low yield potentials (Williams et al. 2001). Food and Agriculture Organization (FAO) reported that unselected or local clones of rubber has yield of 300 to 400 kg ha⁻¹ per year of dry rubber while remarkable improvements have been made in the breeding of high yielding clones of rubber by the Rubber Research Institute of Nigeria (RRIN). RRIN developed clones are one of the best yielding clones in the world (Omokhafa and Nasiru 2004). The Nigerian rubber industry provides employment opportunity and also serves as foreign exchange earner for the country (Abolagba et al. 2003).

The Nigerian rubber industry is labour intensive particular for maintenance and tapping. Studies have shown a significant and negative correlation between wages and rubber production in Nigeria (Aigbekaen and Alika 1984). The bark of the rubber tree is the economic

reserve of the farmer; hence efficient exploitation method is crucial in the determination of financial returns of the rubber estates. The high labour wage has forced majority of plantation owners to either abandon or adopt a share cropping system with willing tappers. This system of management fails to give the owner sufficient control over the tapper. This arrangement motivates tappers to "slaughter tap" all in an effort to extract latex resulting in poor bark regeneration and declining productivity of the trees. There has been an increasing demand for rubber and its products but productivity seems to be inadequate to supply the growing demand for tyres. Considerable research has been conducted on the natural rubber in the areas of crop improvement and other production innovations (Alika 1982; Esekhafe et al. 1996; Omokhafa and Nasiru 2004). However, little has been conducted on the rubber tappers who are very crucial in the sustenance of the natural rubber industry. Do the tappers operate at a level of technical efficiency sufficient to justify future survival of the industry? The main objective of this study was to analyze the technical inefficiency of rubber tapping in Rubber Research Institute of Nigeria. The specific objective was to examine the causes of technical inefficiency of the tappers.

The Concept of Technical Efficiency

Technical efficiency (TE) is defined as the

ability to achieve a high level of output given similar level of production input. Technical inefficiency arises when less than maximum output is obtained from a given bundle of factors. Variation in TE of producers might arise from managerial decisions and firm characteristics that affect the ability of the producer to adequately use the existing technology. Tran et al. (1993) studied the technical efficiency of state rubber farms in Vietnam using the stochastic frontier production function for 33 farms. A mean TE of 0.59 was obtained with varied indices of the TE and the variations were attributed to that of management and different field husbandry methods adopted in the farms

MATERIALS AND METHODS

The study was carried out at RRIN main station, Iyanomo, Benin City, Edo State, Nigeria. It falls within Latitude 6° and 7° North of the Equator and Longitude 5° and 6° East of the Greenwich Meridian. It is within the humid rainforest zone with mean annual rainfall of 2000 mm. Rainfall has two peaks in the month of July and September but highest in July and there is drought in August. The soils of this humid forest belts are mainly ultisols with pH range between 4.0 and 5.5. The soils have been described as the "acid sand belt" derived from unconsolidated grits and stones containing clay beds in varying proportions (Vine 1956; Giroh and Adebayo 2007).

Data for this study were obtained from primary and secondary sources. Primary source was obtained through the use of structured questionnaires that were distributed to the respondents. Questions on tappers' socio-economic variables (age, education, tapping experience, family size, status of tapping and gender) were asked. Data on tappers productivity (dry kilogramme of rubber tapped, salary or wages, man days of labour, tapping tasks and age of plantation were obtained as secondary data from the salaries and tapping Divisions of the Institute. Information on the population of tappers was obtained from tapping division of the Institute. The data was collected from January to December 2006 production period in rubber plantations of the Institute. Random sampling technique was adopted in eliciting information from respondents for the study. A total of 150 respondents were served with the structured questionnaires. However, a sample of 129 tappers was eventually

used. Data collected were subjected to stochastic frontier production function analysis (Meeusen and van den Broeck 1977).

The Stochastic frontier analysis is specified as:

$$Y_i = f(X_i; \beta) \exp(V_i - U_i) \quad i = 1, 2, \dots, N \quad (1)$$

Where:

Y_i = Production of the i th firm

X_i = Vector of input quantities of the i th firm

β = Vectors of unknown parameters

V_i = Assumed to account for random factors such as weather, risk and measurement error.

U_i = due to technical inefficiency

Technical efficiency (TE) of the firm in the context of the stochastic frontier production function is given by

$$TE = \exp(-u_i)$$

i.e

$$TE = Y_i^* / Y_i =$$

$$\frac{f(X_i; \beta) \exp(V_i - U_i)}{f(X_i; \beta) \exp(V_i)} = \exp(-u_i) \quad (2)$$

The Empirical Stochastic Frontier Production Model

The stochastic frontier production model used was specified as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + V_i - U_i \quad (3)$$

Where:

Y_i = Output (kg of dry rubber) of the i th tapper

X_1 = Tapping tasks (No. of trees tapped)

X_2 = Wage (in naira)

X_3 = Labour use (in man days)

X_4 = Age of plantation (in years)

V_i = Random noise (white noise) which are $N(0, \sigma_v^2)$

U_i = are inefficiency effects which are non negative, half normal distribution $N(0, \sigma_u^2)$.

The inefficiency model is defined by:

$$U_i = \delta_0 + \delta_1 \ln Z_1 + \delta_2 \ln Z_2 + \delta_3 \ln Z_3 + \delta_4 \ln Z_4 + \delta_5 \ln Z_5 + \delta_6 \ln Z_6 + \delta_7 \ln Z_7 \quad (4)$$

Where:

U_i = Inefficiency effect

Z_1 = Age of tapper (in years)

Z_2 = Literacy level (in years)

Z_3 = Tapping experience (in years)

Z_4 = Training (1 for those trained, 0 for no training)

Z_5 = Gender of tapper (1 for male, 0 for female)

Z_6 = Family size (total number of persons in household)

Z_7 = Status of tapper (1 for permanent, 0 for non permanent rubber tappers).

The Maximum Likelihood Estimates (MLE) for all the parameters of the stochastic frontier production and the inefficiency model were obtained using the computer program frontier 4.1 (Ajibefun 1998).

RESULTS AND DISCUSSION

The Maximum Likelihood Estimate (MLE) of the parameters of the stochastic frontier model of rubber tappers show that the estimates of the parameters for the frontier production function, the inefficiency model and the variance parameters of the model is presented in Table 1. The variance parameters of the stochastic frontier production function are represented by sigma squared (σ^2) and gamma (γ) and were significantly different from zero at one percent. This implies that the ordinary least squares estimate (OLS) will not be adequate in explaining the inefficiencies on rubber tapping; the specification of a stochastic frontier production function is therefore justified.

The estimate of the parameters of the stochastic production frontier indicates that elasticity of output with respect to wage is positive and statistically significant at one percent

Table 1: Maximum Likelihood Estimate of parameters of Cobb-Douglas Stochastic Frontier Production function for Rubber tappers

Variable	Parameter	Coefficient	T.value
<i>Stochastic frontier</i>			
Intercept	β_0	1.64***	5.12
ln no. of trees tapped	β_1	3.22	1.21
ln wage (in naira)	β_2	1.09***	8.90
ln labour (man days)	β_3	0.03	0.20
ln age of plantation	β_4	-4.19*	-1.70
<i>Inefficiency model</i>			
Intercept	δ_0	0.49	1.20
Age	δ_1	4.23	0.16
Education	δ_2	-0.78***	-4.15
Tapping experience	δ_3	-0.009	-0.24
Training	δ_4	-0.69***	-3.52
Gender	δ_5	-5.75***	-2.97
Family size	δ_6	-0.03	-0.51
Status of tapper	δ_7	0.45***	7.20
<i>Variance parameter</i>			
Sigma squared	σ^2	0.011***	5.43
Gamma	γ	0.96***	33.00
Number of observation	129		

Source: Computer output from frontier 4.1.

***Significant at 1percent

*Significant at 10 percent

level. The production elasticity of age of plantation is negative and statistically significant at one percent. This showed that age of rubber tree is a critical factor in rubber tapping as output or yield declines when the trees are too old. The result of the inefficiency model shows that all the coefficients of the efficiency variables with the exception of age and status of tappers have the expected signs. A negative sign on an estimated parameter implies that the associated variable has a positive effect on efficiency and a positive sign indicates the reverse is true. Hence tapping experience and family size have positive influence. However, education, training and gender were found to have significant effect on tappers efficiency at one percent probability level. However, the coefficient for gender variable was estimated to be negative and statistically significant at one percent. This implies that male tappers are more efficient than female tappers. A plausible reason for this is that female tappers are constrained by socio- cultural factors and the devotion of their times in household activities taking care of their children. This study is in line with the findings of Giroh et al. (2006) who found out the most Extension activities focused mainly on the men and not women and land allocation only favoured the men and not the women in many farm settlements in Nigeria. This therefore calls for deliberate policy where women would be given equal opportunity to participate in many economic activities in the country.

Technical Efficiency Ratings of Tappers

Table 2 shows the technical efficiency ratings of the tappers. This reveals substantial variations in estimated efficiencies ranging from 0.38 for the least practiced tapper and 0.99 for the best tapper with a mean technical efficiency of 0.72. The wide

Table 2: Frequency distribution of technical efficiency ratings of rubber tappers

Range of TE	Number	Percentage
≤ 0.59	63	48.83
0.60 - .69	5	3.88
0.70 - .79	2	1.55
0.80 - .89	0	0.00
≥ 0.90	59	45.74
Total	129	100.00
Minimum		0.38
Maximum		0.99
Mean		0.72

Source: Computer output from frontier 4.1

efficiency differentials among tappers are an indication of substantial potential for efficiency improvement in rubber tapping. This result indicates that on the average, output of rubber tapping fall by 28% from the maximum possible level and 1% from the best tapper. Also, 54.26 percent of the tappers have TE index below the mean figure attributed to non utilization of the existing tapping resources. This result shows that Nigerian rubber tappers' mean efficiency is higher as compared to what was found in Vietnamese rubber plantation (Tran et al. 1993).

CONCLUSION AND RECOMMENDATION

The study revealed that some of the production coefficients have the expected positive signs. The technical efficiency of the entire tappers is less than one indicating that they were not operating on the efficiency frontier (mean TE of 0.72). The implication of this is that TE of the tappers can be improved by 28% through intensive use of available resources. This can be achieved through improvement in the tappers specific factors especially education, training as these would enable tappers improve their productivity. Policies to make tappers literate through training in institution of high learning should be put in place.

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