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Analysis of the Technical Efficiency of Rubber Latex Exploitation in Edo State, Nigeria

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Abstract: This study investigated the technical efficiency of rubber latex exploitation in Southern Nigeria. Data were collected on 100 rubber tappers obtained through the use of structured questionnaires which were randomly administered. Data collected were analysed using descriptive statistics and stochastic frontier production function analysis. Results show that a mean of 387 trees were tapped/ day with 41.69 and 4,478.46 L/man/day annually, respectively. Tappers were literate and had one form of formal education or the other. The technical efficiency effects are highly significant, implying that the traditional production function model is inadequate for the analysis of rubber latex production in the study area. The total elasticity of the production frontier was 1.56 and showed increasing returns to scale and in stage 1 of the production function. There was considerable variation in the technical efficiency of tappers where 66.67% operated below the mean technical efficiency of 0.80. School and training increase the technical efficiency of the respondents. The use of improved clones, exotic clones have positive and significant effect on rubber latex at p>0.01 and p>0.05, respectively.

Key words: Technical efficiency, stochastic frontier, rubber latex, exploitation, Edo, Nigeria

INTRODUCTION

Rubber latex is a milk liquid that comes out of the rubber tree and has been a source of raw materials for the automobile industries. It is obtained through tapping. Tapping is defined as the controlled wounding of a matured rubber tree to extract latex while at the same time ensuring that the economic life of the tree is preserved. Tapping requires the use of resources (inputs) to obtain output (dry kilogramme of rubber or litres of latex) and these resources could be aggregated into land, capital, labour and management in agriculture.

In order to achieve optimum production level, resources must be available and whatever quantities of available resources must be used efficiently. Successful and result oriented farm planning and policies require the knowledge of productivities of farm resources whose quantity or rate of use should be increased or decreased. The concept of efficiency is concerned with the relative performance of processes used in transforming given inputs into output (Mijindadi, 1980). Lau and Yotopoulos (1971); Olayide and Heady (1982) distinguished between two types of efficiency; technical efficiency and economic efficiency. Technical efficiency focuses on physical productivity, which occurs when larger quantity of output is consistently produced from the same quantities of measurable inputs. Technical Efficiency (TE) is the achievement of the maximum potential output from a given quantity of inputs under a given technology. It is the attainment of production goal without wastage (Jondrow *et al.*, 1982; Amaza and Olayemi, 1999). According to Olayide and Heady (1982) efficiency that measures the average productivity of input can only be meaningful index of technical efficiency if any of the resources is limiting in the production process. Economic efficiency on the other hand occurs when a firm chooses resources and enterprises in such a way as to attain economic optimum. The optimum implies that a given resource is considered to be most efficiently used since it marginal value productivity is just sufficient to offset its marginal cost (Adegeye and Dittoh, 1985).

Stochastic frontier production functions have been applied in large number of empirical studies to account for technical inefficiencies of production (Battese *et al.*,

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1996). Deterministic and stochastic models are the 2 types of frontier models, respectively. The term deterministic is used to describe that group of methods that assumed a parametric form of production frontier along with a strict one sided error term (Coelli, 1995) and example of such work are the works of Aigner and Chu (1968), Afriat (1972) and Schmidt (1976). Coelli (1995) observed that the deterministic frontier takes no account of the possible influence of measurement errors and other noise upon the shape and position of the estimated frontier, since all observed deviations from the frontier are assumed to be the result of technical in efficiency. Aigner and Chu (1968) considered estimation of a parametric frontier production in input/output space and specified a Cobb Douglas production in logarithm for a sample of N firms as $\ln(y_i) = F(x_i; \beta) - U_i$ where $_i = 1,2\ldots\ldots N$.

The stochastic model specification not only address the noise problem associated with earlier deterministic frontiers, but also permitted the estimation of standard errors and tests of hypotheses which were not possible with the early deterministic models because of the violation of maximum likelihood conditions. The main criticism of stochastic frontier is that there is no *apriori* justification for the selection of any particular distributional form for Ui. The stochastic frontier production function was independently proposed by Aigner *et al.* (1977) . It differs from the traditional production function in that its disturbance term has two components: One to account for technical inefficiency and the other to permit random events that affect production (Tran *et al.*, 1993).

It is specified as:

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

Where,

Y_i = Production of the ith firm.
X_i = Vector of input quantities of the ith 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.

The production technology of the farms was assumed to be specified by the Cobb- Douglas functional form.

Similar study is necessary on rubber tapping in order to determine how resources should be optimally utilized to increase rubber production. The study on technical efficiency of rubber latex exploitation is likely to give an idea or direction of how many of the tappers operating near the frontier in order to increase output from natural rubber latex production.

MATERIALS AND METHODS

The study was carried out at Rubber Research Institute of Nigeria, (RRIN) Main station Iyanomo Benin City Edo State. It falls within the humid rain forest zone of southern Nigeria. The area is rich in fertile soil suitable or the cultivation of natural rubber. The soil pH ranges between 4.0 and 5.5 with an estimated annual rainfall of 20 cm (Vine, 1956; Aigbekaen *et al*., 2000). Primary data was used for the study. A random sampling technique was used to select 100 rubber tappers. Structured interview schedules were used to obtain the primary data.

Econometric model: The stochastic frontier production function for rubber tappers is assumed to be:

$$\text{Ln}Y = \beta_0 + \beta_1 \text{Ln}(X_1) + \beta_2 \text{Ln}(X_2) + \beta_3 \text{Ln}(X_3) + \beta_4 \text{Ln}(X_4) + \beta_5 D_1 + \beta_6 D_2 + V_i \,.\, U_i \quad (2)$$

Where,

Ln = Denotes logarithms to base e.
Y = Represents the quantity of latex produced (litres) of the ith tapper.
X_1 = Total trees tapped.
X_2 = Labour (man days).
X_3 = Age of plantation (years).
X_4 = Operating expenses (in naira).
D_1 = A dummy variable equal to one if the clone tapped is improved, zero otherwise.
D_2 = A dummy variable equal to one if the clone tapped is exotic, zero otherwise.
V_i = Random noise (white noise) which are $N(0, \sigma^2_v)$.
U_i = Are inefficiency effects which are non negative, half normal distribution $N(0, \sigma^2_u)$.

U_i is defined by:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 \quad (3)$$

Where,

U_i = Inefficiency effect.
Z_1 = Age of farmer (in years).
Z_2 = Status of cultivation (1 wild, 0 cultivated).
Z_3 = Family size (total number of persons in household).

The technical efficiency of latex exploitation for the ith tapper, defined by the ratio of observed production to the corresponding frontier production associated with no technical inefficiency, is expressed by:

$$TE = \exp(Ui) \quad (4)$$

Battese and Coelli (1988) suggest that this quantity be predicted by using its conditional expectation, given the composed random error Vi-Ui evaluated at the maximum likelihood estimates (MLE) of the parameters of the model. σ^2, δ, γ and βs are unknown parameters that were estimated.

RESULTS AND DISCUSSION

A summary of the values of the variables is presented in Table 1. From the Table 1, the mean tree /ha tapped was 387 lower than the 450 tree/ha/daz. This shows about 86% of extraction, the balance of 14% (about 63 trees) that could not be tapped is attributed to the effect of wind damage, diseases and management constraints. The mean age of plantation exceed the recommended economic age of 25 years. Yield decline is likely to be experienced in latex production. Tappers are trained and it is expected that slaughter tapping would be minimized.

Table 1: Summary statistics for rubber tappers

Variable	Sample mean	Sample std deviation	Minimum value	Maximum value
Output (litres)	4,478.46	223.92	1,144	7,018
Labour (man days)	128.50	6.43	90	239.3
Total trees tapped	387	19.35	256	450
Age of plantation(years)	31	1.65	9	41
Age (years)	34	1.70	25	44
Wage (naira)	7,179.45	358.97	3,090	11,341.75
Tapping experience (years)	8	0.40	2	13
Training (days)	18	6.37	14	28
Family size (No. of people)	7	2.35	1	12
School (years)	7.08	1.68	6	12

Source: Field survey data, 2007

The maximum likelihood estimates for the parameter of the stochastic frontier and inefficiency model are given in Table 2. It is evident that the variance parameters sigma squared (δ^2) and gamma (γ) were estimated to be close to 1 (0.52 and 0.95) and significantly different from zero. This suggests that stochastic frontier is fit and the traditional production function with no technical efficiency is not adequate representation of the data. The coefficients for total tree tapped, age of plantation and operating expenses carried negative sign implying that any increase in these variables would lead to decrease in output. For instance, an increase in total number of tappable trees becomes difficult for tappers to cover within stipulated tapping time of the early hours of the morning. Extension of time to tap may result to low latex flow. Output declines when the trees are older as indicated by the negative coefficient of -0.09. The slope coefficient for clones is 0.12 and significantly different from zero. The use of improved rubber clones was suggested by Williams *et al.* (2001) to improve the productivity of natural rubber. However, the positive coefficient of 0.065 was estimated for clonal type (exotic clones) and significantly different from zero. The exotic clones are those planting materials that were introduced into Nigeria from Malaysia, Indonesia. Nigeria developed clones have been reported to yield more than the exotic clones (Omokhafe and Ugwa, 1997) but the clones are more susceptible to wind damage than the exotic clones that are wind resistant. Another theoretical plausibility is the fact that many of the plantations were planted with exotic clones rather than the Nigeria developed clones recently released by varietal release council as commercial planting materials for farmers in Nigeria. The total elasticity of this frontier production function is 1.56 indicating that rubber latex production is in stage 1 of the production function or increasing returns to scale.

Table 2: Maximum likelihood estimate for parameters of the stochastic frontier and inefficiency model for rubber tappers

Variable	Parameter	Coefficient
Stochastic frontier		
Constant	β_o	0.95(0.17)***
Ln (total trees)	β_1	-0.057(-0.28)
Ln (labour)	β_2	0.48(0.59)
Ln (age of plantation)	β_3	-0.16(- 0.03)***
Ln (operating expenses)	β_4	-0.09(-0.07)
D_1	β_5	0.99(0.20)***
D_1 (clone)	β_6	0.12(0.07)*
D_2	β_7	0.70(0.11)***
D_2(Clonal type)	β_8	0.065(0.026)**
Inefficiency model		
Constant	δ_0	0.15(0.33)
Age	δ_1	0.71(1.26)
School	δ_2	-0.26 (-0.14)*
Training	δ_3	-4.70(-0.45)***
Variance parameter		
Sigma squared	δ^2	0.52(0.018)***
Gamma	γ	0.95 (0.13)***
Mean TE	0.80	
Ln (Likelihood)	148.98	
Number of iterations	10	

Figures in parentheses are the estimated standard errors for the maximum likelihood estimators. The values are obtained by the use of the computer program FRONTIER4.1 written by Coelli, 1994. ***Significant at 1% **Significant at 5%* Significant at 10%

The coefficients of the explanatory variables in the inefficiency model (school and training) are estimated to be negative and statistically significant. The variables increased technical efficiency of rubber tappers.

Technical efficiency of respondents: The technical efficiencies of the tappers defined by Eq. 3, are predicted on the basis of the preferred frontier model. Since, the in efficiency effects are significant, the technical efficiencies of the sampled rubber tappers is less than one. Table 3 gives the percentages of tappers with technical efficiencies. The mean TE for tappers was estimated to be 0.80. There was considerable variation in the individual technical efficiencies and the mean technical efficiency. Sixty-six percent of the tappers have T.E index below the

Table 3: Technical efficiencies of respondents

Range of TE	Frequency	Percentage
≤0.59	54	54
0.60-0.79	6	6
0.80-0.891	1	
0.90 and more	39	39
Total	100	100
Mean	0.80	
Minimum	0.38	
Maximum	0.99	

Source: Field survey data,2007

Table 4: Test of hypotheses of explanatory variables for the technical inefficiencies effects in the stochastic frontier production function for rubber tappers in Nigeria

Null hypothesis	X^2 statistic	$X^2_{0.95}$	Decision
H_0: $\gamma = 0$	36.51	7.82	Reject H_0
H_0: $\delta_1 = \delta_2 = \delta_3 = 0$	70.69	7.82	Reject H_0

mean (0.80) while another 34% attained technical efficiency above the mean. T.E. The reasons for the variation in T.E are worthy of further investigation. Some of the variations may be due to lack of a variable describing weather conditions in the stochastic frontier which may result in production variability. Management as a factor of rubber production is likely to be a major factor explaining the variations in technical efficiencies of tappers was not included in the model. Management factors are very complex matters to study and may deserve analysis in a separate study.

Tests of hypotheses: The first null hypothesis is H_0: $\gamma = 0$, which specifies that the inefficiency effects in the stochastic frontier are not stochastic. The null hypothesis is rejected. The second null hypothesis is H_0: $\delta_1 = \delta_2 = \delta_3 = 0$, which specifies that the explanatory variables in the model for inefficiency factors have zero coefficients. This null hypothesis is rejected (Table 4). Thus, it can be concluded that the explanatory variables in the model contribute significantly to the explanation of technical efficiency in rubber latex exploitation in Nigeria.

CONCLUSION

Results show that stochastic frontier production function was adequate in the analysis of data on rubber latex production. The stochastic frontier production function shows increasing return to scale or stage 1 of the production. The use of improved clone, exotic clone and labour contribute significant to production of latex. Yield declines when the trees are too old and cost of operations were over utilized in the exploitation of rubber latex. Training and school enhance technical efficiencies of rubber tappers. On the average, tappers operated 80% of the maximum TE. At this level of operation, it is clearly very attractive to invest in rubber production. The model results suggest considerable scope to improve the technical efficiency of the rubber plantations. Supervisory and motivation techniques should be used on rubber tappers for appreciable increase in TE by raising labour productivity.

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