JOURNAL OF AGRICULTURE & SOCIAL SCIENCES
1813–2235/2007/03–4–107–111
http://www.fspublishers.org

Comparative Productivity Analysis of Permanent and Non-permanent Rubber Tappers in State Rubber Farms of Nigeria

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ABSTRACT

The study was a comparative productivity analysis of permanent and non-permanent rubber tappers in Rubber Research Institute of Nigeria Benin City, Edo State. The use of structured questionnaire was adopted and administered to a random sample of 129 (68 permanent & 61 non-permanent) tappers. Data collected were analysed using descriptive statistics, budgetary techniques and stochastic frontier analysis. The result indicated that a mean of 399 and 375 trees were tapped per day by permanent and non-permanent tappers with an annual output of 2,446.98 kg and 2,665.96 kg of dry rubber, respectively. Output per man-day^{-1} of permanent and non-permanent tappers were 11.93 kg and 17.09 kg of dry rubber, respectively. The result of the gross margin analysis shows total revenue (TR), gross margin (GM) and net farm income (NFI)/hectare of $582.39, $444.65and - $205.26 was realized for permanent tappers. However, the result for non-permanent tappers indicated that the TR, GM and NFI/hectare were $596.08, $371.86 and $317.99, respectively. The result of the stochastic frontier analysis also revealed that the variance of parameters (gamma & sigma squared) of the frontier production function were both significant at $p < 0.01$. The mean technical efficiency index was 0.72. However, a comparison of the technical efficiencies of permanent and non-permanent tappers also indicated that the mean TE of 0.50 and 0.95 were observed for permanent and non-permanent tappers, respectively. Minimum TE index is 0.38 and 0.83, while the maximum of 0.63 and 0.99 was for the categories of tappers, respectively. It was however recommended that flexible wages and other forms of incentives be provided for tappers, further recruitment policy should favour more young male rubber tappers to increase tapping efficiency and hectare (s) of rubber plantations with trees that are too old should be replanted.

Key Words: Productivity; Permanent tappers; Non-permanent tappers; State farms; Stochastic frontier; Budgetary technique

INTRODUCTION

Natural rubber (*Hevea brasiliensis* Muell Arg) is the best source of plant, because of its singular ability to renew its bark and thus ensure sustained harvest (Uraih, 1980).

Kpolo (1999) and Delabarre and Serier (2000) reported 247,100 hectares of land under cultivation in Nigeria mainly from small-scale farmers. In 1990, Nigeria overtook Liberia as the largest rubber producer in Africa when its production rose from 60,000 tonnes in 1986 to 147,000 tonnes in1990. However, it dropped to 125,000 tonnes in 1995 and 107, 00 tonnes in 2000 but went up again in 2003 to 142,000 tonnes and remained at 142,000 in 2004.

Tapping is defined as the controlled wounding of the matured rubber tree with the aim of extracting from it the economic fluid called latex, while at the same time that the economic life of the tree is preserved. The study was a comparative analysis of the productivity of permanent and non-permanent rubber tappers in state rubber farms in Nigeria. The specific objectives were to estimate costs and returns associated with rubber tapping and to estimate and compare technical efficiencies of permanent and non-permanent rubber tappers.

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 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 un-consolidated grits and stones containing clay beds in varying proportions (Vine, 1956).

Data for this study was obtained from primary source. The primary data were obtained through the use of structured questionnaires, which were distributed to the respondents. Data on the respondents' salaries was also obtained at the salary unit for analysis. Price of dry rubber kg^{-1} was obtained at the sales unit of the Institute for the determination of revenue from tapping.

Random sampling technique was adopted in eliciting information from respondents for the study. Information on the population of tappers was obtained from tapping

division of the Institute. A total of 150 respondents comprising the categories of tappers were served with the structured questionnaires. However, a sample of 129 tappers (68 permanent & 61 non-permanent) was eventually used.

Descriptive statistics, budgeting technique and stochastic frontier production function model were employed for data analysis. Budgeting technique was used to estimate income generated from rubber tapping for each system. The specific type of budgeting technique used was the gross margin. The model used for the estimation of the Gross margin was explicitly stated thus:

Gross margin (GM) = GI – TVC …… (1)

Where,

GM = Gross Margin

GI = Gross Income

TVC = Total variable cost.

NFI = GM – TFC...…….…… (2)

Where,

NFI = Net farm income

TFC = Total fixed cost.

The stochastic frontier production function model was employed to determine efficiencies of the tappers.

It is specified as:

$Y_i = f(X_i: \beta) \exp(V_i - U_i)$ i =1, 2.., N…….. (3)

Where,

Y_i = Production of the ith firm

X_i = Vector of input quantities of the ith firm

B = 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.

The empirical stochastic frontier production model. The stochastic frontier production model used was specified as follows:

$\text{Log } Y_1 = \beta_o+\beta_1 \log X_1+\beta_2 \log X_2+\beta_3 \log X_3+\beta_4 \log X_4+V_i-U_i$ …….. (4)

Where:

Y_1 = Output (kg of dry rubber) of the ith tapper

X_1 = Tapping tasks (No. of trees tapped)

X_2 = Wage (in dollars)

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:

$U_i=\delta_0+\delta_1 Z_1+\delta_2 Z_2+\delta_3 Z_3+\delta_4 Z_4+\delta_5 Z_5+\delta_6 Z_6+\delta_7 Z_7$….. (5)

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)

σ^2, δ, γ, βs are unknown parameters that were estimated.

The Maximum Likelihood Estimates (MLE) for all the parameters of the stochastic frontier production function and the inefficiency model and the technical efficiency were obtained using the program frontier 4.1 (Coelli, 1994; Ajibefun, 1998).

RESULTS AND DISCUSSION

Productivity measurement. Productivity is measured using parameters such as the number of trees tapped; output (litres of latex or dry kilogramme of rubber tapped. Table I shows the variables associated with productivity. Total trees tapped were below the 450 to 500 trees recommended by Schroth *et al.* (2004). The variation could be attributed to poor management of plantations, wind damages, pest and diseases especially the white root rot disease. Output per man-day is higher as compared to the 9.56 kg per day as reported in Nigeria and 7.6 kg for Sri-Lankan rubber tappers (Aigbekaen & Alika, 1984; Rubber Research Institute of Sri-Lanka, RRIS, 2002). Non-permanent tappers were motivated to tap more as their payment is based on total kilogrammes tapped unlike permanent tappers whose payment is not based on output. Low productivity could be attributed to intermittent wet weather, which also affected tapping days. Inadequate training of tappers, lack of infrastructures in rubber plantation like living quarters, pipe-borne water, electricity, health facilities and roads, poor wages, delay in payment, job insecurity are considered as factors affecting their productivity of rubber tappers(Uraih, 1980; Ojo & Imoudu, 2000).

Gross margin analysis. The gross margin analysis for permanent rubber tappers indicated that the average variable cost/ha/permanent rubber tapper was $137.74, which accounted for 17.49% of the total tapping cost (Table II). The average fixed cost was $649.90 (82.51%) of the total cost of tapping. Thus the total cost of tapping operation/ha/tapper was $787.64. The total revenue (TR), Gross margin (GM) and Net farm income (NFI) per hectare were $582.39, $444.65 and - $205.26, respectively.

It can be deduced from the data (Table II) that rubber tapping is not profitable under the permanent rubber tappers but was found to be profitable under the non-permanent tappers. The returns to naira invested on permanent tapper by the Institute revealed that $0.002 was lost. This may cause rubber estate owners not to properly tap their

plantation thereby resulting to decline in output of natural rubber to meet the needs of rubber industries in Nigeria.

Average variable cost per hectare for non-permanent rubber tapper was $224.22 This accounted for 80.63% of the total cost of tapping operation, while the average fixed cost was $53.88 (19.37%) of the total cost of tapping. The total cost of tapping per hectare was $278.09 the total revenue (TR), Gross margin (GM) and Net farm income (NFI) per hectare were $596.08, $371.86 and $317.99, respectively. In the case of non-permanent rubber tappers, the return to naira invested showed that for every one naira invested, the Institute makes a profit of $0.09. Thus this finding indicated that engaging more of non-permanent tappers in the study area might increase revenue. Increasing their wage and ensuring prompt payment of the wages could enhance their productivity (Table III). Profits from rubber production were found be influenced by several factors like world market prices, price volatility and un-seasonal rains disrupting tapping and ownership status (Abolagba *et al.,* 2003; Rubber Asia, 2006). The mean age of the plantation was 30 years old. This result indicated that the plantations are younger as compared that of Sumatra, which was reported to peaked at 32 and 34 years (Suyanto *et al.,* 2001). Age of rubber trees is determinants of gross revenue and residual profit. Over tapping can have detrimental effects on profitability over time, since tapping intensity is negatively related to future latex production.

Results of the stochastic frontier production function analysis. The Maximum Likelihood Estimate (MLE) of the parameters of the stochastic frontier model of rubber tappers is presented in Table IV. The Table contained the estimates of the parameters for the frontier production function, the inefficiency model and the variance parameters of the model. The variance parameters of the stochastic frontier production function [sigma squared (δ^2) & gamma (γ)] are significantly different from zero at one percent level and indicated a good fit and correctness of the distributional form assumed for the composite error term. The systematic influences that are un-explained by the production function are the dominant sources of random error as indicated by gamma, which is 0.96 that shows the amount of variation resulting from the technical inefficiencies of the tappers. This means that more than 95% of the variation in tappers output is due to difference in technical efficiency. This implies that the ordinary least squares estimate (OLS) will not be adequate in explaining the inefficiencies on rubber tapping thereby justifying the specification of a stochastic frontier production function. Typical of the Cobb-Douglas production function, the estimated coefficients for the specified function can be explained as the elasticities of the explanatory variables. Except for age of plantation, the sign of the slope coefficients of the stochastic production frontier are positive.

The estimate of the parameters of the stochastic production frontier indicate that elasticity of output with respect to wage is positive and approximately 1.09 and it is statistically significant at 1% level. This implies that wage is a positive and significant factor that influences the output of rubber tappers. An increase of one percent in wage will result to an increase in output by 1.09% depending on the management of the rubber plantations. The production elasticity of age of plantation is negative -4.19 and statistically significant at one percent. This shows that output from rubber trees is necessarily a function of age. Output declines when the trees are too old. Other possible reasons may include the types of clones used, agronomic practices, management and other soil and climatic conditions and incidences of pest and diseases. The coefficients of the variables associated with total trees tapped and labour were 0.03 and 3.22 and were not statistically significant. The implication of this is that total trees tapped are not a critical factor in output if such tappers do not efficiently tap the tasks allocated. As for labour, tappers may report for work and may not actually tap thereby reducing output for that day especially among the permanent rubber tappers, whose payment is not based on daily output, but the non-permanent rubber tappers are paid on daily output. Another possible reason may be that of poor supervision.

Table I. Average variables associated with tappers productivity

Variable	Permanent tappers	Non permanent tappers
Total trees tapped	399	375
Mean output (kg)	2,446.98	2,665.96
Output/ man day (kg)	11.93	17.09

Source: Field survey, 2006

Table II. Average cost and Return of Permanent Rubber Tappers

Variable	Value ($)
A. Variable cost	137.74
B. Fixed cost	649.90
Total cost of production	787.64
C. Returns	
Total output	1,468.66 kg
Price/kg	0.39
Total Revenue	582.39
Gross margin (TR-TVC)	444.65
NFI (GM- TFC)	- 205.26
Return of naira invested	-0.002

Source: Field Survey, 2006

Table III. AverageCost and Reyurn of Non-permanent Rubber Tappers

Variable	Value ($)
A. Variable cost	224.22
B. Fixed cost	53.88
Total cost of production	278.09
C. Returns	
Total output	1,503.19 kg
Price/kg	0.39
Total Revenue	596 .08
Gross margin (TR-TVC)	371 .86
NFI (GM- TFC)	317.99
Return to Naira invested	0.009

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

Variable	Parameter	Coefficient	T. Value
Stochastic frontier			
Constant	β_o	1.64***	5.12
No. of trees tapped	β_1	3.22	1.21
Wage (in naira)	β_2	1.09***	8.90
Labour man days	β_3	0.03	0.20
Age of plantation	β_4	-4.19*	-1.70
Inefficiency model			
Constant	δ_0	0.49	1.20
Age	δ_1	4.23	0.16
Education	δ_2	0.16	1.50
Tapping experience	δ_3	-0.009	-0.24
Training	δ_4	0.001	0.001
Gender	δ_5	-5.75***	-2.97
Family size	δ_6	-0.03	-0.51
Status of tapper	δ_7	0.45***	7.20
Variance parameter			
Sigma squared	δ^2	0.011***	5.43
Gamma	γ	0.96***	33.00
Mean TE	0.72		

Source: Field survey, 2006 *** Significant at 1percent * Significant at 10 Percent

Table V: Frequency Distribution of Technical Efficiency of Permanent and Non- permanent Rubber Tappers

	Permanent tappers		Non permanent tappers	
Range of TE	**Number**	**Percentage**	**Number**	**Percentage**
≤ 0.59	63	92.65	0	0.00
0.60 - .69	5	7.35	0	0.00
0.70 - .79	0	0.00	0	0.00
0.80 - .89	0	0.00	2	3.28
≥0.90	0	0.00	59	96.72
Total	68	100	61	100
Mean	0.50		0.95	
Minimum	0.38		0.83	
Maximum	0.63		0.99	
Mode	0.52		0.98	

Source: Field Survey, 2006

Technical efficiency of permanent and non-permanent rubber tappers. Technical efficiency indices are derived from the analysis of the stochastic frontier function. The frequency distribution of tappers T.E. indices is presented in Table V. Majority of the permanent tappers fall to the range of ≤ 0.59, while none has more than ≥ 0.90, whereas for the non-permanent tappers, majority (96.72%) is in the range of more than 0.90. The result implies that non-permanent rubber tappers are more efficient than permanent rubber tappers. This is presumably due to the fact that non-permanent tappers are paid based on daily output un-like the permanent tappers, whose payment is not measured by the daily output as their salaries are fixed. The mean TE for permanent and non-permanent tappers is 0.50 (50%) and 0.95 (95%), respectively. This implies that the permanent tappers are not efficient as their observed output is 50% less than the maximum output, whereas the non-permanent rubber tappers observed output is 5% less than the maximum output. This can be increased by 50% and 5% through improved resource allocation with no additional cost for the two categories of tappers. The mean TE of 0.72 (72%) is higher than what was obtained in Vietnamese rubber farms (Tran *et al.,* 1993). Also, forty seven percent (47.06%) of the permanent rubber tappers have TE index below the mean TE of 0.50, while 48.53% are those with TE above the mean. 16.39% of the non-permanent rubber tappers are below the mean TE of 0.95, while 72.13% are whose TE is above 0.95. Non-permanent rubber tappers are relatively more efficient in rubber tapping. Thus, policy should encourage rubber tapping on non-permanent basis under a flexible wage regime to enhance output.

CONCLUSION

Based on the results of this study, the following major conclusions are drawn. A mean of 399 and 375 trees were tapped/day by permanent and non-permanent tappers with an annual output of 2,446.98 kg and 2,665.96 kg of dry rubber, respectively. The study also revealed an output/man day of 11.93 kg and 17.09 kg of dry rubber for permanent and non-permanent tappers.

The budgetary analysis revealed a gross margin and net farm income of $444.65 and – $205.26 per hectare, while return to investment was – $0.002 for permanent rubber tappers. However, for the non-permanent rubber tappers, a gross margin per hectare of $371.86 and a net farm income per hectare of $317.99 were realized. For every one naira invested yielded a net return of $0.009.

The result of the stochastic frontier analysis showed that some of the production coefficients had the expected positive signs indicating that increase in any of them will lead to increase in output. The technical efficiency of the entire tappers is less than one, indicating that the tappers were not operating on the efficiency frontier. The mean technical efficiency index is 0.72 suggesting that tappers output can be improved by 28% through improved resource allocation. However, a comparison of the technical efficiencies of permanent and non-permanent tappers also indicated that the mean TE of 0.50 and 0.95 were observed for permanent and non-permanent tappers, respectively. Minimum TE index is 0.38 and 0.83, while the maximum of 0.63 and 0.99 was for the categories of tappers, respectively. Output can be increased by 50% and 5% for permanent and non-permanent tappers.

Based on the findings of the study, the following recommendations are made:

i. The budgetary analysis indicated that tapping under non-permanent rubber tappers is profitable, thus policy should be geared towards retaining non-permanent tappers by offering them flexible wages and other forms of incentives.

ii. Further recruitment policy should favour more young male rubber tappers to increase tapping efficiency.

iii. Hectare (s) of rubber plantations with trees that are too old should be replanted.

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(Received 07 May 2007; Accepted 15 September 2007)