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EFFICIENCY OF SAWMILL INDUSTRY IN THE RAIN FOREST ZONE OF OSUN STATE, NIGERIA

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ABSTRACT

This paper investigated the effects of firm specific socioeconomic factors on the efficiency of the sawmill operators with a view to improve lumber production in Osun State of Nigeria. The sawmill firms were grouped into scales of operation based on the number of bandsaw machines in operation. Sixty sawmill firms representing about a third of total were selected through proportional random sampling method. Primary data were collected from the managers of the selected firms through the use of pre-tested questionnaire. Data were analysed using MLE stochastic frontier production function package. Comparisons of the technical efficiencies of the firms were made among the three scales of operation. Results showed that the large-scale firms had the lowest average technical efficiency (0.90) while the small-scale firms had the highest (0.95). Some socio-economic factors like level of education, manager's experience and age were significant determinants of efficiency. The sawn wood production estimate showed that the elasticity of production for sawlog was highest for hardwoods (0.645) than for softwoods (0.358).

Keywords: economic efficiency, sawn wood, stochastic frontier, Osun State

INTRODUCTION

Forests provide a range of goods and services with significant economic values. These include fertile soil, timber, recreation, landscape value and a wide range of environmental benefits such as climate regulation, watershed protection and the conservation of biodiversity. The forestry sub-sector has over the years contributed immensely to the socio-economic development in Nigeria. It ranks among the highest revenue and employment generating sectors (Fuwape, 2001). The raw materials for the production of timber, pulp and paper are derived from the forest.

Forest is an ecological, social, environmental and economic resource. Its management and product utilization

should thus be considered from these points of view. The role of forestry in the environmental protection and management programmes therefore lies in the conservation capacity of forests of various types and the amelioration of harsh environmental factors. This can be achieved through, among other things, efficient utilization of the forest products especially timber products. The efficiency of the processing sector, especially the sawmill, must be taken with seriousness for this to be attainable. This will therefore reduce the pressure on the forestland, which will eventually release land for other uses, especially agriculture.

The forestry sub sector has contributed a great deal to the growth of the agricultural sector and the Nigerian economy at large. The forest has great potentials for the exportation of several millions of cubic meters timber. It also provides wood for domestic and industrial uses through the wood based industries especially sawmills. The sawmill accounted for about 93.32% of the total number of wood based industries in Nigeria (Fuwape, 1998). These mills are concentrated in the southwestern part of the country. The main type of log conversion machine used in these mills is the DC horizontal band saw. Badejo and Giwa (1985) found out that in Nigeria the lumber (sawnwood) recovery ratio can be as high as 60% and 70% for the horizontal and vertical types of headrig machines respectively. However, the lumber recovery ratio in most of the sawmills varies between 45% and 50% (Alviar, 1983; Fuwape, 1998). This implies that 50 to 55% of the log inputs are left as wood residues. The poor log conversion efficiency of the mills may partly be responsible for the high pressure on the forest for timber purposes.

Over the years, a lot of forest exploitation had been carried out to meet the increasing demand for wood products. There has been rapid increase in the number of sawmills producing wood for construction activities. This has led to increased demand for wood raw materials by the wood-based industries in recent times, thereby outstripping the production capacity of the forests. Thus over-exploitation of forest resources for subsistence and

industrial purposes has been occurring in Nigeria. This may be deleterious to the country's economy and its environment. Since sawmill firms dominate the wood based industries, studies on the performances of this industry is expected to influence the forest economy as a whole. The efficiency and the scale of operation of the sawmill firms are likely to affect the wood based industry. The recent global concern about the environment and natural resources especially forest and forest products as critical factor of economic development calls for efficient exploitation, processing and utilization of these resources. The Nigerian forest can be more sustainable if the forest products are efficiently processed and utilized. What then are the factors affecting technical efficiencies in the sawmill industry? Is this technical efficiency in the sawmill industry affected by the scale of operation, and/or socio-economic factors?

There is a global concern about the environment and natural resources, especially renewable resources, as critical factors of economic development and growth in recent times. Forests have been the major source of livelihood for most Nigerians and the forest sub-sector is one of the main pivots on which the nation's welfare was built (Fuwape, 2001). According to Alviar (1983), the estimated log input capacity of the country's sawmills is more than 11million m^3 per annum or 97.4 percent of the total log input capacity of all the major wood processing industries. The sawmill firms employed over 16,000 workers (excluding maintenance and logging force) or roughly 82 percent of the total labour force in the wood processing industries (i.e. the plywood, pulp and paper, sawmill and veneer industries) in 1980.

Much research works have been done on forests and forest industries in Ondo, Lagos, Oyo and Ogun States (Fuwape, 2001; Ajayi, 2001; Adeyoju, 2001). However, very few researches have been conducted on forest industries; especially sawmill firms, in Osun State despite the high proportion of the country's sawlogs and sawnwood generated in the state. The state is endowed with vast forest reserves such as Shasha, Oni, Ife N.A., Ila, Ikeji-Ipetu, Oba Hill and Ago-Owu Forest Reserves. It is on this premise that this paper is intended to examine the performance of sawmill industry, with a view to suggesting ways of improvement in efficiency of sawnwood production and hence a reduction in wastes generated. This will eventually reduce the wood demand pressure on the forests. Furthermore, many of the past studies on the sawmill industry in Nigeria have used lumber recovery ratio as a measure of efficiency. This ratio has always given a deterministic value of the wood input-output relationship. However, in the real economic sense, input–output relationship is stochastic. This paper uses the stochastic production frontier model to determine the input-output relationship. This will capture the efficiency, and also identify the influence of the socio-economic factors on the efficiency of production among the small, medium and large-scale sawmill operators.

THEORETICAL MODEL

The stochastic production frontier also called 'composed error' model of Aigner et al. (1977) and Meeusen and van den Broeck (1977) is defined as

$Y_i = f(x_i; \beta) \exp(V_i - U_i); \; i = 1, 2, \ldots n$ ……(1)

This paper adopted the model described by Battese and Coelli (1995) which is expressed as:

$Y = x_{jit}\beta_j + (V_{it} - U_{it}), \quad ,i=1,...,N, \; t=1,...,T,$ ……(2)

and

$U_{it} = (U_i \exp(-\eta(t-T))), \; i=1,...,N, \; t=1,...,T,$ ……(3)

V is the usual symmetric random error term independently and identically distributed as N $(0,\sigma_v^2)$ which is intended to capture the influence of exogenous events beyond the control of the firm; U is one sided error which is assumed to capture technical inefficiency in production as a result of the socioeconomic factors. It is independently and identically distributed, such that U_{it} is obtained by truncation of the normal distribution with mean, $z_{it}\delta$ and variance, σ_u^2, i.e.

$U_i = z_i\delta + w$

Where w is a truncation of a normal distribution with zero mean and variance σ_u^2.

Z is a (1xm) vector of firm-specific variables;

δ is an (mx1) vector of unknown coefficients of the firm-specific inefficiency variables.

The technical efficiency of an individual firm is defined as the ratio of the observed output (conditional on the levels of inputs used and firm effects), to the corresponding frontier output. Thus the technical efficiency of firm i is

$$EFF_i = E[Y^*_I/U_i,x_i]/E[Y^*_I/U_i = 0,x_i] \quad (4)$$

$$EFF_i = \exp(-U_i) \quad (5)$$

$$Y^*_I = \exp(Y_I) \quad .(6)$$

and EFF will take a value between zero and one.

Y is the logarithm of the production of i-th firm; x is the logarithm of the j-th input of i-th firm; β is a K x 1 vector of unknown parameters;

The parameterization of Battese and Corra (1977) who replaced σ_v^2 and σ_u^2 with $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \sigma_u^2 / \sigma_u^2 + \sigma_v^2$ is followed. This is done with the calculation of the maximum likelihood estimates in mind.

Here η is set to be zero, which provides the time-invariant model set out in Battese et al (1989).

RESEARCH METHODOLOGY

Study area

The study was conducted in Osun State of Nigeria. The state is located in the Southwestern part of Nigeria. Since the sawmill firms are mostly located in the southwestern part of the country, the choice of the study area is therefore considered appropriate. Osun state is divided into two ecological zones i.e. the rain forest and the derived savanna zones. The study area reported in this paper is the rain forest zone where about 78% of the sawmill firms in the State are located.

Data source

The data set were basically primary. The data were collected on socio-economic characteristics of the sawmill managers, sawlog (input), sawnwood (output), land area of the sawmill firm, labour used, type and number of bandsaw, costs of establishment, revenue, other variable and fixed costs. These data were collected through the use of pre-tested sets of questionnaire, which were distributed to the sawmill managers (respondents).

Sampling procedure

Proportional random sampling method was employed. The preliminary survey revealed that there were one hundred and eighty three sawmill firms (locations) in the rain forest zone of Osun state. These were distributed as follows: 93 in Ikire, 76 in Ife and 14 in Ilesa Zones. Out of these, sixty firms (representing about one third of total) were proportionally sampled as follows: thirty one in Ikire, twenty four in Ife, and five in Ilesa.

Analytical techniques

The maximum likelihood estimation method was used to estimate the lumber production function and the efficiency of operation of individual firm. The model of stochastic frontier production function was implicitly stated as:

$$Y_i=f(X_i;\beta)\exp(v_i-u_i);\ i=1,2,3, \qquad (1)$$

The functional form adopted here was a variant of the stochastic frontier production function proposed by Battese and Coelli (1995), which builds hypothesized efficiency determinants into the inefficiency error component so that one can identify focal points for consideration in order to increase the efficiency levels.

$$\log Y = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \ldots \beta_n \log X_n + V - U \qquad (2)$$

Where X is a column vector of input variables; βs are unknown parameters; V is the random error component that is assumed to be normally distributed with mean zero and variance σ_v^2. U, which is non-negative is the error component representing the effect of technical efficiency and it is assumed to arise from normal distribution with mean μ and variance σ_u^2; which is truncated at zero. The efficiency effects are defined as a function of the firm specific factors:

$$m = \delta_0 + \delta_i Z_i \qquad (3)$$

They are then incorporated directly into the MLE. Z_i is a column vector of hypothesized efficiency determinants, and δs are unknown parameters to be estimated.

Where : Y = volume of sawnwood produced, X_1 = volume of softwood sawlog,

X_2 = volume of hardwood sawlog, X_3 = land area of sawmill, X_4 = labour used,

X_5 = Machine hour, X_6 = number of machines, U = Firm's specific characteristics related to production efficiency, V = statistical disturbance term.
m =inefficiency factor, Z_1 = family size, Z_2 = Manager's sex, Z_3 = Manager's age
Z_4 = level of education, Z_5 = income, Z_6 = income form other sources,
Z_7= membership of socio-group, Z_8 =Manager's experience, Z_9 = sex of owner,
Z_{10} = number of time of owner's visit, Z_{11} = firm's years of operation
Z_{13} = scale of operation, Z_{14} = number of labour and operator, Z_{15} = marital status,
Z_{16} = firm assets, Z_{17} = age of bandsaw machine.

RESULTS AND DISCUSSIONS

Empirical results for this model are presented in Tables 1 and 2. Table 1 shows the result of the stochastic frontier analysis. The Cobb-Douglas model was preferred to others because it has the highest LR test of the one sided error. The high LR test shows the presence of the one-sided error component. The implication of this is that the effect of the technical inefficiency is significant and a classical regression model of production function is inadequate to represent the data. The fact that gamma has very high value shows that the systematic influences that are unexplained by the production function are the dominant sources of random errors. The high significance of gamma confirms that the inefficiency parameter has a significant effect on sawnwood production.

The softwood log input, hardwood log input, labour used in the production process, number of band saw machines used and the time spent in the conversion of sawlog to sawnwood are the significant determinants of the sawnwood output in the sawmill industry. The betas are the elasticities of production.

$$\text{Log } Y = -0.009 + 0.358\log X_1 + 0.645\log X_2 + 0.001\log X_3 + 0.152\log X_4 - 0.051\log X_5 - 0.026\log X_6$$

(-0.537) (426.080)** (205.839)** (1.431) (67.680)** (-6.618)** (-8.173)**

Figures in parentheses below the coefficients are the asymptotic t- statistics.

** means significant at 5% level, $t_c = 2.02$

* means significant at 10% level, $t_c = 1.68$

The production function estimates indicated the relative importance of factor inputs in sawnwood production. Hardwood sawlog is the most important factor of production with an elasticity of 0.645 followed by softwood sawlog with an elasticity of 0.358. It is evident that sawlog is the limiting factor of production and that production could better be increased by an increase in sawlog than by increasing any other input. The next important factor is labour with an elasticity of 0.152, followed by the machine time with an elasticity of -0.051 and the number of bandsaw machines used in operation with an elasticity of -0.026. The negative elasticity indicates more or less a mis-match of fixed assets with the level of saw milling operations. Those mills with idle bandsaws can dispose them off without a reduction in their output.

Table 1 also shows the effect of the socio-economic factors on the technical efficiency of the firms.

$$m = 5.131 - 1.340Z_2 + 0.055Z_3 - 1.086Z_4 - 0.074Z_8 - 0.004Z_{10} + 0.087Z_{11}$$

(11.155)** (-3.267)** (2.880)** (-8.684)** (-5.048)** (-2.361)** (2.974)**

Table 1. Maximum-likelihood estimates for parameters of stochastic frontier production function for sawmill industry in the rain forest zone of Osun State, Nigeria.

	Parameter	Value of parameter	Asymptotic t-statistics
Constant	β_0	-0.009	(-0.537)
Softwood log	β_1	0.358	(426.080)**
Hardwood log	β_2	0.645	(205.839)**
Land area	β_3	0.001	(1.431)
Labour used	β_4	0.152	(67.680)**
Machine hour	β_5	-0.051	(-6.618)**
Number of machines.	B_6	-0.026	(-8.173)**
Constant	δ_0	-5.131	(-11.155)**
Manager's family size	δ_1	0.080	(0.746)
Manager's sex	δ_2	1.340	(3.267)**
Manager's age	δ_3	-0.055	(-2.880)**
Level of education	δ_4	1.086	(8.684)**
Manager's income	δ_5	-0.000007	(–1.458)
Manager's income from other sources	δ_6	-0.000003	(-0.654)
Membership of socio-group (dummy)	δ_7	0.065	(0.288)

Manager's experience.	δ_8	+0.074	(+5.048)**
Sex of owner	δ_9	-0.407	(-1.186)
Number of time of owner's visit	δ_{10}	0.004	(2.361)**
Firm's years of operation	δ_{11}	-0.087	(-2.974)**
Scale of operation (dummy: 0 = small scale, 1 = medium and large scales)	δ_{12}	0.356	(0.471)
Scale of operation (dummy: 0 = small and medium scales, 1 = large scale)	δ_{13}	0.838	(1.807)*
Number of labour and operator	δ_{14}	-0.250	(-3.089)**
Manager's marital status	δ_{15}	1.548	(4.096)**
Firm assets	δ_{16}	0.0000004	(5.698)**
Age of bandsaw machine	δ_{17}	-0.211	(-6.988)**
Diagnostic statistics			
Sigma-squared		0.200	(7.744)**
Gamma		0.999999	(21916032)**
Log likelihood function		88.814181	
LR test of the one-sided error		248.03273	
Total observations		60	

Source: Field survey, 2003
Notes: (1.) This statistic has a mixed chi-square distribution
(2.) ** 5% level of significance, t_c =2.02
(3.) * 10% level of significance, t_c =1.68

Table 2: Distribution of technical efficiency in the industry

Efficiency	Small Scale		Medium Scale		Large Scale		Industry	
	No of Firms	%	No of Firms	%	No of Firm	%	No of Firm	%
< 80	0	0.00	0	0.00	0	0.00	0	0.00
80-84.99	0	0.00	0	0.00	1	12.50	1	1.67
85-89.99	3	8.11	4	26.67	3	37.50	10	16.67
90-94.99	18	48.65	6	40.00	3	37.50	27	45.00
≥ 95	16	43.24	5	33.33	1	12.50	22	36.67
Total	37	100.00	15	100.00	8	100.00	60	100.00
Mean Efficiency	0.95073505		0.93064921		0.90116758		0.93910446	

Source: Field survey, 2003

$$-0.838Z_{13} + 0.250Z_{14} - 1.548Z_{15} - 0.0000004Z_{16} + 0.211Z_{17}$$

(-1.807)* (3.089)**
(4.096)** (5.698)** (6.988)**

Figures in parentheses below the coefficients are the t- statistics
** 5% level of significance.
- 10% level of significance.
-

The manager's marital status is the most important marginal factor of the efficiency in the sawmill industry. Married managers are more efficient than those who are not married. These married managers are likely to be more responsible and more committed to their work because of the family financial

needs which they must fulfill. The managers' sex is the next important

contributory factor of the efficiency in the industry. Male managers are more efficient than their female counterpart. This is consistent with the a priori expectation because these managers can assist other workers in carrying out sawmill operations that require physical strength such as off loading of logs from the truck, mounting the sawlog on the machine and other activities. The female managers cannot assist in these kind of operations which can result in operational inefficiency. Efficiency also increases as the level of education of the manager's increases. The more educated the managers, the higher the tendency of their firms to be efficient. It is obvious that education is an important factor to be considered in employing a manager. The educated managers possess better managerial skills that resulted in high efficiency. A large proportion of the managers of the large-scale firms acquired low level of education, but they have stayed in the business for a long time. The contribution of education factor to the efficiencies of the firms is significant to the trend of the efficiencies among the small, medium and large-scale firms as also dictated by the previous factors.

The next important factor is the scale of operation. Although the large-scale firms are less efficient than medium and small scale, the inefficiency in the large scale could be as a result of the inefficient use of the technical inputs. The per unit output of these firms could be higher due to the economies of scale, efficient use of the technical factors and the synergetic effect of these factors of production. The managers' efficiency also increases as the available workforce decreases. There are too many workers in the industry for the current level of output. This implies that labour should be released to other sectors of the economy or the current level of labour should increase its productivity. This will bridge the gap between the observed production level and the frontier production level.

Firms with older bandsaw machines are less efficient than those with newer bandsaw machines. Older machines have depreciated over time and are weaker than newer machines. Newer machines are easier to operate due to their improved technology. Therefore, saw-operators and managers prefer to work with firms with newer bandsaw machines. As the firms' years of operation increase, the efficiency decreases in the industry. This means that older firms are less efficient than younger firms. The older firms have stayed in the business for too long a period the 'wear and tear' of the equipments in the firm, and over time, had resulted in low efficiency levels. This low efficiency level is associated with the large-scale firms. Periodic renewal of the equipment will increase efficiency in the industry. Managers with greater years of experience in the sawmill business are more efficient than those of less years of experience. This is consistent with the *a priori* expectation because the technical know-how acquired over time is an advantage for efficient performance. Older managers tend to be less efficient than the younger ones. This is because younger managers are strong and active in assisting other workers to ensure efficient operation in the industry. These managers are dynamic and are equipped with current innovations. Firms that are visited more frequently by their owners are more efficient than those that are less visited. The presence of the owners prevents the managers and other workers from being lazy. The increase in number of times of owners' visits increases the firms' efficiency.

Also, an increase in firm assets will increase the efficiency levels of the firms. The firm assets like trucks, electric generator machine ensure that the bandsaw machine can be operated at installed capacity.

Table 2 shows the distribution of the technical efficiency of the firms in the industry according to the scale of operation. Given a technology to transform log input into sawnwood output, some managers are able to achieve efficiency close to 100 percent while others are not as technically efficient. Many of the managers in the small scale are more technically efficient than those of the medium and large-scale firms. About 8%, 27% and 50% of the managers in the small, medium and large-scale firms, respectively fall below 90% efficiency level. The average technical efficiency for the small, medium and large scales is 95.07%, 93.06% and 90.12, respectively. On the average, the small-scale firms are the most technically

efficient firms, while the large scale firms are the least.

CONCLUSION

This paper has shown that, on the average, the small scale firms are the most technically efficient while the large scale firms are the least technically efficient in the rain forest zone of Osun State, Nigeria. The socio-economic factors of manager's marital status, experience, age, sex, and level of education are the significant determinants of the efficiency in the sawmill operation. Other significant factors are number of bandsaw, number of available labour, age of bandsaw, years of existence of the firm, number of owners visit to the firm and firm's assets.

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