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Productivity and technical efficiency of palm oil extraction mills in Nigeria

S.O. Ojo

Department of Agricultural Economics & Extension, Federal University of TechnologyP.M.B. 704, Akure, Nigeria.
e-mail:drojoso@yahoo.com

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Abstract

The productivity and technical efficiency (T.E) of intermediate technology palm oil extraction mills were studied in Nigeria. One hundred mill operators were randomly selected from Okitipupa, Irele and Ese Odo Local Government Areas of Ondo State using a set of structured questionnaire. Data were analysed using descriptive statistics and stochastic frontier production function. The performance evaluation of the intermediate mills revealed that the mills had low capacity utilization (38.25%), averagely high extraction ratio (15%) and high extraction efficiency (83.33%). The stochastic frontier analysis revealed the presence of technical inefficiency effects as shown by the large gamma value (γ= 0.85). The study showed that the variables, namely, fresh fruit bunches (FFB) milled, labour and operating expenses were efficiently used. The variables of age and household size of mill operators led to decrease in T.E., but the other two variables, namely, experience and years of education led to increase in T.E. The predicted T.E. ranged between 0.32 and 0.95 with a mean of 0.75, indicating that the T.E. varied among the various mills and that they were relatively efficient.

Key words: Technical efficiency, intermediate technology, fresh fruit bunches, capacity utilization, extraction ratio, extraction efficiency.

Introduction

Oil palm production in Nigeria is in the hands of small scale farmers who are characterized by small holding, low production, poor resource base and low income [3] and hence the acquisition of the expensive high technology mills for palm oil extraction is almost impracticable. The farmers thus resort to the use of traditional method for the extraction of palm oil.

The traditional method entails boiling or fermenting and pounding of the fruits by using mortals and pestles, cooking of foaming oil and collection of the oil. The palm oil extracted, using the traditional method, is usually of low quality, that is, high in free fatty acid (ffa) and of low extraction efficiency. The method is slow, labour intensive and can only cope with relatively small quantity of fruits. It is wasteful and can only extract about 55% of palm oil content of the fruits [5].

The high technology mill is completely automated with extraction ratio as high as 18-24% and with capacity ranging between 1 and 20 metric tons per hour. The stork type is in this category. The palm oil from this type of mill has good quality with low ffa and low moisture content. The method is fast and uses less labour and can handle a large quantity of FFB at a time.

The intermediate technology mill is a combination of traditional and modern mills. It utilizes all the principles of modern milling technology but the operations of the different mechanical components are manual. Palm oil got from it is of average quality. The major equipment involved is the digester, press (screw or hydraulic), axe, spades, shovel, rake, cutlasses, drums for cooking fruits and clarification of oil and a 6 or 8 horsepower engine. The adoption of the intermediate technology mills is a welcome development for it ensures increased palm oil extraction efficiency, and high quality palm oil apart from its acquisition being within the reach of the average small farmer. A standard unit could be procured at a price not exceeding ₦100,000 ($1000).

This paper examines the performance, productivity and technical efficiency of intermediate technology palm oil extraction mills in Nigeria. The study tested for the presence of inefficiency effects in their production and the influence of some socio-economic characteristics of the mill owners/operators on the technical efficiency of the mills.

Methodology

Study area: The study was based on cross sectional data collected from palm oil extraction mills in Okitipupa, Irele and Ese Odo Local Government Areas of Ondo State, Nigeria. This area was chosen because oil palm is the main permanent crop grown and it plays a dominant role in the socio-economic activities of the people in particular and the state at large. There are two big oil palm companies in the area, namely, Okitipupa Oil Palm PLC, Okitipupa and Ore Irele Oil Palm Company with oil palm plantations totaling about 18,743 hectares. The activities of these oil palm companies and government oil palm revamping strategies through the small holders management unit (SMU) have actually encouraged the small scale farmers to adopt the cultivation of oil palm as their main permanent crop.

Data collection and sampling techniques: Primary data were collected using structured questionnaire administered on 100 operators/owners of the intermediate technology palm oil extraction mills. The operators were randomly selected using random sampling technique.

Method of analysis: Both descriptive statistics and quantitative methods were used. The quantitative technique used in this study was the stochastic frontier production function. The stochastic frontier function assumes the presence of technical inefficiency effects in the production function, that is, it assumes the error term has two components, V and U. The V is a white noise, which covers random effects on production outside the control of the decision unit. It is normally, independently and identically distributed with zero mean and constant variance (σ_v^2) and independent of U. The U is an asymmetrical component, which measures technical inefficiency and is assumed to be the result of behaviour factors, which come under the control of the decision unit. It is non-negative half normal distribution with zero mean and constant variance (σ_u^2)[7].

For this study, a Cobb-Douglas function of the following form was specified, thus:

$$\text{Log } Yi = \beta_0 + \Sigma\beta_j \log X_{ij} + V_i - U_i$$

where Yi = Quantity of palm oil produced in tons by the i^{th}-mill
j = inputs 1, 2, 3, 4 as stated below
X_1 = FFB milled metric tons (mt)
X_2 = Labour used in mandays
X_3 = Operating expenses (fuel and lubricant, repairs and maintenance of mill components) in Naira (₦)
X_4 = Other costs (depreciation on capital inputs) in naira
V_i and U_i are as defined above.
The σ_v^2 and σ_u^2 are the variance of the parameters V and U.

The variance of the general model is $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and the ratio of the two standard errors (λ) or the ratio of the inefficiency variance and the general model variance (γ) as used by Jondrow et al.[4] defined the total variation of output from the frontier which can be attributed to technical efficiency [1] that is, $\lambda = \sigma_u/\sigma_v$ or $\gamma = \sigma_u^2/\sigma^2$.

On the assumptions that V_i and U_i are independent and normally distributed, the parameters of the production function are estimated by a three step procedure maximum likelihood estimation technique using the program, Frontier 4.1 [6]. The technical efficiency of the i^{th} mill, given the specifications of the model was estimated by using the expectation of U_i conditional on the random variable (V_i-U_i) as shown by Battese and Coelli [2] that is,

$TE = \exp(\beta_j X_{ij} + V_i - U_i)/\exp(\beta_j X_{ij} + V_i) = \exp(-U_i)$
so that $0 \leq T \leq 1$.

The inefficiency model: The U_i are the technical inefficiency effects. For this study, they were defined thus $U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4$ where Z_1, Z_2, Z_3, and Z_4 represent age, years of experience, level of education and household size respectively of the owner/operator of the intermediate mills. They were included in the model to know their influence on the technical efficiency of the mill operators. The σ_v^2, σ_u^2, σ^2, β's, γ, δ's are unknown scalar parameters to be estimated.

Results and Discussion

Performance evaluation of the intermediate mills: Mill performance was examined using the following criteria: capacity utilization, extraction ratio and extraction efficiency. Table 1 shows the summary of performance evaluation of the mills. The average capacity utilization of the mills was 38.25% of installed capacity with large variability as depicted by the standard deviation. It is low and since capacity utilization is a function of time utilization, which is affected by factory downtime or field out of FFB, the main cause of low capacity utilization was shortage of fruits brought to the mills.

The extraction ratio (ER) is the index of palm oil produced from a quantity of fruits processed. The average ER was 15% with a standard deviation of 1.76% (Table 1). It is a significant improvement on the traditional mills whose extraction ratio could be as low as 5% but it is still far less compared with an average ER of modern mill of 17.69% from Ipoke mill of Okitipupa oil palm PLC[5].

The extraction efficiency (EE) is the ratio of palm oil obtained to the amount obtainable from the same quantity of fruits. It is a function of the extraction ratio, fruit type and efficiency of supervision of the milling operations. For the study the extraction efficiency of the mills was high with the average being 83.33% with a low variability depicted by the standard deviation of 5.93% (Table 1).

Table 1. Summary of performance evaluation of mills.

Variable	Mean	Standard deviation
Capacity utilization (%)	38.25	25.72
Extraction ratio (%)	15	1.76
Extraction efficiency (%)	83.33	5.93

Summary statistics of variables used in the stochastic frontier model: The summary statistics of variables used in the stochastic frontier model are presented in Table 2. The average quantity of fruits handled by each mill was 295.01 metric tons per annum with a standard deviation of 157.95 tons implying that the quantity of fruits handled by each mill was small. The average output of palm oil was 44.25 mt, which means that the average extraction ratio was 15%. Labour utilization was an average of 650 mandays per annum implying that about 14.69 mandays were used to produce a ton of palm oil. The average operating expenses were ₦45,050 implying that an average of ₦1018.08 was used as operating expenses to produce one ton of palm oil. The average age of the mill owners was 47 years implying the mill owners were middle-aged people. They have large household sizes, average of seven years of experience in operating the mills and are educated with about twelve years of schooling.

Estimates of stochastic frontier model: The maximum likelihood estimates of the frontier model for the preferred model are presented in Table 3. The coefficients of FFB milled, labour and operating expenses were decreasing positive function to the factors implying that those factors were efficiently used. FFB milled and labour variables were significant at 5% level. The

Table 2. Summary statistics of variables of stochastic frontier model.

Variable	Mean	Standard deviation
Output (metric tons)	44.25	16.95
FFB milled (mt)	295.01	157.95
Labour (mandays)	650	303
Operating expenses (₦)	45050	15900
Other cost (₦)	28500	7685.82
Age of mill owners (years)	47.5	10.22
Experience (years)	6.9	5.45
Level of education (years)	12	7.5
Household size	12	10.74

coefficient of other costs was a decreasing negative function of the factor, implying over-use of the factor. The returns to scale (RTS) estimate of mills was 0.55. This implies that the operations of this category of mills were efficient since it fell within stage II of the production region.

Technical efficiency analysis

Presence of inefficiency effects in mill operations: The analysis of the variance parameters shows that the estimate of sigma squared (σ^2=0.049) was large and significantly different from zero, indicating a good fit and the correctness of the specified distributional assumptions (Table 3). The gamma estimate was large (γ=0.85) and significant at 5% level indicating the presence of technical inefficiency effects in the operations of the mills. The high value of γ indicates that about 85% of the variation in output of the mills was due to technical inefficiency effects and not to random effects.

Table 3. MLE for parameters of stochastic frontier model.

Variable	Parameter	Coefficient	T-ratio
General model			
Constant	β_0	2.75	1.5
FFB milled	β_1	0.62*	4.25
Labour	β_2	0.05*	2.51
Operating expenses	β_3	0.01	1.75
Other cost	β_4	-0.13	-0.75
Inefficiency model			
Constant	δ_0	9.50	5.65
Age of mill operator	δ_1	2.05*	3.06
Experience	δ_2	- 0.58*	-2.15
Education	δ_3	-1.23*	-3.92
Household size	δ_4	0.55	1.76
Variance parameters			
Sigma squared	σ^2	0.05*	7.0
Gamma	γ	0.85*	15
Log likelihood fcn	LLF	22.57	

*Estimate is significant at 5%

Technical efficiencies: The study revealed that the technical efficiencies of the mills varied substantially and ranged between 0.32 and 0.95 with a mean value of 0.75 indicating high relative technical efficiency. Thus in the short run, there is a scope for increasing the performance of intermediate technology palm oil extraction mills by 25% by adopting the technology and techniques used by the best practiced mills. These technologies and techniques include acquisition of a 6 or 8 horsepower lister engine, hydraulic press and ensuring adequate sourcing of palm fruits by owning oil palm plantations as well as purchasing more palm fruits from the oil palm estates and leasing oil palm farms to improve capacity utilization.

Inefficiency model: The estimates of the inefficiency model (Table 3) throw light on the effects of the socio-economic characteristics of the mill owners on the TE of the mills. The coefficients of age and household size were positive indicating increase in technical inefficiency. In other words, higher age and household size led to decrease in TE of the mill owners. The average age of 47 years of mill owners indicates the mill owners are relatively young (middle aged) men who are still restless in pursuing other moneymaking ventures other than making mill operation a major occupation. Their involvement in other businesses such as farming, government jobs and trading reduces the intensity of their supervision of the palm oil extraction mills.

The negative effect of household size on TE is explained by the use of family labour for some mill operations. Mill owners with a larger proportion of their labour supply got from the family source reveal lower TE than those that employed hired labour. This is because since the mill owners do not pay directly for the family labour used they tended not to be economical with this category of labour and also workers in such category were not effectively supervised. On the other hand, years of experience and education coefficients were negative indicating that the higher the years of experience and education, the less the technical inefficiency. That TE increases with education is due to the fact that the better educated the mill owners the more readily they adapt to changes in their business environment. The average years of schooling of twelve years indicates that the mill owners are well informed and could readily source for information that would improve their operations.

Also, that experience in mill operation increases TE is explained by the fact that experience is a better teacher. With an average experience of seven years doing an almost routine job in mill operations, the operators are expected to have mastered how to do most of the operations efficiently so as to have positive influence on their TE.

Summary and Conclusions

The study revealed that the intermediate technology mills had low capacity utilization, high extraction ratio and high extraction efficiency. The study also revealed that FFB milled and labour were the most significant variables in the operations of the mills and increasing their use would lead to increase in output. The TE analysis showed the existence of technical inefficiency effects in the mill operations. The TE varied between 0.32 and 0.96 with a mean of 0.75 indicating a relatively high TE. The technical inefficiency analysis showed that experience and education led to decrease in technical inefficiency. The study thus concluded that the intermediate technology mill was technically efficient in the study area. The mill owners should expand their sources of FFB through establishment of oil palm farms and purchasing of fruits to increase their production, productivity and TE.

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