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Analysis of the Technical Inefficiency of Gum Arabic Based Cropping Patterns among Farmers in the Gum Arabic Belt of Nigeria

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ABSTRACT

Causes of technical inefficiency in gum arabic based cropping patterns among farmers in the gum arabic belt of Nigeria were studied by selecting 166 gum arabic farmers through purposive and simple random sampling techniques. Data collected were analyzed using descriptive statistics and stochastic frontier production function analysis. Results of the analysis indicated that majority of the farmers (67.47%) intercropped immature plantation with high yielding varieties of arable crops. The variance parameters of the stochastic frontier production function; sigma squared (δ^2) and gamma (γ) is significantly different from zero at one percent probability level. The mean technical efficiency (TE) of gum arabic farmers was 0.97. Considerable variations in TE indices existed with 46.67% of the farmers with TE index below the mean figure, while 53.33% attained TE of more than the average. Family and hired labour were statistically significant. It was also revealed that the causes of technical inefficiency (age, family size & farming experience were estimated to be – 0.321, – 0.234 & –0.233 & affect efficiency positive but not significantly). However, the coefficient for education and status of gum arabic culvation variables were statistically significant and enhances the TE of the farmers. It is recommended that encouraging organized planting of gum arabic and educating the farmers would enhance efficiency of production.

Key Words: Technical inefficiency; Gum arabic belt; Cropping patterns; Stochastic frontier; Nigeria

INTRODUCTION

Gum arabic (*Acacia* species) is the dominant leguminous tree crops that belong to the family *Mimosaceae. Acacia. senegal* and *A. seyal*, which are the most commercially exploited species of the whole Acacia family. Gum arabic thrives well in entisols and inceptisal soil types. The soils are sandy, droughty and low in organic nitrogen and have low cation exchange capacity. It can tolerate a wide mean annual temperature of between14^{o}C and 43^{o}C with a rainfall of 800 mm annually. A best performance was recorded in areas with mean annual rainfall of 300 – 450 mm annually (Aghughu, 1998). Gum arabic is a non-cultivated product, which is largely under exploited in spite of a strong production potential in Nigeria. Production in Nigeria is largely from the wild except in Borno, Yobe Jigawa where large plantations of several hectares were established. The gum arabic belt in Nigeria is the Sudano-sahelian l zone of the country. The states in the zone are Adamawa, Bauchi, Gombe, Taraba, Katsina, Kebbi, Zamfara, Sokoto, Plateau and Nasarawa states. The gum is useful in industrial application such as food and beverages, pharmaceuticals, cosmetics and textiles. The tree has the potentials of improving soil fertility through the dropping of its leaves; pods are valuable sources of livestock feeds (Duke, 1997; Hayward, 2004). Gum arabic is an important revenue earner for the country, production varied due many factors (Table I). The use of intercropping of immature gum arabic plantation with arable crops is recommended for effective utilization of land resources and it is expected to motivate farmers adopt gumarabic innovations.

Considerable research has been conducted using the stochastic production frontier (Battese & Broca, 1977; Tran *et al.*, 1993; Tadesse & Krishnamoorthy, 1997; Ojo & Imoudu, 2000; Amaza *et al*., 2001). Many of them examined technical efficiency of production in other crops and gum arabic based intercrop has been limited in Nigeria. Therefore, this study was conducted to analyse the causes of technical inefficiency in Gum arabic based cropping patterns among farmers in the Gum arabic belt of Nigeria.

MATERIALS AND METHODS

The study was conducted in some selected Local Government Areas of Yobe and Jigawa States. Bade,

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Damaturu, Gujba, Nguru, Yusufari and Karasuwa Local Government Areas were selected in Yobe State while Gumel, Sule Tankarkar, Kazaure, Ringim, Garki, Mallam Madori and Hadejia Local Government Areas in Jigawa State, respectively. The sites are suitable for the cultivation of gum arabic in the States.

Data collection and sampling techniques. Primary data were collected using multi- stage, purposive and random sampling techniques. Stage one is the purposive selection of North East and North West Zone of the gum arabic belt of Nigeria. Stage two involved the selection of Jigawa and Yobe States purposively. It was followed by the random selection of six and seven major gum arabic producing Local Government Areas of Yobe and Jigawa States. The final stage involved the random selection of farmers from the villages of the Local Government Areas proportionate to the population of gum arabic farmers. A total of 130 gum arabic farmers were obtained and served with structured questionnaires supplemented with oral interviews. One hundred and sixteen (116) farmers (76 from Jigawa & 90 from Yobe) were eventually used. Data collected were analysed using descriptive statistics and stochastic frontier production function analysis. 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 & Olayemi, 1999).

Russell and Young (1983) stated that technical inefficiency arises when less than maximum output is obtained from a given bundle of factors and allocative inefficiency arises when factors are used in proportions that do not lead to profit maximization. Efficiency measurement is important, because it leads to a substantial resource savings. Efficiency measurement is important for the three main reasons: Firstly, it is a success indicator and performance measure by which production units are evaluated. Secondly, the exploring of hypothesis concerning the sources of efficiency differential can only be possible by measuring efficiency and separating its effects from the effects of the production environment. Thirdly, identification of sources of inefficiency is important to the institution of public and private policies designed to improve performance (Ogunjobi, 1999).

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 affects production (Tran *et al.,* 1993).

It is specified as:

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

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.

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

$$\text{Log } Y_1 = \beta_o + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + V_i - U_i \ldots\ldots\ldots (2)$$

Where, Y_1 = Output (kg of gum arabic) of the ith farmer, X_1 = Farm size (hectares), X_2 = Family labour (man days), X_3 = Hired labour (in man days), 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 $(0, \sigma^2_u)$.

The inefficiency model is defined by:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 \ldots\ldots\ldots (3)$$

Where, U_i = Inefficiency effect, Z_1 = Age of farmer (in years), Z_2 = Status of cultivation, Z_3 = Family size (total number of persons in household), Z_4 = Education (in years), Z_5 = Farming experience(years), Z_6 = Gender. Yilmaz and Ozkan (2004) and Giroh *et al.* (2007) adopted the use of dummy variables for structural comparison in their studies. In this paper, gender of farmers and status of cultivation were included as dummy variables. This approach was preferred to benefit from using all data as a whole. As gender and status of cultivation were qualitative variables. They took the values of 1 in the case of male and organized plantation and the value of 0 in the case of female and wild or non-organized plantation, respectively.

The Maximum Likelihood Estimates (MLE) of the stochastic frontier production function was obtained using the computer program frontier 4.1 (Coelli, 1994).

RESULTS AND DISCUSSION

The Maximum Likelihood Estimate (MLE) of the parameters of the stochastic frontier model of gum arabic farmers is shown in Table II. 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 are represented by sigma squared (δ^2 and gamma (γ). The sigma squared in Table II is 0.051 and significantly different from zero at one percent level. This indicated a good fit and correctness of the distributional form assumed for the composite error term. Gamma indicates that the systematic influence that are unexplained by the production function are the dominant sources of random error .The gamma estimate which is 0.96 shows the amount of variation resulting from the technical inefficiencies of gum arabic farmers. This means that more than 95% of the variation in farmers' output is due to difference in technical efficiency. Typical of the power function (Cobb-Douglas), the estimated coefficients for the

specified function can be explained as the elasticities of the explanatory variables. Except for farm size and hired labour, the sign of the slope coefficients of the stochastic production frontier are positive. The negative coefficient for hired labour is consistent with *apriori* expectation.

The mean technical efficiency (TE) of gum arabic farmers is 0.97 (97%) implying that the farmers are not fully efficient as the observed output is 3% less than the maximum output. Also, 46.67% of the farmers have TE index below the mean figure while 53.33% attained TE of more than the average. This result shows that for Nigerian gum arabic farmers TE is higher than the mean TE of 0.59 and 0.72 reported in Vietnamese and Nigerian rubber farms (Tran *et al.,* 1993; Giroh, 2007).

The estimate of the parameters of the stochastic production frontier indicated that elasticity of output with respect to family labour is positive and approximately 0.642 and it is statistically significant at 1% level. This implies that family labour is a positive and significant factor that influences the output of gum arabic farmers. An increase of one percent in family labour will result to an increase in output by 0.642%, ceteris paribus.

Measurement of technical inefficiency. The existence of technical inefficiency provides a good ground to find out the sources of inefficiencies for gum arabic in the study area. Variations in TE of the farmers may arise from their characteristics and the existing technology. Socio-economic variables were considered and estimated in the model and result is presented in Table IV The signs and coefficients in the inefficiency model are interpreted in the opposite way such that a negative sign means the variable increases efficiency and vice versa. The result of the inefficiency model shows that the coefficients of the efficiency variables with the exception of family size and gender have the expected signs. The coefficients for age, status of cultivation of gum arabic, family size and farming experience were estimated to be – 0.321, – 0.234 and – 0.233, respectively implying that they affect efficiency but not significantly. However, the coefficient for education variable is estimated to be negative (-0.212) and statistically significant at five percent level. This implies that education enhances efficiency of farmers. With education, farmers could be able to read and understand instructions on agricultural innovation and can easily adopt them for enhanced productivity.

Cropping combination. Majority of the farmers (67.47%) intercropped their plantations with improved varieties of arable crops while only 32.53% had sole planting (Table III). The improved cultivars are those of early and medium maturing varieties of *vigna unguiculata* (cowpea), *arachis hypogea* (groundnut), sorghum, millet and sesame. The cereals in the combination (sorghum, millet) are agriculturally beneficial and compatible as the gum arabic plant provided nutrients by their nitrogen-fixing bacteria in the root nodules of the plants. This implies that farmers have put to the productive utilization of the land resources as the labour used for arable crop maintenance is also used for the gum arabic saplings. Farmers who practiced sole cropping may loose economically, sole cropping in gum arabic should be discouraged the intercropping with arable crops as an improved practice may perhaps motivate farmers to adopt gum arabic and its allied technology. This finding

Table I. Nigeria gum arabic statistics (1995 – 2003)

Year	Quantity(metric tonnes)	Values(000US $)	Unit value(US $)
1995	4866	8793	1807
1996	15963	13257	748
1997	12034	8999	830
1998	9875	6571	748
1999	11386	6600	665
2000	11700	7400	580
2001	10800	6800	632
2002	9300	5200	559
2003	9703	5511	568

Source: FAO STAT various reports

Table II. Maximum likelihood estimate of parameters of Cobb – Douglas stochastic frontier production function for gum arabic farmers

Variable	Parameter	Coefficient	T.value
Constant	β_o	7.51***	8.41
Farm size	β_1	-0.012	-0.28
Family labour (man days)	B_2	6.415***	7.48
Hired Labour (man days)	B_3	-7.74***	11.31
Inefficiency model			
Constant	δ_0	0.269	0.29
Age	δ_1	0.321	- 0.48
Status of cultivation	δ_2	- 0.234*	- 1.82
Family size	δ_3	0.044	0.31
Education	δ_4	- 0.212**	- 2..63
Farming experience	δ_5	- 0.233	- 0..24
Gender	δ_6	0.100	0.18
Variance parameter			
Sigma squared	δ^2	0.051***	8.86
Gamma	γ	0.96***	10.65
Mean TE	0.97		

Source: Field survey, 2006*** Significant at 1percent** Significant at 5 percent

* Significant at 10 Percent

Table III. Distribution of gum arabic farmers by cropping patterns

Cropping pattern	Number	Percentage
Sole cropping	54	32.53
Intercropping	112	67.47
Total	166	100

Table IV. Frequency distribution of technical efficiency of gum arabic farmers

Range of TE	Number	Percentage of farms
≤ 0.96	77	46.67
0.96 - 0.97	80	48.19
0.98 – 1.00	9	5.14
Total	166	
Mean	0.97	
Minimum	0.95	
Maximum	0.98	

Source: Field survey, 2006

lends support to studies that intercropping has been found to be of economic benefits to rubber farmers in Nigeria and other rubber producing countries of the world (Esekhade *et al.,* 1996; Schroth *et al.,* 2004).

CONCLUSION

The study has identified that age, family size and farming experience affect efficiency but not significantly. However, statuses of cultivation of gum arabic and education have significant effects on technical efficiency at various probability levels. Encouraging farmers to plant gum arabic in organized plantations and educating them would enhance the efficiency of farmers. With education, farmers could be able to read and understand instructions on agricultural innovation and can easily adopt them for enhanced productivity. Majority of the farmers also practiced intercrop combination that is agriculturally compatible and farmers tend to benefit economically.

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