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Full Length Research Paper

Technical efficiency of beekeeping farmers in Tolon-Kumbungu district of Northern region of Ghana

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This paper investigates technical efficiencies of beekeeping farms and their determinants, using stochastic production frontier function, in Tolon-Kumbungu district of Northern region of Ghana. Primary data were collected using a multi-stage sampling technique on 48 respondents. Results show that the mean technical efficiency of the beekeeping farms is 0.894. Most of the respondents are also fairly efficient in the use of available resources. The most important factors, which determine technical inefficiency, are age, main occupation and membership of social group of the honey producers. Although, the beekeepers were found to be generally fairly efficient, there is room for improvement in the use of available resources under a guaranteed and conducive environment.

Key words: Technical efficiency, bee keepers, returns to scale.

INTRODUCTION

The need to tackle unemployment and improve the standard of living by increasing the income of the populace has led to the promotion of various types of small-scale income generating activities, one of which is beekeeping. Modern honey production commonly known as Beekeeping and scientifically known as Apiculture can be defined as the practice and management of bees in a hive in such a way that it will be observable for its developmental stages and manipulation (Ojeleye, 2003).

Beekeeping probably began at different times in different part of the world (National Honey Board, 2004). Many agree that the first evidence of beekeeping appears in the painting of ancient Egypt, dating back to around 2500 BC (NHB, 2004). No one knows when the first human became a beekeeper but the Reverend L. L. Langstroth who developed a wooden hive in 1862 known as Langstroth hive and which still bears his name up to date is designated the Father of Modern Beekeeping (Caron, 1999). The Langstroth hive is based on the simple principle of surrounding movable frames with a “bee-space”– an area just large enough to discourage bees from gluing their combs solidly to the walls. Until recently, modern beekeeping was almost non-existent in Ghana. The country’s’ crude honey produced each year come mostly from honey hunters and a few traditional bee farmers. Traditionally, honey bees in Ghana are kept in clay hives, wooden reeds and hollow tree trunks and so harvesting was done on instincts, on the type of aroma around the hives and on the weather condition at a specific period of the year.

The contribution of modern or improved beekeeping to honey production started in the 70s when the top-bar hive was introduced in Ghana. The Technology Consultancy Centre of Kwame Nkrumah University of Science and Technology, Kumasi played a leading role in this event. Currently many beekeeping projects have been carried out by development organizations to improve the income levels of rural communities. These include World Vision International (WVI), Adventis Relief Agency (ADRA), TECHNOSERVE, OIC etc. Ghana now has about 5000 beekeepers with an average of five hives per person. Working on an average yield of 14 kg honey per beehive per year, beekeepers provide about 70 metric tonnes of honey on to the Ghanaian market (Aidoo, 2005).

Problem statement

Ghana has good potentials for honey production. The tropical climate with varying agro ecological conditions ensures the availability of flowers from numerous species

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of wild and cultivated plants throughout the entire year from which honey bees can forage for food (nectar and pollen). Despite these potentials, Beekeeping as a commercial venture is still rudimentary in Ghana.

The country only meets the domestic demand for honey mostly by importation from other countries as several types of imported bottles of honey can be found in supermarkets and shops across the big cities of the country. Furthermore, it is estimated that about 60% of honey produced locally in Ghana is harvested from the wild by honey hunters (Aidoo, 2005) and thus the quality of the honey is poor.

This is as a result of the crude harvesting techniques employed by these honey hunters. Sometimes too, the available honey is adulterated in order to increase the quantity and meet local demand. When it is not adulterated, that is, pure honey, the price per kg is so high that most people cannot afford it. For instance, a kilogram of pure honey is priced at GH¢6 (Aidoo, 2005) and GH¢7 (OIC, 2010), respectively.

Efficiency measurement have received considerable attention from both theoretical and applied economics in Ghana. However, little attention has been directed to beekeeping and to the various components of efficiency of the Beekeeping industry despite the availability of a number of techniques for estimating efficiency components of production units. This paper therefore attempts to bridge this gap by focusing among other things, on firm level technical efficiency measurement in modern honey production. Technical efficiency measurement provides the much needed information which gives useful insight into the potentials for improved performance as well as the possibility of increasing the output of honey. The study estimated technical efficiency among a sample of beekeepers in the Tolon-Kumbungu district of Northern region of Ghana.

METHODOLOGY

The study area

Tolon- Kumbungu district is in the northern region of Ghana. It is in savannah zone and occupies the western part of the region. The district covers an area of about 2.741 km^2 and thereby forming about 3.09% of the total land area of the region. It shares administrative and political boundaries with the West-Mamprusi district to the north, West- Gonja to the west, Savelugu- Naton district and the Tamale Metropolis to the east. The total population of the district is 135,084 (Ghana Statistical Service, 2002) representing 6.8% of the total population of the Northern region. The total population is made up of 67,590 female and 67,494 males with an estimated annual growth rate of about 4%.

The Tolon-Kumbungu district like other districts in the savannah zone experiences one major rainy season, thus, from April to October and often followed by a long dry and sunny season. The climate of the district is suitable for beekeeping with average monthly rainfall of 140 to 250 mm which is within the recommended range by FAO (1990), 125 to 1875 mm per annum. The main wet season records about 950 mm amount of rainfall and it occurs between May-September. The mean temperature ranges between 17 and 40ºC depending on the season. The main economic activity in the area is agriculture (farming). It is estimated that between 60 to 70% of the total population are engage in the agricultural sector. Subsistence and peasant agriculture remain dominant in the area.

The main crops grown are cassava, yam, maize and millet. Industrial crops like groundnuts, tobacco, cotton and jute are also grown in the district. However, the irrigation sites at Buntanga and Golinga are used for the cultivation of vegetables and other food crops such as rice, beans etc.

Data collection and sampling procedure

The primary data used for the study were collected during the 2010/2011 production year through structured questionnaires. A multi-stage sampling technique was used for the study. The first stage was to identify and select at random, communities where beekeeping is being practiced. The second stage was to use a purposive sampling to get a respondent. A snowball sampling was the final stage used to select other respondents. Out of the 50 bee farmers sampled to be interviewed, only 48 of them responded to the questionnaires and were subsequently used for the analysis. The data collected focused on the following: Data on output level, number ofhives and top bar frames, cost of beekeeping equipment and their useful live were obtained. Type of labour and cost of honey per gallon were also obtained.

Analytical framework and techniques

The analytical tool employed in this study emanates from the framework of productive efficiency. This is based on the attainment of production goal without waste. The fundamental idea underlying all efficiency measures however, is that of the quantity of goods and services per unit of input (Ajibefun and Daramola, 1999). There are two basic methods of measuring technical efficiency: the classical and the frontier approach. Controversies and dissatisfaction with the shortcomings of the classical approach led economists to develop advanced econometric, statistical and linear programming techniques aimed at analysing technical efficiency related issues. All of these techniques have in common, the concept of a frontier. This implies that efficient firms are those operating on the production frontier, while inefficient firms are those operating below the production frontier. The amount by which a firm lies below its production frontier is regarded as the measure of inefficiency. The frontier approach to efficiency dates back to the earliest work of Farrell (1957). Various transformations have been made on frontier production function in considering the possibility of its estimation.

Literature on the application of this is found in the works of Battese (1992), Bravo-Ureta and Pinheiro (1993) and Coelli (1995) among others. They are (the works elicited above) however efforts to bridge the gap between theory and empirical works. There exist the single and two-stages of analysing the technical inefficiencies of firms (Kumbhakar et al., 1991). However, works of some authors in the last decade of the last century, for example, Huang and Lui (1994) and Battese et al. (1996) have challenged the theoretical consistency of the two-stage analytical techniques in the investigation of the sources of technical inefficiencies in different industries. They have therefore proposed the use of stochastic frontier specifications, which incorporate models for the technical inefficiency effects and simultaneously estimate all the parameters involved.

The analytical model applied to the data collected for this study considered specifications related to those of Battese et al. (1996) and Ajibefun and Daramola (1999) among others. The empirical stochastic production frontier model (via Cobb-Douglas) applied in the analysis of Technical Efficiency of honey production is specified as follows:

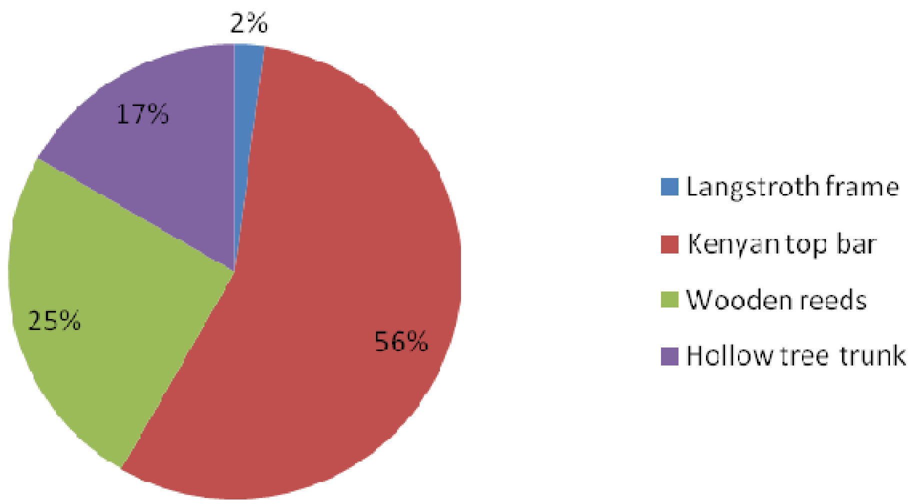

Figure 1. Type of hive (Source: Field survey, 2011).

$$lnY_i = \alpha_0 + \alpha_1 X_{1i} + \alpha_2 X_{2i} + \alpha_3 X_{3i} + \alpha_4 X_{4i} + V_i - U_i \quad (1)$$

where i (I = 1, 2... n) represents the *ith* sample farm, j(j = 1, 2, 3, 4) represents the *jth* independent variable, ln denotes logarithm to base e, Y = Quantity of honey produced in the season (in gallons), $\alpha_0 - \alpha_j$ = Coefficients to be estimated, X_{ji} = Independent variable j (j = 1, 2, 3, 4) as follows: X_1 = Number of hives, X_2 = Labour use in man-day, X_3 = Number of top bar frames, X_4 = Extension service, V_i = Stochastic disturbance term, U_i = Technical inefficiency term.

However, technical inefficiency is assumed to be explained by;

$$U = \delta_0 + \delta_1 Z_1 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + \delta_6 Z_6 \quad (2)$$

where U_i = Technical inefficiency term (The U_is are nonnegative random variables and are associated with technical inefficiency of production of the respondent farmers), $\delta_1 - \delta_6$= Coefficients to be estimated, Z_1 = Age in years, Z_2 = Educational level in years, Z_3 = Marital Status (1 if married; 0 otherwise), Z_4 = Major occupation (1 if farming; 0 otherwise), Z_5 = Membership of social group, Z_6 = Number of years of experience in honey production.

In this study, parameters of the stochastic frontier production function are estimated using maximum likelihood estimation method, using the computer program; STATA (Version 9). The maximum likelihood estimated of (1) provides estimators for the α's as well as the variance parameters (σ^2,γ,λ). The following relationships are worth noting according to Battese and Corra (1977):

$\sigma^2 = \sigma_u^2 + \sigma_v^2$, $\gamma = \sigma_u^2 / \sigma^2$ or $[\lambda^2/(1+\lambda^2)]$ and $\lambda = \sigma_u / \sigma_v$

The parameter γ has the value between zero and one, that is, $0 < \gamma < 1$ (Battese and Tessama, 1993). According to Battese and Corra (1977), γis the total output attained at the frontier which is attributedto technical efficiency. Similarly, 1- γ measures technical inefficiency of the beekeepers (Awoyinka and Ikpi, 2005). The parameter λ is expected to be greater than one. Such a result according to Tadesse and Krishnamoorthy (1997) indicates a good fit for the model and the correctness of the specified distribution assumptions for Vi and Ui. σ^2 is expected to be statistically significant.

RESULTS AND DISCUSSION

Descriptive analysis

The study was carried out in fourteen communities and target groups were bee farmers. In all, 48 farmers responded to our questionnaire and subsequently used for the analysis. Interestingly, all the bee farmers interviewed were males and this was explained to have been so because of the aggressive nature of the bee and the possible over burden household chores of the females. Majority of the farmers (75%) do not have formal education and mainly engaged in peasant farming. Ages of respondents ranges from 25 to 60 years with a mean of 41 years.

The study revealed that, mean number of hives owned by a farmer was 4 and a maximum of 14 hives. Average number of honey produced was 2 gallons and a maximum of 18 gallons per farmer. Figures 1 to 4 illustrate the type of hives, number of respondents in each community, the output of honey produced by each community and number of hives and farmers per community respectively.

The estimates of the stochastic production frontier are presented in Table 1. The value of lambda λ greater than one implies a good fit for the estimated model and also correctness of the specified distributional assumption of the error terms. More so, the estimated value of gamma (0.8936) which is between zero and one as required implies that the beekeepers attained about 89.4% technical efficiency level in their production. This value represents the total output made on the frontier production function attributed to technical efficiency (Rahji, 2005). Thus estimate of technical inefficiency (U = 1-γ) is 0.1064, that is, 11%. This implies that in the short-run; it is possible to increase yield in the study area on

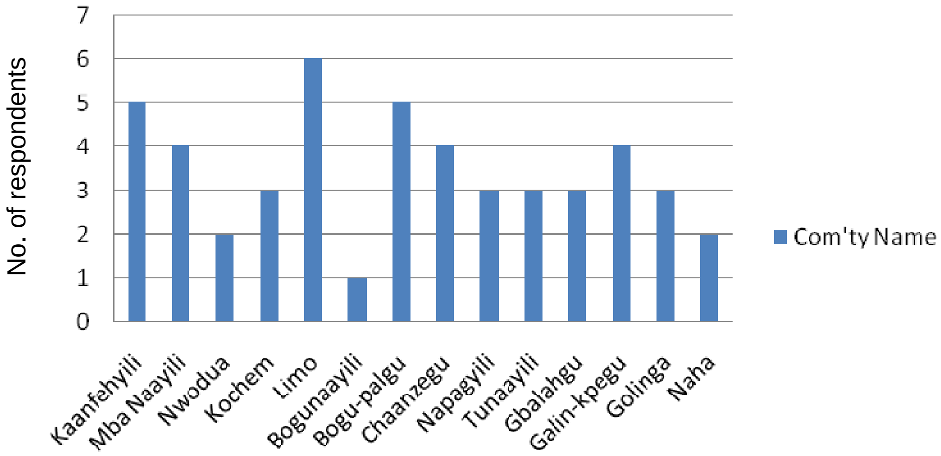

Figure 2. No. of respondents in visited communities (Source: Field survey, 2011).

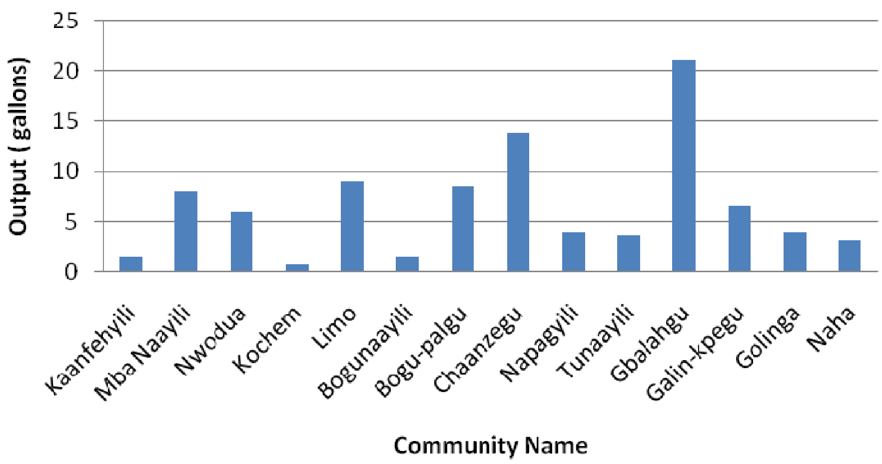

Figure 3. Honey output by communities (Source: Field survey, 2011).

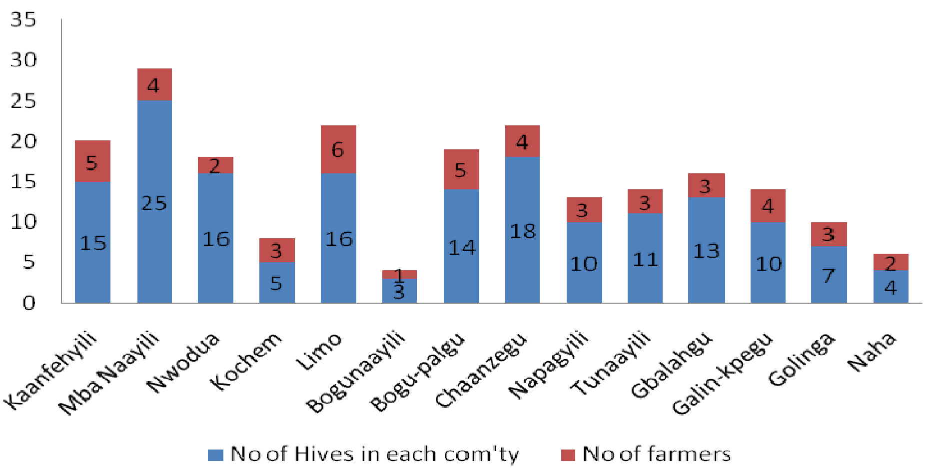

Figure 4. Number of hives and farmers in each community (Source: Field survey, 2011).

Table 1. Maximum likelihood parameter estimates of stochastic production frontier for beekeepers in the study area.

Variable	Coefficient	z-statistic	Standard error
Number of Hive (X_1)	0.2917	4.4900***	0.0650
Total number of top bars (X_3)	-0.0042	-1.2600	0.0033
Labour used (X_2)	-0.1330	-1.2500	0.1065
Extension service (X_4)	0.6009	1.9000**	0.3167
Constant	0.4138	1.5300*	0.2707
σ_u	0.9528		0.3649
σ_v	0.3287		0.2569
σ^2	1.0159		0.5479
Lambda (λ)	2.8986		0.6068
Log likelihood ratio	-39.7515		
Inefficiency factors			
Variable	**Coefficient**	**t-statistic**	**Standard error**
Constant	0.8963	1.5300*	0.5846
Age	0.0142	1.6000*	0.0089
Education	-0.0010	-0.0400	0.0231
Marital status	0.2574	0.6600	0.3894
Main occupation	-0.9971	-3.1900***	0.3127
Membership of social group	0.5176	3.1000***	0.1670
Experience	0.0408	2.6800**	0.0152

***, ** and * represent 1, 5 and 10% respectively, Prob> F = 0.0001, R^2 = 0.5100, Adj R^2 = 0.4346, N = 48. Source: Field survey (2011).

the average by 11% by using the technology of best performers.

The estimates of the error variances σ_u^2 and σv^2 are 0.9078 and 0.1080, respectively. The variance of the one sided error σ_u^2 is larger and dominates that of the random error σ_v^2. Thus the value of lambda σ_u/σ_v shows the dominant share of the one sided error over the estimated variance of the whole error term implying that a larger part of the variation in bee keeping in the study area is associated with the variation in technical inefficiency than with measurement error.

The parameter estimates for X1 and X_4 are both positive and significant at 1 and 5%, respectively. The positive signs of these variables are expected as the number of hives owned by a farmer and access to extension services increases output of honey. The coefficients of number of hive and extension services imply that if these variables are increased by 1%, output will increase by 29.17 and 60.09%, respectively. Conversely, though not significant, the negative values of labour and number of top bars imply that, output turn to decrease by 13.3 and 0.4%, respectively if those variables increase by 1%. This finding contradicts that of Aburime (2006) which indicate a positive relationship between number of top bars and output of honey produced.

For policy purposes, it is useful to identify the sources of these technical inefficiencies which can be done by investigating the relationship between the computed technical inefficiency and the farmer characteristics. On the determinants of inefficiency among bee farmers, all the variables significantly explain inefficiency with the exception of education and marital status. Main occupation for instance negatively enhances inefficiency. This means that bee farmers whose major occupation is farming are more efficient (less inefficient) than other occupations, as one percentage increase in farming decreases inefficiency by 99.7%. Age and experience on the other hand impacts positively on inefficiency which is expected. This can be explained by the fact that as a farmer becomes more aged in life, it becomes practically difficult if not impossible for him/her to take proper care of the apiary and therefore becoming more inefficient.

Returns to scale

The regression coefficients of Cobb-Douglas production function are the production elasticities, and their sum indicates thereturn-to-scale. The sum of elasticity $\sum e_p$ as presented in Table 2 is 0.7554 which implies decreasing returns to scalesuch that when all inputs specified in the model for the production of honey are increased by 1 unit, output will in turn increase by 0.7554 units. The non-negative and less than one value of the sum of elasticity imply that producers are operating in the stage two of the

Table 2. Elasticity estimates and returns to scale for honey producers.

Variable	Elasticity	Remarks
Number of Hive	0.2917	Inelastic response to output
Total number of bars	-0.0042	Inelastic response to output
Labour used	-0.1330	Inelastic response to output
Extension service	0.6009	Inelastic response to output
Total	0.7554	Decreasing returns to scale

(Source: Field survey, 2011).

production process, which is usually considered as the rational stage of production.

Conclusion

This study empirically estimated technical efficiency of beekeeping farmers and also identified the socio-economic factors that determine the level ofestimated technical efficiency of the sampled respondents. The results indicate that the mean technical efficiency of the sampled respondents is not too far from the frontier. This implies that there is a significant potential for the bee keepers to sustainably increase output using the available inputs and existing technology. Thus, there will be no need to develop new technologies to raise productivity but that technical efficiency can be increased by increasing the usage of inputs already available.The direct variables (inputs), which will increase production, are number of hives and extension services. This implies that the combined effects of the above stated direct variables will bring about a substantial increase in beekeeping output. This also means the consistent availability ofthese inputs will ensure commensurate beekeeping products.

Results from the socio-economic characteristics ofthe respondents in the study area shows that married men currently dominate honey production. It also reveals that beekeepers whose major occupation is farming are more technically efficient than those who are into other occupations (smock weaving, fitting, etc.). Age also impact negatively on inefficiency; the implication is that increased and sustainable honey production would better be achieved through young producers who can devote their full time to honey production.

RECOMMENDATIONS

Although, the beekeepers were found to be generally fairly efficient, there is room for improvement in the use of available resources under a guaranteed and conducive environment. For instance, the number of bee hives per farmer should be increased. Also, patronage of extension services should be encouraged. Furthermore, the youth should be encouraged to take bee farming as a major occupation so as to invest enough time and material resources to increase honey production.

Finally, there should be guaranteed market for honey so that farmers will be well compensated for their effort.

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