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FINANCIAL PERFORMANCE AND TECHNICAL EFFICIENCY DIFFERENTIALS FOR APICULTURAL TECHNOLOGIES IN NAKASEKE DISTRICT, UGANDA

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ABSTRACT

Despite apiculture being potentially a large income earner, the financial performance of various apicultural technologies at farm-level is still poor yet very few studies have delved in this sub sector. Using a representative sample of 69 respondents from Nakaseke District, the Ordered Probit analysis revealed that farming experience, apiary plot size, shortness of distance of water source and hive colonization levels were the major positive determinants of apicultural financial performance. A Stochastic Frontier Analysis (SFA) suggested that 62% and 76% of the total variation in honey output in traditional and improved technologies was due to technical inefficiency. The high efficiency levels in traditional technology seemed to suggest that more honey output would only be realized through introduction of improved technologies rather than focusing on technical skills while the low efficiency in improved technology would be improved using technical training. The study recommended policy incentives ranging from specific commodity-targeting extension messages, provision of low interest rate credit products and baiting materials to enhance efficiency.

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INTRODUCTION

Apiculture, also known as bee keeping is a growing economic activity worldwide (Kabasa *et al.,* 2003). In Nakaseke district, bee keeping has remained largely non-commercial with people practicing honey hunting. Recently, there have been interventions in Nakaseke from government programs, Non-Government Organization (NGOs) and other private service providers to promote commercial production of honey. These interventions have risen because of the increased demand and the uses of honey products. Apart from direct consumption of the honey, it is used for dressing of wounds, as anti – diarrhea drug, in alcoholic drink, tobacco curing, bakery and confectionery and in manufacturing of cosmetics using various products like bee wax, propolis, bee venom, and royal jelly (Fadare *et al.,* 2007). Bee keeping, reportedly increases pollination of crops and government revenue through taxes, levies and foreign exchange (Ministry of Natural Resources and Tourism, Tanzania (MNRT), 2004; Kihwele *et al,* 1999). It also gives local people and the government economic incentive for the retention of natural habitats, and is

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an ideal activity in any forest conservation program (Okoso-Amaa *et al,* 2004; Mwakatobe, 2001). Bee keeping also faces a number of constraints and these include: inappropriate management skills, prohibitive costs for equipments, pests and diseases, bush fires, inadequate forage materials, low productivity and lack of organized honey bee products' markets. Despite the constraints, the enterprise is potentially a large income earner.

Unfortunately, there has been little research attention paid to the apiculture as an economic activity which made it necessary to undertake a baseline survey in the Farm Income Enhancement Forest Conservation project (FIEFOC)[2]. Most research has concentrated on the technical aspects of bee keeping like bee diseases and productivity. Available economic studies have largely focused on analysis of socio – economic attributes of farmers involved in bee keeping with little or no empirical testing. These socio economic studies reveal little information on the performance of both traditional and improved apiculture technologies. Among these studies Ja'afar-Furo (2007), analyzed a sample of 160 respondents and found 46.25% would adopt apiculture as a sideline economic activity. Majority of the farmers in the study reported that the stinging propensity of bees was the major constraint to the adoption of apiculture in Adamawa state of Nigeria. Fadare *et al.* (2007) studied the performance of apiculture technologies in Niger Delta state of Nigeria and found that the average yield from modern technology was 12.35 kg while for the traditional, it was 6.72 kg per colony. The same study found the production costs of traditional technology to be 42% of the modern technology.

Empirical studies in the area of apiculture are still very few and these include: Kim *et al.* (2006) who studied the factors influencing the adoption of Russian *Varroa* – Resistant honey bees using a Logit model. The study found the factors associated with the adoption as sales, internet use, and contact with other beekeepers. The negatively associated factors were: age and the income of the household while future adoption depended upon previous use and perception of a technology. Ghorbani and Khajehroshanaee (2009) used a hedonic pricing model and showed that honey with wax was more expensive than the honey without it. Also honey in modern packaging and less sweet was more expensive than that in traditional ones even when sweeter. None of these studies addressed production elasticities and technical efficiency of apiculture technologies, an area preferred in the current study. Production elasticities in apiculture have been examined by Ja'afar-Furo *et al.* (2009) and Olarinde *et al* (2008). In additional, the Olarinde *et al.* study looked at technical efficiency. The former study examined the effects of bush burning and honey theft on overall production benefits and found bush burning and theft reduced total benefits in Adamawa State by 4.16% and 8.55% respectively. The later study used a sample of 60 respondents and found the returns to scale for the bee keepers were less than unity. Secondly, the mean technical efficiency was 0.854 while the main determinants of efficiency were found to be marital status and major occupation of household head.

Technical efficiency (TE) along with allocative efficiency is one of the areas used by economists to study production efficiency or economic efficiency. TE is based on the principle of attainment of the production goal without waste. The fundamental idea underlying all efficiency measures however, is the output in terms of the quantity of goods and services produced per unit of inputs (Olarinde *et al.,* 2008). It is assumed that the efficient firms/ farms 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

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its production frontier is regarded as the measure of inefficiency. According to Bravo – Ureta and Evenson (1993), several authors have investigated the relationship between efficiency and various socio – economic variables using two alternative approaches. One approach is to compute correlation coefficients or to conduct other simple non - parametric analyses. The second way, usually referred to as a two-step procedure, is to first measure farm level efficiency and then to estimate a regression model where efficiency is expressed as a function of socio-economic attributes. All these methodologies of analysis have been criticized by various scholars. However, Kalirajan (1991) defended the two – step procedure by contending that the socio-economic attributes have a roundabout effect on production and, hence, could not be incorporated into the analysis directly. Thus, the current study on apiculture in Nakaseke used the two – step procedure that is commonly used by economists.

The factors determining financial performances of the apicultural enterprise have not been studied while the returns to scale of various apicultural technologies at farm level are unclear. The effects of membership with farmers group, farming experience, foraging vegetation type, agro-chemicals and water sources on apicultural farmers' technical efficiency is not empirically known. Farmers generally feel comfortable using local hives because of the ease of colonization and low cost of outlay. Thus, attitudinal change among these farmers will require explaining the differences in the performance of traditional and improved technologies using empirical evidence. Therefore, this study set out to empirically examine determinants of financial performance of apicultural enterprise. The study also estimated the production elasticities of both traditional and improved technologies and examined their related technical efficiency among farmers as well as the factors affecting technical efficiency.

DATA SOURCES AND ANALYTICAL METHODS

Study Area and Data Collection

The study was carried out in four sub counties of Nakaseke District in which bee keeping has/ or is taking off as an economic activity and these are: Kinyogoga, Kikamulo, Ngoma and Wakyato. The main source of livelihood in the area is livestock herding, an activity that demands a lot of chemical spray. This means that the bee keepers in the area must adapt the apicultural activities to other farm activities requiring chemical spray. The area is relatively sparsely populated making the farmers in the area to have land holding which in some cases is as large as 700 acres. The vegetation type consists of short growing tree shrubs and savannah type grasses. In Kikamulo, the farmers also practice mixed crop and livestock production on relatively smaller farm land sizes.

Primary data was collected in August 2009 through interviewing a sample of respondents using a survey questionnaire. The questionnaire contained structured questions for generating values for categorical variables and unstructured questions that captured continuous variables and opinion-based responses. Structured questions were accompanied by a list of all possible alternatives from which the respondents were able to select the answer that best described the situation. Where it was impossible to exhaust all categories, the study included a category 'other specify' to take care of those responses. In unstructured questions, the respondents were given the freedom of responses. In cases of

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continuous variables, units of measure were specified for the respondents so as to generate standardized responses. Overall, the questionnaire consisted of 35 questions. A sampling frame was established by obtaining a list of bee keepers in each sub county with the assistance of agricultural extension staff in the study areas. The sub counties of Ngoma, Kinyogoga and Wakyato had longer lists of apiarists compared to Kikamulo. Thus, the sub counties in the former category were each allocated 23 questionnaires while in the later only 10 questionnaires. To obtain a representative sample of respondents, random sampling was subjected to each of the above sampling frames. A total of 79 questionnaires were issued for the survey out of which 69 were returned with satisfactory data.

Theoretical and Analytical Frameworks for Data Analysis

Factors Affecting Financial Performance

Welch (2006) explains that business firms are often compared in terms of economic performance (profits, sales, market share, productivity, debt ratios, stock prices, etc.). Welch (2006) captured the variable of financial performance as discrete values ranging from 0 – 2. In the current study, profitability could not be used due to data limitation on costs of production on the three hives used in the area namely: Local, KTB and Langstroth, and hence the variable of financial performance was used as shown in **Table 1**.

TABLE 1: DEPENDENT VARIABLE (*PERF_RATE*) CONSTRUCTION

Variable	Ordinal values description for Annual Farm Sales (Uganda Shillings)	Assumption
	= 0 if ≤ 0	Enterprise is not economically producing
	= 1 if 1 – 499,999	Enterprise just starting or nearing business exit
	= 2 if 500,000 – 999,000	Enterprise 'only' surviving
PERF_RATE	= 3 if 1,000,000 – 4,999,000	Enterprise making sales marginally
	= 4 if 5,000,000 – 10,000,000	Enterprise making adequate sales
	= 5 if > 10,000,000	Enterprise making sales outstandingly

Common determinants of financial performance or profitability are farming experience in years; level of formal education and farmland size in acres (Maliwichi *et al.*, 2010; Olujenyo, 2008); all these variables have been adopt for the current study. Additional variables in the model included: hive colonization, plot size of apiary in acres, distance of water source to apiary in meters and distance of field plots with agro – chemical applications in meters as described in **Table 2**. The model specification for determinants of financial performance was stated as shown in equation (1):

$$PERF_RATE_i = \beta_0 + \beta_i.[X_i] + \varepsilon_i \quad (1)$$

Where $PERF_RATE_i$ is the financial performance of the ith apiarist in the sample $[X_i]$ is a vector of explanatory variables described in **Table 2**, β_0 and β_i are the coefficients to be estimated whereas ε_i represents the error term. The discrete nature of

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values of the dependent variable rendered the empirical framework unsuitable for the Ordinary Least Squares (OLS) model. *PERF_RATE* is a generated latent unobservable dependent variable (Y) underlying threshold financial performance level of the ith honey producer. The latent variable (Y_i) exhibits itself in ordinal categories rendering the Ordered Probit Model (OPM) the most suitable model for the empirical framework.

TABLE 2: DESCRIPTION OF EXPLANATORY VARIABLES (FACTORS AFFECTING FINANCIAL PERFORMANCE)

Variable	Variable type	Variable Description	Rating
FAREXP_CAT	Categorical	Farming experience	= 0 if 0 years = 1 if 1-5 years = 2 if > 5 years
APLAND_CAT	Categorical	Plot size of apiary	= 1 if 0 - 1 acres = 2 if 1 - 2 acres = 3 if > 2 acres
WATSOC_CAT	Categorical	Distance of water source to apiary (Meters)	= 1 if 0 – 100 = 2 if 101 – 200 = 3 if 201 – 300 = 4 if 301 – 400 = 5 if > 400
EDUC_CAT	Categorical	Education level of household head	= 0 if No formal educ = 1 if primary = 2 if secondary = 3 if post-secondary
KTB_COL	Continuous	Ratio of colonized KTB hives to total number of KTB hives	-
LOC_COL	Continuous	Ratio of colonized local hives to total number of local hives	-
lnFARM_LAND	Continuous	Linearized variable of Farmland in acres	-
lnAGR_CHEM	Continuous	Linearized variable of distance of field plots with agro – chemical applications in meters	-

In the OPM, the dependent variable can be coded as 0, 1, 2, 3, 4, 5.....k. The response of category k is thus observed when the underlying continuous response falls in the kth interval as follows;

$Y^* = 0$ if $Y^* \leq \delta_0$

$Y^* = 1$ if $\delta_0 < Y^* \leq \delta_1$

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$$Y^* = 2 \text{ if } \delta_1 < Y^* \leq \delta_2$$
$$Y^* = 3 \text{ if } \delta_2 < Y^* \leq \delta_3$$
$$Y^* = 4 \text{ if } \delta_3 < Y^* \leq \delta_4$$
$$Y^* = 5 \text{ if } \delta_4 < Y^* \geq \delta_5 \quad (2)$$

Where Y* (i = 0, 1, 2, 3, 4, 5) are the unobservable threshold parameters that will be estimated together with other parameters in the model as explained in Greene (2000). A priori expectation is positive signs for the coefficients on the farming experience, plot size of apiary, distance of water source, education level, colonization of KTB and local hives. The variables of size of farmland and the distance of field plots with agro – chemical applications were expected to bear negative coefficients.

Determining Productivity and Returns to Scale of Apicultural Technologies

Consider an economic agent (honey producer) whose objective of production is profit maximization. The honey producer attains honey output that yields revenue (Y) using factors namely: land (X), capital or bee hives (K) and labor (L). The production technology would then be defined by a Cobb- Douglas production function:

$$Y = AX^{\beta_1} K^{\beta_2} L^{\beta_3} \quad (3)$$

Olarinde *et al.* (2008) used a similar framework to estimate production elasticities for apiculture in Nigeria and added two other variables namely: cost of baiting material and cost of other implements. In the current study, the empirical framework of Olarinde *et al.* (2008) was modified as shown in equation (3) below;

$$\ln Y_i = \beta_0 + \beta_i.[X_i] + \varepsilon_i \quad (4)$$

Where; $\ln Y_i$ = linearized value of honey output for either KTB or local hives for the ith sampled apiarist. For the improved technology $[X_i]$ contains a dummy for membership with farmers' group (*GP_MSP*), linearized quantity of KTB hives erected on the farm (*lnKTB_QTY*), size of plot allocated to apiary (*AP_LAND*) in acres, labor time of apiary supervision in a day in minutes and ratio of number of colonized KTB hives (*KTB_COL*). In the alternative model for the traditional technology, *lnKTB_QTY* and *KTB_COL* were replaced with quantity of local hives erected (*lnLOC_QTY*) and ratio of number of colonized local hives (*LOC_COL*). β_0 and β_i are the parameters to be estimated while ε_i is the error term. All variables with the exception of the revenue and quantity of hives for both traditional and improved technologies were not transformed to natural logarithm (*ln*) because of their small magnitudes. This enabled the resultant elasticities to be interpreted as percentage change in the dependent variable in response to a change in one explanatory variable at time. Variables were transferred from SPSS to STATA for regression analysis using OLS. A priori expectation was positive signs for all coefficients on explanatory variables.

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Determining Technical Efficiencies of Apicultural Technologies

Arega and Hassan (2003) present a framework for analysis of technical efficiency (TE). TE is defined by the production technology of a firm represented by a stochastic frontier production function (SFPF). The approach is also a Cobb – Douglas production function as given below:

$$Y=f(X;\alpha)+v-u \tag{5}$$

where Y measures the quantity of agricultural output; X is a vector of the input quantities; α is a vector of parameters; f (X; α) is the production function; v is assumed to be independently and identically distributed $N(0,\sigma^2 v)$ random error, independent of the u; and u is a non-negative random variable, associated with technical inefficiency in production. The maximum likelihood estimation of equation (4) yields estimators for α and λ where $\lambda = \frac{\sigma u}{\sigma v}$ and $\sigma^2 = \sigma^2 u + \sigma^2 v$. For the first stage estimation using stochastic frontier normal distribution – exponential procedure, the empirical model was specified as shown in equation (5),

$$\ln Y_i = \alpha_0 + \alpha_i.[X_i] + V_i - U_i \tag{6}$$

All variables in equation (3) are included in equation (5) except membership with farmers groups that was preferred to be test on efficiency. α_0 and α_i are the coefficients to be estimated and V_i is the disturbance term while U_i is the non – negative random variable associated with technical inefficiency of the respondent farmer. The model was used to predict technical efficiency variable that was used in stage II regression using OLS in equation (6).

We adopt explanatory variables used in previous studies such as membership with social group(*GP_MSP*) which is equal to 1 if household head belonged to a group and 0 otherwise and farming experience (*FAR_EXP*) of household head as sources of technical efficiency (Olarinde *et al.*, 2008; Ogundele and Okoruwa, 2006; Arega and Hassan 2003). Other variables included in the model are: dummy variable for Vegetation type (*DVEG_TYPE*) which is equal to 1 if the vegetation in apiary vicinity was wild and 0 otherwise, distance of field plots with chemical spray(*lnDAGR_CHEM*), length of distance of water source (*lnDWater*) as follows;

$$\eta = \delta_0 + \delta_i.[X_i] + \varepsilon_i \tag{7}$$

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Where η represents predicted technical efficiency, $[X_i]$ is a vector of explanatory variables on i^{th} sampled farmer, δ_0 and δ_i are the parameters to be estimated by the model and ε_i is the error term.

RESULTS AND DISCUSSIONS

Determinants of Financial Performance of Apicultural Enterprise

Results of the Ordered Probit model shown in **Table 3** revealed that farming experience of apiarist, plot size allocated to apiary, length of distance of water source and colonization of both KTB and local hives were positively signed and significant, conforming to theoretical expectation. It was only education level that was not significant at any level but still it carried the expected positive sign. The farmland size and the length of distance of fields with agro-chemical application also conformed to theoretical expectation with negative signs although distance of field with agro-chemical application was not significant. The measure of goodness of fit (Prob > chi-square) was 0.000 meaning the overall model specification was highly significant while the coefficient of determination was 0.38. The pseudo R – square of 0.38 implied that the model was explaining 38% of the total variation in the financial performance of apicultural enterprises. Therefore, this study stands to conclude that honey production and overall enterprise financial performance are mostly enhanced by farmers' experience, water source, scale of operation and colonization levels.

Categorical variables are difficult to interpret in terms of marginal impacts. However, the positive signs on their coefficients indicated that they increase the overall performance. For instance, the variable of length of distance of water source which rated shorter distances as '1' could be interpreted as shorter distances were likely to improve honey yield as well as the derived revenue. For the ratio variables with continuous values i.e. KTB and local hive colonization, marginal impacts can be explained in percentage change. Thus, the coefficient of KTB (0.013) and local hives (0.011), meant that increasing the level of hive colonization by 1% would lead to a rise in honey production and revenue by 0.013% and 0.011% respectively holding all other factors constant at a time. Similarly, the linearized continuous variable of size of farmland was also explained in terms of percentage change and response in the dependent variable. The coefficient of -0.262 meant that increasing the size of farmland by 1% would reduce honey revenue by 0.262%, all else constant. This suggests that large sizes of farmland are likely to be negatively affecting farm-level efforts of managing apiaries because farm managers divide up their time for various activities on the farm.

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TABLE 3: ORDERED PROBIT ANALYSIS – DETERMINANTS OF APICULTURAL ENTERPRISE FINANCIAL PERFORMANCE

Explanatory Variable	Dependent Variable: PERF_RATE			
	Co-ef	Std Err	z	P>|z|
FAREXP_CAT	1.409	.402	3.50	0.000
APLAND_CAT	.644	.268	2.40	0.016
WATSOC_CAT	.354	.143	2.48	0.013
EDUC_CAT	.233	.204	1.14	0.253
KTB_COL	.013	.005	2.51	0.012
LOC_COL	.011	.005	2.25	0.025
lnFARM_LAND	-.262	.138	1.90	0.058
lnAGR_CHEM	-.106	.150	0.71	0.480
Prob > chi – square	0.000			
LR chi2 (8)	74.55			
Log likelihood	-59.84			
Pseudo R Square	0.38			
Observations	65			

Secondly, large farms are likely to have so many activities, some of which such as livestock rearing require regular chemical spraying and consequently deter foraging activities of bees as well as causing hive absconding. Whereas the co-efficient on distance of fields with agro-chemical spray was not significant, its negative sign signaled that chemical sprays reduced honey production.

Productivity and Returns to Scale

Estimation of the empirical models on improved and traditional technologies yielded interesting results. Beginning with the improved technology; the coefficients of: group membership (*GP_MSP*), quantity of KTB hives (*lnKTB_QTY*) and colonization of KTB hives (*KTB_COL*) carried the hypothesized positive signs as presented in **Table 4** and they were all statistically significant. On the other hand, the coefficients of size of plot allocated to apiary (*AP_LAND*) and labour time for supervision of apiary (*TIM_SUP*) deviated from theoretical expectation with negative signs however both variables were not significant. On the contrary, all variables in the model specification for traditional technology carried the hypothesized positive signs. Like in the improved technology model, membership with farmers' group, quantity of hives and level of colonization were significant. It was only land portion for apiary and time spent to supervise apicultural activities that were not significant.

The measure of goodness of fit (Prob > F) in either models was 0.000 meaning that the two models were highly significant. The R - Square at 0.76 and 0.68 in the improved and traditional model specifications indicated high explanatory power for the two model specifications and were explaining 76% and 68% of the total variation in the dependent variables respectively. It can therefore be concluded that high productivity and revenue levels in apiculture are more likely to be attained only when apiarists organize

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themselves in producer groups, having adequate stocking of hives per unit land area and high colonization levels.

TABLE 4: PRODUCTION ELASTICITIES (OLS ESTIMATES)

Explanatory Variables	Improved Technology				Trad. Technology			
	Coef	Std Err	t	P>|t|	Coef	Std Err	t	P>|t|
GP_MSP	1.197	.341	3.51	0.001	.596	.240	2.48	0.019
lnKTB_QTY	1.441	.179	8.03	0.000				
AP_LAND	-.033	.093	-0.35	0.726	.009	.061	0.15	0.884
TIM_SUP	-.014	.009	-1.61	0.114	.005	.008	0.68	0.504
KTB_COL	.033	.004	8.39	0.000				
lnLOC_QTY					.887	.162	5.49	0.000
LOC_COL					.023	.005	5.01	0.000
Constant	6.71	.683	9.83	0.000	9.37	.666	14.7	0.000
F (5, 49)	31.64				13.12			
Prob > F	0.000				0.000			
R – Square	0.76				.68			
Adj R – Square	0.74				.63			
Observations	55				37			

The coefficient of *GP_MSP* (1.197) meant that the revenue of an apiarist belonging to a group was likely to be 119.7% higher than the revenue of an apiarist who does not belong to any group. The magnitude of this finding is extremely high compared but related to earlier studies and it can be attributed to the fact that interventions such as collective action for production in a poorly performing enterprise yield initial marginal impacts that are very high which only decline with successive implementation of the intervention. In a related study in Nigeria, Omonona *et al.* (2010) reported that farmers belonging to a cooperative society were 46% efficient while non-cooperative members were just 20% efficient. When calculated, the percentage change from non-cooperation to farmers' cooperation in Omonona *et al.* study is also more than 100%. Club membership has been argued to provide incentives for efficient production, a precondition for increased revenue (Binam *et al.*, 2004).

Collective action is said to be instrumental in enabling smallholder farmers meet basic requirements for high value products such as minimum quantity, quality and frequency of supply, which they may be unable to achieve as individuals, improves bargaining power and reduces barriers to market entry (Kayobyo *et al.*, 2010). For the continuous variables, *lnKTB_QTY* (1.441) and *KTB_COL* (0.033), the findings meant that a 1% increase in the quantity of KTB hives and the percentage of colonized KTB hives would increase the revenue by 1.441% and 0.033% respectively *ceteris paribus*. In the model of traditional technology, *lnLOC_QTY* (0.887) and *LOC_COL* (0.023) suggested that a 1% rise in the number of local bee hives and the percentage of colonized local hives would lead to an increase in the revenue by 0.887% and 0.023% respectively all else constant.

Calculation of returns to scale in the two technologies yielded even more interesting results. The sum total of values of the coefficient (elasticities) of factors of production namely: bee hives (capital), apiary plot sizes (land) and apiary supervision time

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(labor) were 0.901 and 1.394 for traditional and improved technologies respectively as shown in **Table 5**. It can thus be inferred that economically, the improved apicultural technology potentially out – performs its counterpart traditional technology. The finding in the traditional technology of 0.9 implied that the production technology involving local hives was only yielding Decreasing Returns to Scale (DRS). This suggested that scaling up the inputs by doubling their quantities could only cause less than proportionate increase in total output, a situation that can lead to over exploitation of natural resources. Therefore, local hives are not environmentally sustainable in the long run. In the alternative production technology with returns to scale of 1.394, the chances for generating more rewarding benefits using technical skills enhancement were potentially higher.

TABLE 5: RETURNS TO SCALE

Source	Traditional Technology	Improved Technology
Capital (Bee hives)	0.887	1.441
Land (Apiary Plot Size)	0.009	-.033
Labour (Time of Supervision)	0.005	-.014
Total	**0.901**	**1.394**

Since the sum of elasticities is greater than unity, the production technology exhibited Increasing Returns to Scale (IRS). Literally, doubling the quantities of inputs would lead to more than doubling the income streams from KTB hives. This further confirms that the improved technology was likely to out – perform the traditional one. The comparison finding is in support of earlier studies that recommended modern hives for honey production. Assefa (2009) had reported that local hive productivity was just a third or less of the productivity of modern hives. The author further noted that shifting the production technology from local hives to improved hives was not only important at increasing productivity but also improving the quality of produced and marketed honey. Kerealem *et al.* (2009) observed that the quality of honey produced using local hives is usually limited by presence of brood, wax pieces and pollen unlike the modern hives. Any production technology relying on modern hives is thus critical for accessing international markets which do not compromise on quality of foodstuffs.

Technical Efficiency Estimates

Estimates of the stochastic production frontier for two separate models under the traditional and improved technologies are presented in **Table 6**. The estimates of sigma-square (σ^2), which were 0.475 and 0.299 were significantly different from zero, indicating good fit and correctness of distributional assumptions specified in the models of improved and traditional apicultural technologies. Estimated lambda (λ) was 1.288 for traditional technology and 1.647 for improved technology. Based on λ, gamma (γ) was derived as follows; $\gamma = \lambda^2 / [1 + \lambda^2]$ and this measures the effect of technical inefficiency in the variation of observed output/ revenue.

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TABLE 6: TECHNICAL EFFICIENCY FOR APICULTURAL TECHNOLOGIES

Explanatory Variables	Dependent Variables: *lnKTB_REV* (IMPR); *lnLOC_REV* (TRAD)							
	Improved Technology				Traditional Technology			
	Coeff	Std. Err.	z	P>|z|	Coeff	Std. Err.	z	P>|z|
lnKTB_QTY	.310	.178	7.35	0.000	-	-	-	-
lnLOC_QTY	-	-	-	-	.824	.140	5.89	0.000
APLAND	.001	.075	0.01	0.993	-.030	.052	-0.57	0.565
lnTIM_SUP	-.188	.157	-1.20	0.231	.266	.125	2.12	0.034
KTB_COL	.030	.003	9.92	0.000	-	-	-	-
LOC_COL	-	-	-	-	.022	.005	4.90	0.000
Constant	9.152	.549	16.66	0.000	10.004	.737	13.57	0.000
lnsig2v	-2.057	.389	-5.28	0.000	-2.184	.724	-3.01	0.003
lnsig2u	-1.059	.412	-2.57	0.010	-1.677	.813	-2.06	0.039
Sigma Square(σ^2)	.475	.132			.299	.106		
Lambda(λ)	1.647	.162			1.288	.279		
LR test (sigma)	14.80				2.00			
Prob> chi – square	0.000				0.000			
Observations	55				36			
Factors Affecting Technical Efficiency								
Constant	.661	.194	3.41	0.001	.433	.189	2.29	0.031
DVEG_TYPE	.073	.080	0.91	0.366	-.011	.062	-0.18	0.862
lnFAR_EXP	.010	.036	2.74	0.009	.067	.040	1.67	0.107
GP_MSP	.188	.093	2.02	0.050	.017	.068	0.24	0.810
lnDWater	-.016	.031	-0.54	0.593	.060	.030	1.97	0.060
lnDAGR_CHEM	-.065	.036	-1.80	0.080	-.036	.034	-1.07	0.295

The estimated values of γ were: 0.62 for traditional technology and 0.73 for improved technology, meaning that 62% and 73% of the total variation in apiary output in the traditional and improved technologies were due to technical inefficiency and not related to random variability. Thus, the effects of technical inefficiency are economically important and are more felt in the improved than traditional technology. When compared with Nigerian apiarists' reported variation relating to technical inefficiency of 3% (Olarinde *et al.*, 2008), Uganda bee – keepers still need to do a lot if improved gains from the apiculture sub sector are to be realized.

The results further indicated that the quantity of hives held at farmstead and the percentage of hive colonization were correctly signed and contributed significantly to the technical efficiency of the farmers in either technology. In addition, the time spent to supervise apiary activities in a day under traditional technology was correctly positive and significant. The same variable under the improved technology was negative and thus deviated from theoretical expectation though it was not significant. The size of plot allocated to apicultural activities was not significant in either technology and it was only positive in the improved technology as expected.

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Results of factors affecting technical efficiency in honey production were mixed for the two technologies. In the improved technology, vegetation type, farming experience and membership to farmers' group were positively affecting technical efficiency meaning they are a source of efficiency. Apart from the vegetation type, all these variables were significant. Water source and the length of distance of fields of agro-chemical sprays were negative. The later variable was statistically significant while the former was insignificant. A negative coefficient shows that the variable is improving technical efficiency; that is the farmer becomes more technically efficient as the level of the variable increases. Mochebelele and Winter-Nelson (1999) pointed out that Technical inefficiency should be considered as a measure of management error, rather than income or gross output. Lower inefficiency does not correspond to greater yields or greater income. The implication is that fewer inputs units if applied in a consistent and timely manner, a low input farmer could achieve a better technical efficiency score than a farmer employing more inputs and achieving a higher yield.

In the model with augments of traditional technology, the signs of the two variables differed from those observed in the improved technology. Water source was positive and significant as expected while the vegetation type was negative but insignificant. The prob > chi square was 0.000 for both traditional and improved technology models suggesting good fit for both models. Therefore, the null hypothesis that the level of farming experience and membership with farmers' group have significant positive while agro-chemicals negative effects on technical efficiency could not be rejected under the improved technology. In the traditional technology, while the null hypothesis could not be rejected on the basis of variable signs, it was rejected in terms of significance levels. Ogundele and Okoruwa (2006) reported a similar finding when farming experience was tested against production technologies among rice farmers in Nigeria.

In the **Table 7**, individual farm-level technical efficiency estimates are presented. The results revealed that TE for the traditional technology ranged between 0.12 and 0.91 while for the improved technology, it was between 0.07 and 0.9. The mean TE for traditional technology was 0.71 while for improved technology, it was 0.62. This implies that in the short-run; it is possible to increase yield in Nakaseke district on the average by 29% and 38% in the traditional and improved technology respectively by using the technology of best performers. The high efficiency level in traditional technology means output increase will be little through technical skills suggesting a need for new technologies. On the hand, the improved technology is likely to yield increased output from skills training. Current study findings are closely related to the observation by Chirwa (2007) who pointed out that the mean TE in Africa was low and ranged between 55% and 79%. Generally, apiarists in the sample operated far below the production frontier under the current technology especially in the improved technology where 55.3% of the farmers had their efficiency levels below 70%. In the traditional technology, if the average farmer was to achieve the TE level of his/her most efficient counterpart, the average farmer would realize 22% increase in the income streams (i.e., 1 - [0.71/0.91]). When the same calculation was applied to the most technically inefficient farmer, the finding suggested an increase in income streams of 86.8% (i.e., 1 - [0.12/0.91]).

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TABLE 7: FARM-LEVEL DISTRIBUTION OF TECHNICAL EFFICIENCY

Efficiency Range	Traditional Technology		Improved Technology	
	Freq.	Cum. (%)	Freq.	Cum. (%)
< .50	6	16.7	8	14.3
.51 - .60	3	25.0	12	35.7
.61 - .70	6	41.7	11	55.3
.71 - .80	7	61.1	15	82.1
.81 - .90	13	97.2	10	100
.91 – 1.00	1	99.9	0	
Other TE statistics				
Mean Technical Efficiency	0.71		0.62	
Least Efficient Farmer	0.12		0.07	
Most Efficient Farmer	0.91		0.90	

In the improved technology, if the average farmer was to achieve the TE of the most efficient counterpart, then the average farmer would realize 30.1% increase in income streams (i.e. 1 – [0.62/0.90]). Similarly, if the most technically inefficient farmer stepped up his/ her efficiency to the level of most TE, the revenue proceeds would be improved by 92.2% (1- [0.07/0.9]).

It is worthwhile to note that the least efficient farmers in improved technology perform much poorer compared to their counterparts in the traditional technology. This could be because the farmers in the area are not yet used to newly introduced technologies and still need a lot of capacity building training. However, this should not be misinterpreted to mean that traditional technology is better but rather to further confirm that strategies that can improve the efficiency levels among improved technology farmers when implemented, the potential gains in economic benefits would be much superior.

CONCLUSIONS AND POLICY RECOMMENDATIONS

Examination of the determinants of financial performance of apicultural enterprise yielded results pointing to the fact that honey output and revenue were mostly enhanced by the level of farming experience of the apiarists, shorter length of distance of water source, apiary plot size and hive colonization. The factor that reduced the financial performance most was size of farmland. Thus, extension programs should focus attention on availing water sources close to apiaries, optimal hive stocking, and training on improving colonization. Empirical analysis of productivity of apicultural technologies using a Cobb-Douglas production function revealed that the improved technology outperformed its counterpart traditional technology. It has also been concluded that any intervention in the traditional technology is likely to lead to over exploitation of natural resources for relatively lower gains in the benefits.

Policy incentives should thus be provided to apiarists to encourage adoption of improved technologies. An incentives package should seriously consider provision of low interest credit products for apiarists, training of local artisans, undertaking on-farm demonstration of improved apicultural technologies and exchange/ exposure visits to successful apiarists. Secondly, the positive response of honey revenue to membership

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with farmers groups should be exploited to initiate and / or strengthen and sustain horizontal structures for market coordination. In his recommendation of farmer cooperation in Nigeria, Idiong (2007) observed that since these farmers' associations significantly and positively affected their performance, making policies that would encourage farmers to form cooperatives/farmers organizations or join existing ones was likely to improve productivity. Such initiatives are also likely to enhance value – addition, reduce transaction costs associated with small - scale operation and provide rewarding markets to farmers. Whereas no verbatim was recorded at the time of the survey, the effect of membership to a farmers' organization on apicultural enterprise performance is clearly evident in Ngoma Sub County. Following the inauguration of honey producers' associations by Uganda Women's Effort to Save Orphans (UWESO), apiarists were able to start the collection, processing and packaging honey (though largely gathered wild honey) using the equipment provided by UWESO and in effect contributing to increased household incomes.

Estimation of technical efficiency of farmers revealed that most income variation stemmed from individual farmers' technical inefficiency rather than random variability. Overall, the improved technology apiarist performed far below the production frontier under the current technology and this has been attributed to the fact that farmers are still not yet used to modern technologies. Thus, these farmers stand to benefit more from technical training while those using traditional technology will maximize output and returns through introducing new technologies. Pests and diseases as natural enemies of bees could be limiting efficient production. Honeybee pests and diseases are reportedly a great threat the apicultural development since they cause high mortality rates and severe economic loss. This calls for research on investigation and diagnosis of factors that endanger the health of local honeybees in different agro-ecological zones and establishing ways of prevention and control measures (Kerealem *et al.*, 2009). Charcoal burning that is common in the study area could also not be ruled out as some of the factors affecting farmers' efficiency since some of the factors studied were not significant. Previous studies have advocated for intensification of agricultural extension services for addressing farm-level efficiency problems (Omonona *et al.,* 2010; Ogundele and Okuruwa, 2006; Arega and Hassan, 2003). Thus, in the current study, focused extension services involving farmer – extension – research linkages are recommended in the apiculture sub-sector.

Policy interventions to improve efficiency levels of farmers should also offer provision for baiting materials, catcher boxes, and hive-pole protectives that guard against apiary attacking pests. Natural resources conservation strategies that enhance bee foraging (including: capturing positive externality between legume crops/ fruit trees and apiaries (Nash, 2009) as well as fruit trees) should be designed and promoted. For instance, indiscriminate tree cutting should be outlawed a long with promotion of fruit trees together with appropriate community sensitization messages.

Future research in apiculture should consider looking at cost and allocative efficiency and supply chain in order to generate more knowledge on the performance of the enterprise as whole in all aspects. Still, more studies are needed in the area of supply response and technology adoption.

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ENDNOTES

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