

Technical Efficiency in Honey Production: The Case of Illubabor and Buno Bedelle Zones, South Western Ethiopia

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Abstract

The gap between demand for and supply of food can be reduced by improving productivity either through introduction of modern technologies or improving the efficiency of inputs. However, in developing countries like Ethiopia, improving the efficiency of inputs has received the utmost attention. As production of honey is a significant contributor to the Ethiopian economy, increasing production and productivity of inputs in honey production could be taken as an important step in attaining food security. Therefore, this study was aimed at analyzing the technical efficiency in honey production in Iluababor and Bunno Bedelle zones using cross sectional data collected from randomly selected 180 sample households during 2017/18 production season. Cobb-Douglas production function was fitted using stochastic production frontier approach to estimate technical efficiency levels, whereas tobit model was used to identify factors affecting technical efficiency levels of the sample farmers. The estimated results showed that the mean technical efficiency was 51.05% that indicated there was significant inefficiency in honey production in the study areas. The discrepancy ratio (γ), which measures the relative deviation of output from the frontier level due to inefficiency, implied that about 51.05% of the variation in honey production was attributed to technical inefficiency effects. Among factors hypothesized to determine the level of technical efficiency, family size, hive size and experience of household head in honey production were found to determine technical efficiency of farmers positively while distance of household head from the nearest market had negative impact with technical efficiency. The result indicated that there is a room to increase the efficiency of honey producers in the study areas. Hence, the efficiency level of less efficient farmers should be improved by adopting the practices of relatively efficient farmers in the area.

Keywords: honey, efficiency, Cobb-Douglas, stochastic frontier, tobit

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Introduction

Ethiopia has huge potential for beekeeping production due to presence of favorable environmental and vegetative resources. Accordingly, there are about 10 million bee colonies and over 800 identified honey source plants (Kebede *et al.*, 2011). Honey production is environmentally friendly practices and can coexist effortlessly with regular farming activities (Miklya *et al.*, 2012).

Those engaged in beekeeping could earn income from production and marketing of honey and its by-products (beeswax, royal jelly, pollen and bee colonies). The sector could also create a non-gender-based employment opportunities. In addition of being the source of livelihood, due to their biological nature bee populations increase the crop productivity and conserve natural flora, since the insects pollinate crops, flowers and trees in their aerial roaming. The country beekeeping and honey production is ancient tradition that has been incorporated into culture (Gezahagne, 2001 and Aklilu, 2002). Ethiopia is the largest honey producers country in Africa and the tenth in the world (FAOSTAT, 2015). Recent data indicates that the total volume of honey production is about 49 thousand tones (CSA, 2015). Thus, the country has huge potential for honey production.

Ethiopian honey's has desirable qualities, such as low moisture content especially in drier areas, and absence of GMO pollen which have been widely recognized in the international market (Gallmann, P., and Thomas, H., 2012). In Oromia region honey production cover the greatest percentage of production in beekeeping compared to other regions of the country. Iluababor and Bunno Bedelle zones, has highest potential of bee colonies due to presence of high vegetation coverage. The number of bee colonies in two zones are about 0.5 to 0.9 million and the product of honey per year is about 6,000 to 8,000 metric ton IZBARDO, 2014. Out of the total product 70% comes from traditional bee hives as crude honey and the remaining 30% comes from transitional and the modern frame hives.

Honey production has been a marginalized activity within most developing countries. Oromia has the largest number of beehives followed by Amhara and SNNP respectively (CSA, 2015). Jimma, Illubabor and West Wellega have been the areas of Oromia region with the highest number of hives (CSA, 2015). High forest, woodland, riverine and plantation forests are available in the BunoBedelle and Illubabor zones.

Introducing modern technology can increase agricultural output. However, in areas where there is inefficiency, trying to introduce new technologies may not have the expected impact and "there is danger of trying to rediscover the wheel" if existing knowledge is not efficiently utilized (Tarkmani and Hardakar, 1996 as cited in Mustefa, 2014). There is limited number of studies done in this regard in general and there is no similar study conducted on

analysis of technical efficiency in honey production in the study areas. Hence, there is a need to fill this gap and provide possible intervention areas to improve the existing honey production and productivity.

Objectives of the study:- The overall objective of the study was to analyze technical efficiency in honey production in Illuabbabor and BunoBedelle Zones.

The Specific objective of the study were;

- i. To estimate the level of technical efficiency of honey production in the study areas and;
- ii. To identify the major factors that affect technical efficiency in honey production in the study areas.

Methodology

Description of the Study Area

The vast area of Ilu Abba Bor and BunoBedele Zones are located in southwestern part of Ethiopia in Oromia Regional State. The zones shares common frontier with East Wollega and Jimma zones in the East, with West and East Wollega in the North; with SNNPR in the south and with Gambella Regional State in the west. The total area of the zones are equal to 1,633,156.6 hectares that sub-divided into 24 districts and two special city administrations. The total population of the zones also accounts for 1,535,482 of which 824,987 are male and 710,495 are females. From this population 12.7% live in urban and 87.3 of them live in country side. These figures are provided based on the Housing and Population Census of the 1999. Mettu and Bedele became the administrative capital of the zones. The capital, Mettu and Bedele town are 600 and 480 kilometers away from Addis Ababa respectively.

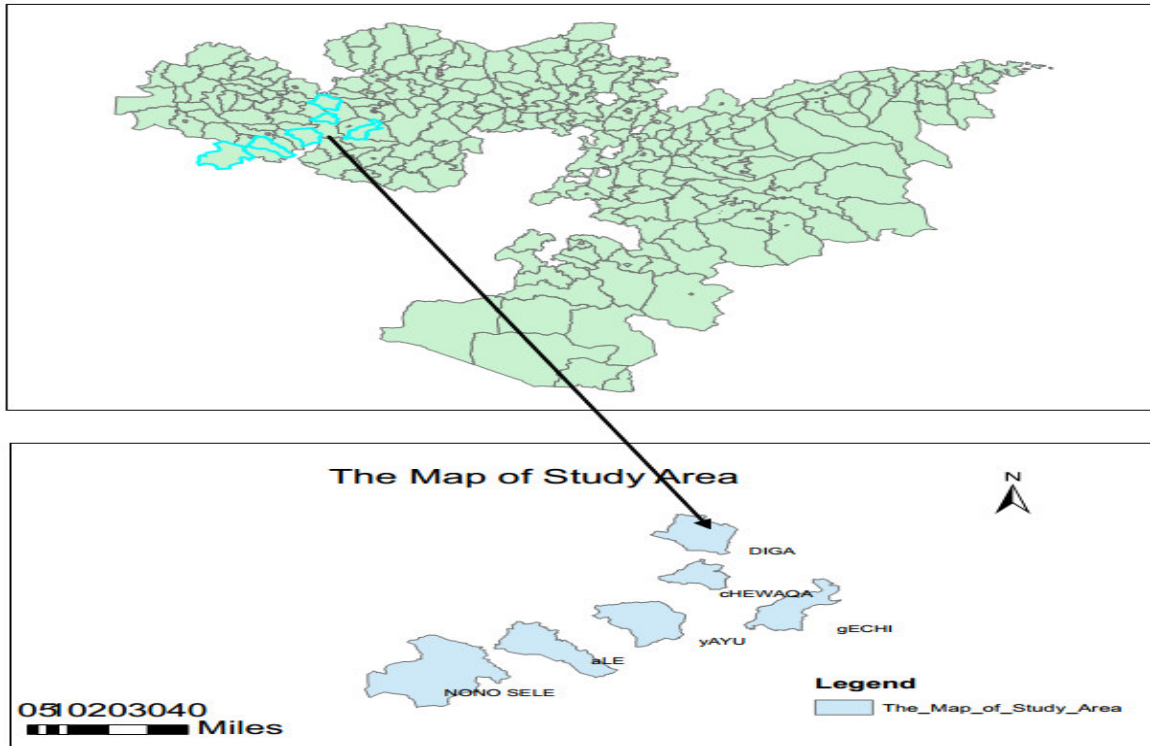


Figure 1:- Location of the study area in Oromia National Regional State

Sampling Technique and Sample Size

Due to the importance of honey and its extent of production in the area, Iluabbabor and Bunno Bedele zones were selected purposively. A three stage random and purposive sampling technique were used to select sample households for this study. In the first stage, six districts that produce honey in 2017/18 production year were selected purposively. In the second stage, eighteen kebeles that produce honey were selected randomly. In the third stage, the sample farmers were selected using random sampling technique from each kebeles proportional to the total number of households of the kebeles. The sample size was determined based on the formula given by (Yemane, 1967).

$$n = \frac{N}{1 + N(e^2)} \quad (3.1)$$

where, n is sample size, N is number of household and e is the desired level of precision. By taking e as 7.5%, total population 1,535,482 the sample size would be 177. However, data were gathered from 180 sample households.

Methods of Data Analysis

To address the objectives of the study and to analyze the data, both descriptive and Econometric methods were employed. Accordingly, in the descriptive part, simple measures of central tendency, frequency and percentages were used; and in the Econometric analyses, a stochastic frontier approach was used to estimate the level of honey production efficiency and a Tobit model to identify factors that affect the efficiency level of the farmers.

Specification of the econometric models

Efficiency Measurement

In this study, the stochastic production frontier was used for its key features that the disturbance term is composed of two parts: a symmetric and a one sided component. Hence, efficiency measures obtained from stochastic frontiers were expected to reflect the true ability of the farmer with the given resources.

The assumption that all deviation from the frontier are associated with inefficiency, as assumed in DEA, is difficult to accept, given the inherent variability of agricultural production due to a lot of factors like weather, pests and diseases(Coelli and Battese, 1995). Besides, because of the low level of education and high illiteracy among farmers in developing countries, keeping accurate records is not a common practice. Therefore, within the stochastic frontier framework, the stochastic efficiency decomposition methodology is chosen as more appropriate for this study. The SFP model for this study were be specified as follows:

$$Y_i = F(X_i; \beta) \exp(V_i - U_i) \quad i=1,2,3...n \quad (3.2)$$

Where Y_i is the production of the i^{th} farmer, X_i is a vector of inputs used by the i^{th} farmer, β is a vector of unknown parameters, V_i is a random variable which is assumed to be $N(0, \sigma_v^2)$ and independent of the U_i which is non-negative random variable assumed to account for technical inefficiency in production. Moreover, the assumptions made about the distributions of the error components U_i and V_i should be respected (Coelli, 1998). For this study it were assumed that U_i and V_i are independently and identically distributed half-normal random variables with mean zero and variance σ^2 .

The parameters for the stochastic production frontier model and those for the technical inefficiency model was also simultaneously estimated by employing the maximum-likelihood estimation (MLE) procedures, FRONTIER 4.1 (Coelli,1996).

As a result of taking the advantages and disadvantages of Translog and Cobb-Douglas functional forms in to consideration the appropriate functional form that better fit the data was selected after testing the hypotheses using the generalized likelihood ratio test. The value of the generalized log-likelihood ratio (LR) statistic to test the hypothesis that all interaction terms including the square root specification (in the translog functional form) is equal to zero ($H_0 = bij = 0$) was calculated as:

$$LR = -2[L(CD)-L(TI)] \quad (3.3)$$

Where: LR = Generalized log-likelihood ratio, L(Cd) = Log-likelihood value of Cobb-Douglas and L(TI) = Log-likelihood value of Translog.

Then this value was compared with the upper 5% point for the χ^2 distribution and decision was made based on that result. The linear functional form of Cobb-Douglas production function used for this study is given by Equation (3.4).

$$\ln(\text{output}) = \beta_0 + \beta_1 \ln(\text{land}) + \beta_2 \ln(\text{labor}) + \beta_3 \ln(\text{forest coverage}) + \beta_4 \ln(\text{hives}) + \beta_5 \ln(\text{forage}) + v_i - u_i \quad (3.4)$$

Technical efficiency of the i^{th} producer can be described as:

$$TE_i = \frac{y_i}{f(X_{ij}; \beta_j) \exp(v_i)} = \exp(-u_i) \quad (3.5)$$

Following Bravo-Ureta and Rieger (1991) for a given level of value of output Y_i^* the technically efficient input

vector of the i^{th} farmer, X_{it} , is derived by solving (3.5) and the observed input ratio) $\frac{X_1}{X_i} = m_i (i > 1)$

simultaneously.

According to Sharma *et al.* (1999), these cost measures are used to compute technical efficiency (TE),

$$TE_i = \frac{\sum_i W_i' X_{it}}{\sum_i W_i' X_i} \quad (3.6)$$

Determinants of Efficiency

In this study technical efficiency estimates that was derived from stochastic production frontier was regressed

using a censored Tobit model on farm-specific explanatory variables that were explain variation in efficiency across farms. The rationale behind using a Tobit model was that there were a number of farm units for which efficiency could be 1 and the bounded nature of efficiency between 0 and 1 (Hussein, 1989; Greene, 2003). To examine the role of relevant farm-specifics in production efficiency, the following Tobit model was estimated.

$$E_i^* = \sum_j \beta_j Z_j + v_i \tag{3.7}$$

$$E_i = 1 \quad \text{if } E_i^* \geq 1$$

$$E_i = E_i^* \text{ if } E_i^* < 1$$

Where E_i is an efficiency score, representing technical efficiency; and $v \sim N(0, \sigma^2)$ and β_j are the vector of parameters to be estimated. Z_j represent various farm specific variables and E_i^* is the latent variable, with $E[E_i^* | X_i]$ equals $X_i \beta$.

Results and Discussions

Descriptive Statistics Results

Summary of variables used in production function

Farmers in the study areas use different combination of inputs like; labour, bee forage and supplement, number of hives, forest coverage of the area in hectare and land owned by the households in the production of honey.

Table1. Descriptive Statistics result of production function variables

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Total labor used	180	.00	8.70	3.9508	1.49766
Expenditure on supplement	180	180.00	750.00	515.3333	259.43299
Number of hives	180	.00	280.00	29.7444	53.79623
Total size of land	180	.25	13	3.6627	2.57037
Forest coverage of the area	180	.00	375.00	7.4065	48.01394
Total production of honey in kg	180	.00	3995.00	400.4167	620.23624

Source: Model Output, 2018

On average, farmers got 400.42 kg of honey, which is the dependent variable in the production function. The total size of land of the sampled farmers during the survey period ranged from 0.25 to 13 ha with an average of 3.66 ha. The other very important variable, out of which production is impossible, is hives. The number of hives that sampled households used were 29.74, on average. Like other inputs, labor inputs were also decisive. Sampled households, on average, used 3.95 man equivalent labor for the production of honey during 2018 production season. In the study area, the average expenditure that the sample household expend on supplement was 515.33 birr. Forest is an important input for honey production. On average 7.40 hectare of the area was covered by forest.

A total of 12 variables were hypothesized to affect efficiency of honey producers, of which three of them were dummy variables.

Table 2. Summary of efficiency model variables

Variables	Mean	Std. Deviation	Percentage of the mean with Dummy 1	Percentage of the mean with Dummy =0
Age (years)	42.49	10.88	-	-
Family size (MDs)	3.95	1.50	-	-
Education (years of schooling)	7.04	2.99	-	-
Farm size (ha)	3.66	2.57	-	-
Distance of the farm from market(Km)	5.82	4.79	-	-
Hive size	29.74	53.80	-	-
EXPERIENCE	9.39	7.96	-	-
INCOME	32435.83	33669.67	-	-
PRICEHONEY	53.61	48.28	-	-
Access to market	-	-	64.0	36.0
Training	-	-	91.6	8.4
Sex of farm household head	-	-	96.1	3.9

Source: Model Output, 2018

The average age of the sampled household was 42.49 years. The average number of family was also 3.95 in man equivalent. Education level of the household heads measured in years of schooling indicated that the average level of education was grade seven (Table 2). The range in level of education varies from zero to grade 12. The average farm size of sampled household was also 3.66 ha. Sampled households, on average, had 29.74 number of hives. The average experience of household in honey production was 9.39 years. The average price of honey in the study area was 53.61 birr per kg. Out of the total respondents, 64% of them reported that they had an access to

market for honey production during the survey period. About 92 percent of the sampled household had access to training given for honey production . Similarly, 96.1% of the sample farmers were male headed households and the remaining 3.9 of them were female headed households.

Honey production constraints: Insect-pests, chemical effect and birds were the major honey production problems that farmers were facing in the study areas. Moreover, about 56%, 20% and 9% of the sample households were facing problems of insect pests, chemical effect and birds respectively. Disease and shortage of availability of modern hives were also another major production constraints in the study areas. Accordingly, 5.2% and 4.6% of the sample household were faced problems of various disease and shortage of modern hives respectively (Table 3).

Table 3. Agricultural production constraints

4.2. Econometric Results

Major Constraints	Number of farmers	Percent
Insect	97	55.7
Disease	9	5.2
Birds	15	8.6
Chemicals	34	19.5
Shortage of modern hive	8	4.6
Shortage of human Labor	2	1.1
Climate change	5	2.9
Others	10	2.4
Total	180	100

The stochastic production frontier was applied using the maximum likelihood estimation procedure. The dependent variable of the estimated production function was honey output (kg) produced in 2018/19 production season and the input variables used in the analysis were area under honey (ha), hives (numbers), labor (man-days in man-equivalent), forest coverage of the area (ha) and forage (Kg).

Table 4. Estimates of the Cobb Douglas frontier production function

Variables	Coefficients	Std. Err.	Elasticities
Ln(Labor)	-0.11	0.152	-0.11
Ln (forage)	0.071	0.089	0.071
Ln(Land)	0.277***	0.099	0.277
Ln (Hives)	0.649***	0.063	0.649
Ln(Forest coverage)	0.125**	0.048	0.125
Constant	4.875***	0.558	
Return to scale			1.012

***, ** and * show significance at 1%, 5% and 10% probability level, respectively

Source: Model output, 2018

Among the total production function variables used in the model, area(ha), number of hives and forest coverage of the area had a positive and significant effect on the level of honey output. The coefficients of the production function are interpreted as elasticity. Hence, high elasticity of output to number of hives (0.649) suggests that honey production was relatively sensitive to number of hives. As a result, 1 percent increase in number of hives will result in 0.649 percent increase in the honey production, keeping other factors constant. Alternatively, this indicates honey production was responsive to number of hives, followed by area and forest coverage seed respectively.

The returns to scale analysis can serve as a measure of total factor productivity (Gbigbi, 2011). The coefficients were calculated to be 1.012, indicating increasing returns to scale (Table4). This implies that there is potential for honey producer farmers to continue to expand their production because they are in the stage I of production, where resource use and production is believed to be inefficient. In other words, a percent increase in all inputs proportionally will increase the total production by 1.012 percent. This result is consistent with Solomon (2012) and Mustefa(2014) who estimated the returns to scale to be 1.04% and 1.039 in their study of EE of wheat seed production in Womberma woreda and EE of barley production in Chole District respectively. However, a study by Gbigbi (2011) in Nigeria found returns to scale to be 0.85, which falls in stage II of production surface.

Test of hypothesis :- It was undertaken to check whether the explanatory variables in the inefficiency effect model contribute significantly to the technical inefficiency variations among honey growing farmers.

Table 5. Generalized likelihood ratio tests of hypothesis for the parameters of SPF

Null hypothesis	λ	Critical value (χ^2 , 95%)	Decision
$H_0: \gamma = 0$	48.125	11.0705	Rejected
$H_0: \delta_0 = \delta_1 = \dots = \delta_{12} = 0$	25.31	21.0261	Rejected

Source: model output

In the first hypothesis, the null hypothesis that the average response function (OLS specification) is an adequate representation of the data was rejected and the alternative hypothesis that stated there exists considerable inefficiency among sample farmers was accepted.

In the second hypothesis the null hypothesis is also rejected in favor of the alternative hypothesis that the explanatory variables associated with inefficiency effects model are simultaneously different from zero. Hence, these variables simultaneously explain the differences in inefficiency among farmers. The model parameters were analyzed using STATA version 13 by employing a two stage estimation procedure.

Efficiency score

The model output presented in Table 10 indicates that farmers in the study area was good in TE. The mean TE was found to be 51.05%. It indicated that farmers on average could decrease inputs by 48.95% if they were technically efficient. In other words, it implied that if resources were efficiently utilized, the average farmer could increase current output by 48.95% using the existing resources and level of technology.

Table 6. Summary statistics of Technical efficiency measure

Type of efficiency	Minimum	Maximum	Mean	Std. Deviation
TE	0.10	0.88	0.55	0.1527

Source: Model output, 2018

Determinants of efficiency differential among farmers

The estimates of the Tobit regression model showed that among 12 variables used in the analysis, family size, hive size, experience and distance from the market were found to be statistically significant in affecting the level of TE of farmers.

Table 7. Tobit model estimates for Technical efficiency measures

Variables	TE	
	Marginal Effect	Standard Error
SEXHH	-0.0646	0.1083
FAMSIZE	0.0180*	0.0104
FARMSIZE	0.0081	0.0076
HIVESIZE	0.0009**	0.0003
EXPERIENCE	0.0060**	0.0028
Agehh	0.0030	0.0022
EDUCLVL	0.0011	0.0067
INCOME	3.15e-07	0.0000
TRAINING	-0.0365	0.0576
ATMARKET	0.0512	0.0585
PRICEHONEY	0.0001	0.0005
DISTFRM	-0.0109***	0.0034

Where: *, ** and *** refers to 10%, 5% and 1% significance level, respectively

Source: Model output

The discussion about each significant variables are presented as follows:

Family size: The coefficient of family size for technical efficiency is positive and statistically significant at 10 percent significance level. The result is similar to the previous expectation that farmers those having large family size are more efficient than farmers having small family size, because; family labor is the main input in honey production as the farmer has large family size he would manage its plots on time. This is in line with the findings of Mohammed *et al.* (2009), Essa (2011), Oluwatusin (2011) and Mustefa(2014).

Hive size: The total number of hives was found to have significant and positive impact on TE which is in line with the hypothesis made. It acts to represent the amount of honey harvested or the amount that a farmer anticipates to harvest come the harvesting season. Therefore, the larger the number of hives owned, the higher the quantity of honey will be harvested.

Experience : The estimated coefficients of experience for technical efficiency was positive signs and significant at 5 percent. As to the interpretation of marginal effects, for example, the marginal effect of 0.006 for experience shows that, for sample period, an increase in experience by one year led, on average, to an increase in technical efficiency by 0.006. The result is similar with the findings of Abdulai and Eberlin (2001), Dolisca and Curtis (2008) and Dawang *et al.* (2011) and Mustefa (2014), which may be because of the accumulated experiences that have been gathered over time. They become skillful as they get experience and may have an interest in the use of new methods of production. Therefore, the more experience the farmers are the more technically efficient they are.

Distance from the nearest market: Distance of the farm from the nearest market was also significant in determining technical efficiency. The negative coefficient implies that farmers far from farm of nearest market are less technically efficient compared to their counter-parts. This may be because of farmers near farm were incurred less cost compared to his counter-parts. This result is in line with the finding made by Alemayehu (2010) and Mustefa (2014).

Conclusion and Recommendations

Conclusion

Improving efficiency of the farmer plays a vital role in increasing productivity, given the current state of technology. This study was undertaken with the objective of assessing the technical efficiency of honey producers in in Illuabbabor and Buno Bedelle zones. The study area were selected purposively based on the level of honey production in the region and the mandate areas of Mettu university.

The Cobb-Douglas stochastic frontier production was estimated from which TE extracted. The results from the production function showed that area in hectare, hives and forest coverage of the area were positive and statistically significant factors that affect honey production. The result of the study also indicated that that 51.05% was the mean level of TE. This in turn implies that farmers can increase their honey production on average by 48.95% when they were technically efficient. This implies that, using the subsisting resource base, improved efficiency can still be achieved and there was a great potential for increasing the gross output with the existing level of resource base.

In the other part of the analysis, relationships between TE and various variables that were expected to have effect on honey farm efficiency were examined. This was relied on Tobit regression techniques, where TE were expressed as functions of 12 explanatory variables. Among them, Family size, hive size, experience of household head in honey production and distance of the farm households from the nearest market were found to be statistically significant to affect the level of technical efficiency.

According to the finding of this study, farmers producing honey can increase their production at the existing level of technology and inputs through improving in technical efficiency. Moreover, sample farmers can produce more than the current output level with the same amount of input they are currently using if they are technically efficient. Thus, the results of the study give information to policy makers and extension workers on how to better aim efforts to improve honey production efficiency as the level and specific determinant for specific efficiency was identified. This could contributes to improve farm revenue, welfare and generally helps agricultural as well as economic development.

Recommendations

The result of the analysis showed that honey producers in the study area are not operating at full technical efficiency level and the result indicated that there is ample opportunity for honey producers to increase output at existing levels of inputs with present level of technologies available at the hand of producers.

Arising from the results of the study, the following recommendations are drawn:

Family size is a positive and statistically significant factors that affect technical efficiency of honey producers. Therefore, in order to improve their motives, a great respect and attention should given to their family labor

The total number of hives (hive size) was also found to be related to technical efficiency level positively. Thus, provision of technologies that would help to carry out such operations more efficiently would improve the technical efficiency level of the farmers.

Distance of the farm household to the nearest market has a significant influence on the technical efficiency of smallholders honey producers. Therefore, farmers has to get inputs easily and communication channels has to be improved to get better level of technical efficiency.

Finally, it is interesting to note that this study was conducted on the measurement of technical efficiency, even though it is by improving the overall economic efficiency that major gains in production could be achieved. Therefore, additional efforts should be devoted to examining the impact of both allocative and economic efficiencies on performance of honey production.

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