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Technical Efficiency and its Determinants of Honey production (The Case of Bibugn District of Amhara Region, Ethiopia)

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ABSTRACT

The general objective of the study was to measure technical efficiency level of smallholder honey producers and to identify the factors influencing their level of technical efficiency on honey production in Bibugn District of Amhara Regional state. Stochastic production frontier approach was employed to estimate a Cobb- Douglas production function and to determine the level of technical efficiency. To establish determinants of technical inefficiency, Tobit model regression was used. The study used cross- sectional data through multistage sampling technique and finally 100 randomly selected sampled respondents from three kebeles. In line with this, the stochastic production frontier estimation result shows honey yield was significantly influenced by number of modern and traditional hives, beeforage and forest coverage. Honey producers achieved mean technical efficiency level of 60.51%. Mean technical efficiency indicates honey producers were operating below the production frontier. Additionally, shows by using the existing inputs with best performer's technology combination it is possible to increase honey yield by 39.49% in the study area. Determinants of technical inefficiency were education level, extension service, usage of modern technology and age of the household age has a significant effect on honey producer's technical inefficiency.

Policies that will lead to improve technical inefficiency; increase investment on number of hives, expand the best performers experience or practice through increasing frequency of extension contact, encourage honey producers to use modern hive and technology, make easy access bee forage and increase forest coverage and vegetation is recommended by the study.

Key words: Technical efficiency, Honey production, Stochastic frontier.

1. INTRODUCTION

Ethiopia registered high economic growth since 2005 at an average of 10.8 percent per annum. While the share of agriculture in the GDP decliend over ten years from 47 percent in 2004/05 to 39 percent in 2014/15. Despite its declining contribution to GDP over the years , agriculture remains the leading sector in terms of contribution to the country's overall economy. It is amajor source of food for domestic consumption, raw materials for domestic manufacturing industries and as a primery commodity for export. More over, the sector contribuits 73% of employment and supplies 70% of the raw material requirment for local industry. Livestock and livestock products as well as food crops were the leading contributers to agricultural sector growth in 2014/15. Ethiopia is generally considered to have the largest population of livestock in Africa.Livestock has value to 20% to Ethiopia's GDP and livelihoods of 60-70% of the nation's population (Admit *et al.,* 2016).

From beekeeping products, Ethiopia is the major producer of honey in Africa and 9th in the world. According to CSA (2014/15), in Ethiopia number of hives estimated to be 5.89 million hives were found in rural areas. From this total hives greater part (96.23 %) is traditional hive. The country's total honey production have been estimated 48.71 million kilograms of which about 91% is harvested from traditional hives. Honey is produced in almost all parts of Ethiopia with distinict types coming from different rigions. Among, Amhara Region is well known for production of large amount of honey in the country. According to CSA (2014/15) agricultural survey report on livestock from 1.36 million hives

11.12 million kilogram honey is produced in Amhara Region. This accounts for nearly 23% of the total honey production of the country.

In the Region many distrcts which has both good moistur pressure and moist areas are well known for honey production particularly Gojjam and Gonder are famus in the country for the production of more quantity with quality honey. By annual production North Gonder, West Gojjam and South Wollo accounts 33%, 20.3% and 10.24% respectively from annual production of Amhara Region (CSA, 2015/14).

Even though in 2014 Ethiopia produce about 49 thousand tonnes,country's honey production is characterized by the widespread use of traditional technology resulting in relatively poor quality and low honey supply of honey harvested in Ethiopia when compared to the potential honey yields and quality gains associated with modern beehives. As compared to traditional behives which yields 6-8 kg, modern behive yield arround 20kg (CSA,2014/15) that shows as a productivity differnce beteween modern and traditional beehives and the country could not use its potential.

However, Honey production is a profitable agricultural enterprise now a day in all parts of the world including Ethiopia.It is one of the few assets avaliable to the rural poor beekeepers rais their socio economic standing in areas with subsistance agriculture and farmers and farmers can substantially supplement the family income. Many farmers sell thier honey to the local markets and use income to purchase livestock, agricultural inputs, food crops and othe items (Kerealem *et al*., 2009). Also honey productiom is belived to play asignificant role in the economy of Ethiopia through pollination services by increasing food production and overall agricultural productivity(ibid).

Honey has multiple market opportunities unlike many other commodities. If an export market collapces people still have some chance to sell or use the honey with in towns and villages at home or creat secondary products largly sell their honey in the nearest local market (Fenet and Alemayehu, 2016).

Honey production has acontribution to income of households and the economy of a nation. It also provides an employment opportunity in the subsector. It is estimated that around one million farm households are involved in honey production business (Giday and Mekonnen, 2010). In addation to direct engaged in production of honey, job opportunity is created to those who are intermediaries and traders is participate in honey collection and retailing at village, district and reginal level. Also thousends of households are engaged in tej making in almost all urban areas and hundreds of processers are emerging (Beyene and David, 2007).

Beekeeping is an enviromentaly friendly and non farm business activity that has immense contribution to the economies of the society and to a nation economy as a whole(Guesh and Asamirew,2016). In addition to their financial value, honey and beeswax have many cultural values and form part of ceremonies for birth, marriages, funerals, Christmas and other religious celebrations in many societies. Beekeepers are generally respected for their craft. All of these aspects are Livelihood Outcomes from the activity of beekeeping. While some may be difficult or impossible to quantify, they are real outcomes that strengthen people's livelihoods and therefore should be acknowledged by a beekeeping intervention (Fenet and Alemayehu, 2016).

The majority of Ethiopians live in rural areas depending on agriculture as their sources of livelihood and apiculture is one of an important agricultural activity in most rural areas. As beekeeping has low start-up cost and requires little land and labor, it is accessible to many rural communities and is promoted as a pro-poor income generation activity. Honey production,which isone of the livestock sub-sectors, contributes significantly to improvement of the livelihoods of the nation's population (Workneh, 2011). According to MOARD (2011), the gross value of livestock output as sum of values obtaind from estimation gives 46,671 million birr of which honey accounts 553 million Ethiopian birr.

BibugnDistrict is one the Districts in East Gojjam Zone which has high potential in honey production and the district covers total area of aproxmatly 614.73 km^2 (61,473 ha).

The main source of livelihood in the district is subsistence agriculture. Although crop production is considered to be the major livelihood activity it is largely complemented by livestock production. The total livestock population of BibugnDistrict comprises cattle, sheep, goat, donkey, mule, horse, poultry and Beekeeping. Beekeeping, which isa sustainable less resource-based farming system without negative impact on the ecology and that canbe practiced without sharing more resources with other agricultural activities and resource. Beekeeping activitys were found in several households. Even though there is apotential for honey and wax production, beekeeping managment system is poor and the productivity is low (Yihenew *et al*., 2011).

In Bibugn District large proportion of inaccessible lands for agriculture arecovered with various types of trees, shrubs, bushes, and field flowers that make this part of theregions still potential for beekeeping. However, to make more productive in sustainable way, it requirs more effort to address some of the major factors related to production, productivety and efficiency particularly techinical efficency of honey production.
In addition, developing countries have scarce resources to undertake new investments on modern agricultural technology; improving the technical efficiency of farmers is essential i.e. there is a wide room for increasing agricultural productivity and production in these areas by improving technical efficiency of farmers at the existing resources (Berhan, 2015).

Beekeeping is an important component of agriculture and rural development program in manycountries. Beekeeping with its huge potentials to savethe natural forests and to earn subsistence income for the rural poor, it is one of the agriculturalsectors believed to serve as an instrument for climate change adaptation and poverty reduction. Since bee keeping is a less landbased activity, it does not compete with other resource demanding components offarming activity. The economic benefits lounge within bee products such ashoney,propels bee pollen, royal jelly and beeswax that are highly important and have high marketprices (FAO, 2012). Ethiopia, being the leading honey producer in Africa, theavailability of huge potential and the attention given by the government and other institutions to the subsector traditional production system isthe main characterstic where 96% of the hives are traditional and 91% of the total honeyproduced gaind from traditional beehives (CSA, 2015).This is resulted from lowproductivity of small holder farms, which in turnresult in lower contribution from apiculture subsector to the countries agricultural GDP. To inprove and increase efficiency of the subsector small farm honey producer technical efficiency need to be improved.

More part of BibugnDistrict is rural set up with about 90% population making their living from agricultur and related activities. The total cultivated land in the district is estimated to be 23,339 hectars. This implies that from the total area of the woreda only 37.97% is sutable to crop farming activities, which shows that from the total area of the woreda more than 62% is not conducive for crop farming activities. It is an opportunity to use this idle area for honey production. Bibugn District has good agroecological condition and the type of bee plants growing in the area is confortable for beekeeping.

According to BibugnDistrict agricultural and rural development office there are estimated to be 11,460 bee colonies and around 23,930 kilogram of honey have been produced for the crop year of 2007 and 19,560 kilogram of honey have been supplied to the market. Even the district has huge potential and honey production has numeros benefits in the society but the few people that engage in it as a business arenot commited and not totaly responsive . As aresult, this low commitment will lead to low productivity and inefficency in the use of an avaliable resource for the production of honey. Since the district has huge potential in production of honey, increase productivity of each honey producers is directly related to improving thier techinical efficency. To raise the productivity of the farmers it is necessary helping them reduce technical inefficencies. Thus there is a need to understand the extent of technical efficency and identify factors that exert influnce on honey producers performance so as to guide policy makers design and impliment effective projects and program in the woreda.

In Amhara Region the study conducted by Tessega (2009), study on honey production in Burie District the finding shows the major constraint were lack of equipment, shortage of bee forage, incidence of pests and disease. Opposing the constraint there were many opportunities and potentials to bost the production of honey in the study area. Among this divers opportunities their is divers distribution of bee floras and indigenous knowledge practicies.

On the other study Kidane (2014), makes assessement on honey production and productivety in Godere Distriict of Gambela Region. According to the result from multiple regression analysis land size, beekeepng expriance, number of collony owned and household adult equivalent were posetive and significant. While years spent in formal education and market price of honey were negative. Also the finding shows production elasticity is 0.667 and recomended that dispite all constraints there is still potential to increase the production and productivity of the study area.

But the above studies doesn't show the production efficiency and couldn't give direction how production and productivity could increase either through increasing inpute requirments or by using the existing resource efficientlly.

Another source of concern is that because of the associated honey production constraints, especialy the seemingly lack of technical know how, nothing is known about the level of techinical efficency who practice honey production activity. This stems from the fact that ability to produce maximum output from agiven set of inputs i.e techinical efficency, given the available resources has not fully utilized for honey production.

On this background information the main focus of this study will be to identify the factors that determine technical efficency of honey production and characterstics of honey producers in Bibugn District.

2. METHODOLOGY

2.1. Sampling Procedure and Data Collection

The targate population for this study was honey producers in the study area. In this study a multi-stage sampling technique had employed. In the first stage, BibugnDistrict has been selected purposely. In the second stage, 10 potential honey producing Kebeles was selected intentionally. In the same stage, 3 Kebeles (Debrezeit, Digokanta and Genamemicha) were selected using simple random sampling technique. In the third stage, 80 respondents were selected randomly from lists of honey producing farmers in the selected kebeles collaburating with wereda agricultural and rural development office experts. The total number of respondants were only 100 farm housholds by considering cost of collecting the data and to minimize data managment problem. Finaly the required sample respondants in each kebele will determined based on proportions of honey producer housholds of the respective kebele and simple random sampling techinique will followed to identify sample farm housholds.

Both primary and secondary data was used for the study. The primary data was collected for 2008 production year by using structured questionnaire. Finnaly, secondary information which supports for the interpritation and analysis were collected from wereda agricultural and rural development office and different published and unpublished sources.

2.2. Analytical Framwork

This study was focus on techinical efficency of honey production in BibugnDistrict based on the production theory that relates farm output to farm inputs which is also the foundation for computing efficency of production. Several approaches have been applied to estimate production efficency. However,the stochastic frontier approach is mostley employed particularly in agricultural production,because of its ability to show inefficency effect from measurment error and random shock. The advantage for stochastic frontier approach over the other non parametric approach is that it accounts for a composite error term(one for statistical noise and another for technical inefficiency effects) in the specification and estimation of the frontier production function.

For a number of reasons, the stochastic frontier analysis (econometric) approach has generally been preferred in the emperical application of stochastic production function model in efficiency of developing countries agriculture like Ethiopia. This might be due to most production of honey is oprated by family labor and hence the records are kept rarely. The available data on honey production are most likely subject to measurement errors.There fore, in this studystochastic frontier production method was used for estimating houshold level efficiency of honey production.

Stochastic production frontier analysis has been widely used to study techinical efficency in various settings in agricultural production studies since its introduction by Aigner et.al.(1977), and Meeusen and Van den Brock(1977) and the generalized stochastic frontier is given as:

$$Yi = f(Xi;\beta).exp(Vi-Ui), \quad Ui \geq 0 \quad \text{......} (6)$$

Where Yi denotes the maximum output for the i^{th} farm

f (Xi;β) represents a sutable production function of row vector of inputs X_i for the i^{th} farm and vector β is unknown parameters to be estimated. The stochastic frontier model which is specified above attributes the total variation in output to an error term which is made up of two components(Vi – Ui).

Where Vi is the random error which captures the effects of conditions beyond the control of the farmer and Ui is the non negative error term which accounts for technical inefficency(condition under the direct control of the farmer).

The i^{th} farm's technical efficency (TEi) measure is given by the ratio of the realized output(Yi) given the value of it's inputs and inefficency effects to corrsponding maximum potential output(Yi)*assuming there were no inefficency arising from the production process. Thus the technical efficency of the i^{th} farm is given as;

$$TEi = \frac{Yi}{Yi*} = \frac{f(Xi;\beta).\exp(Vi-Ui)}{f(Xi;\beta).\exp(Vi)} = \exp(-Ui) \quad (7)$$

The TEi ranges between 0 and 1

Equation 7 shows that the difference beteween Yi and Yi* is captured by Ui. And if Ui=0 then Yi=Yi* denoting that the output lies on the frontier and thus the farm is technically efficient and obtains its maximum potential output given the level of inputs. However, if Ui >0 the production lies below the frontier and the farm is technically inefficent. Following Battese and Coelli(1993) Vi is assumed to be independant of Ui and it is also assumed to be independently, identically and normaly distributed with a mean of zero and a constant variance, $\sigma^2{}_v$, [Vi ~N (0, $\sigma^2{}_v$)].

Ui is also assumed as a truncation of the normal distribution with mean Ui and variance $\sigma^2{}_u$, [Ui, $\sigma^2{}_u$)], seach that the mean is defined as;

$$Ui = \delta Z_i \quad (8)$$

Where Zi is a vector of inefficency factors and δ is avector of unknown parametrs to be etimated. Based on the distributional assumptions which underpin the random error term, this study will adopt the maximum likelihood estimation procedure to estimate the parametrs of the stochastic frontier and the inefficiency models.

Battese and Corra (1977) proposed the Log Likelihood (LL) functions for the model in equation assuming half normal distribution for the technical inefficiency (Ui) effects. They expressed the likelihood function using γ parameterization, where

$\gamma = \sigma^2 u/\sigma^2 = \sigma^2 u / (\sigma^2 v + \sigma^2 u)$ instead of λ in Aigner*et al.* (1977).

Gamma(γ) has avalue which ranges beteween zero and one. For 0<γ<1 then output variability is a result and presence of both technical inefficency and the stochastic errors. The existence of inefficiency can be tested using γ parameter and can be interpreted as the percentage of variation in output that is due to technical inefficiency. Likewise, the significance of δ^2 indicate whether the conventional average production function adequately represent the data or not.

2.3. Empirical Model Specification and Variables

The analysis basically employed both econometric and descriptive methods. The descriptive statistics is employed summary of the variables used in the model and describe other honey producer characters in the study area. Before getting on the empirical model specification and analysis method, it is very important to start by defining the selected variables which were used on production function and technical inefficiency model in this study.

2.4. Empirical model specification

The functional form that used in this study is spesify as the stochastic production frontier in the form of Cobb-Douglas function. Because the small number of observations makes it impossible to estimate a model with fully flexible functional forms. Although the Cobb-Douglas function is restrictive since it imposes that the mariginal rate of substitution of all input pairs are independent of other inputs and that all elasticities of substitution are equal to one. According to Brovo-Ureta and Pinheiro(1993) it is applied in agricultural farm(houshold) specific efficiency analysis for both developing and developed countries.

Inspite of its restrictive properties Cobb-Douglas production function is preferd becouse its coefficents directly represent the output elasticity of inputs and easy for interpritation and estimation than translog frontier (Colli and Battese, 1998).

Hence, in this study Cobb-Douglas production function will be used due to the above reasons and the empirical model of the production frontier equations is sspecified as follws.

$$\ln Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta 5 X_{5i} + \beta_6 X_{6i} + Vi - Ui \quad (9)$$

where

i represents the i^{th} sample farm, ln denotes logarithm tobase e, Y = Quantity of honey produced in 2008 E.C (in kilogram), $\beta_0 - \beta_6$= Coefficients to be estimated, Xji = Independent variable *j* (*j*= 1, 2, 3, 4,5,6) as follows: *X1* = Labor use in person day, *X2*= Number of traditional hives, *X3*= Number of modern hives(transitional hives + modern hives), *X4* = total expenditure on bee forage, X5 = land owned by the houshold in hector, X6 = forest coverage of the area in three kilo meters radius,*Vi*= Stochastic disturbance term, *Ui*= Technical inefficiency term.

To achieve the second objective of this study, a two-limit Tobit regression analysis was used to identify determinants of technical inefficiency, since the technical inefficiency scores (index) range between 0 and 1depicting the upper and lower limits. Technical inefficiency scores obtained from Stochastic Frontier Analysis (SFA) model above were regressed against selected input and honey producer characteristics variables to establish their influence on technical inefficiency.

On equation (3) the Ui value is distributed as follows;

$Ui = 1$ if $Ui^* \geq 1$

$Ui = Ui^*$ if $0 < Ui^* < 1$

$Ui = 0$ if $Ui^* \leq 0$

Therefore, the model assumes that there is an underlying stochastic index equal to ($\delta nZi + \varepsilon i$) which is observed only when it is some number between 0 and 1; otherwise Ui* considered as an unobserved variable. The empirical Tobit model for this study there for takes the following form.

Technical inefficiency is assumed to be explained by

$$Ui^* = \delta_0 + \sum_{n=1}^{12} \delta nZi + \varepsilon i$$

OR

$$Ui^* = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \ldots\ldots\ldots\ldots\ldots\ldots + \delta_9 Z_{12} + \varepsilon i (10)$$

where *Ui*= Technical inefficiency term that explain the nonnegativerandom variables and are associated with technical inefficiency of honey production of the respondent farmers, δ_0-δ_{12}=

Coefficients tobe estimated, *Z1* = Age in years, Z2 = Number of years of experience in honey production, *Z3*= Educational level in years,Z4 = Extension service(Number of extension visits), Z5 = Distance to town, Z6 = family size, Z7 =other income,*Z8* = Membership of Association (number of participation),Z9 = credit access(1 if ther is acsses; 0 otherwise), Z10 = Modern (1 = use modern technology 0 = otherwise), Z11 = sex of the respondant farmer(1 if male; 0 otherwise) and*Z12*= Marital Status (1 ifmarried; 0 otherwise).In this study, parameters of the stochastic frontier productionfunction willbe estimated by using maximum likelihood estimationmethod and the determinants for technical inefficiency factors are determined by using Tobit model.

3. RESULT AND DISCUSSION

To achieve the stated objectives, the data was collected by using structured questionnaire from targeted populations of honey producer farmers during 2008 production year. From 100 selected honey producers and distributed questionnaires 80 were returned and considered for the analysis which shows the response rate was 94.1%. From the sampled respondents 97.5% was males while 2.5% was females and age ranged from 25 to 72 years.

This chapter presents the empirical results from descriptive statistics, estimation of technical efficiency and identifying determinants for technical inefficiency in honey production. The estimations were conducted by stochastic frontier analysis and the examination of determinants of technical inefficiency was obtained using Tobit regression analysis. Descriptive statistics of sampled honey producer households, input and output variables which used to estimate technical efficiency index and determinants for inefficiency are presented in section 4.1, 4.2 and 4.3. In section 4.3 reports the result of technical efficiency estimation from the stochastic frontier and Tobit regression analysis with discusses the result.

3.1. Descriptive Results

31.1. Descriptive statistics related to socio economic characteristics of sampled household

The socio economic characteristics of farmers who engaged in honey production had observed 97.5 percent of honey producers are male headed while the rest 2.5 percent were female. This shows that most of the honey producers were male. The mean age of farmers was 47.3 years and around half of sampled honey producer farmers were has 45 and below years of age. This implies that majority of the honey producers are in their active age which adds a good advantage to the production level of honey in the study area. In this study, as shown from the sampled honey producers there is no any honey producer below 25 years' age which shows young farmers could not participate in this subsector and they could not use the opportunities to create job for themselves. The result from this table shows 98.7 percent of the sampled honey producers has married and had 2.4 average schooling years. The mean years of experience on honey production and family size was 12 years and 4.5 persons respectively. By considering sources of income in cash the mean income gained from selling of honey and other (cash crops, plants, livestock, livestock products etc) was 3801 and 6380 Ethiopian birr(ETB) respectively. The result of income share of sampled households shows that on average around 49 percent of their income was earned from selling of honey. This indicates honey production has a contribution to farmers for cash based expenditures like; land tax, to purchase education material for their children and to facilitate their agricultural activities.

Table 2. Descriptive statistics related to socio economic characteristics

Variable	Obs	Mean	Std. Dev.	Min	Max
dsex	80	0.975	0.15711	0	1
age	80	47.275	11.39728	25	72
convfmsz	80	4.525	1.629436	1	8.3
educat	80	2.3875	2.155322	0	8
expirince	80	12.3	8.08092	2	36
Dmarital	80	0.9875	.1118034	0	1

Honincom	80	3801.625	3078.788	0	12300
Incother	80	6379.813	6731.159	0	32100
honincomsha	80	0.4930935	.3372903	0	1

Source: Own Computation (2019)

3.1.2. Descriptive statistics related to production and inputs

The summary of continues variables prevailed that the average honey produced per sampled household in 2008 production year was around 69 kilo gram. Regarding honey production inputs the average number of beehive by type showed that traditional, transitional and modern hive was 6.3, 1.04 and 0.63. The mean total number of hive owned by sampled households was around 7.9 hives. As presented from this table the average values expended for bee forage was 61.19 ETB which shows honey production could not need much money.

Table 3. Descriptive statistics related to production and inputs

Variable	Obs	Mean	Std. Dev.	Min	Max
Output	80	68.7875	45.19233	6	180
Tradhiv	80	6.3125	3.976493	0	18
Transhiv	80	1.0375	0.8779111	0	5
Modhiv	80	0.625	0.9192044	0	3
Totahivies	80	7.975	4.423685	1	19
Before	80	61.1875	42.66594	10	200
Land	80	1.656125	0.6857952	0.125	3.76125
Labor	80	1.10625	0.3851989	0.25	2
Forest	80	2.5675	1.173254	0.5	5.3

Source: Own Computation (2019)

The average land ownership for sampled household was 1.65 hectors and labor force used to keep honey bees in active season was around one person used per day which shows honey production can be operated by single person.

When we see summary of forest coverage on average 2.56 hectors of forest were exist in three kilo meters radius which shows there is a good opportunity and potential to expand honey production in the study area.

3.1.3. Descriptive statistics related to honey bee management

From this summary result; only 41.25 percent of the sampled households were used modern beehives which show above half of the sampled household's uses only traditional hive. Further analysis of variables related to honey bee and farm management shows that from sampled observations 70 percent of households have access to credit. On average honey producers get extension contact with experts was 9 days per year. This is not that much enough they could not get one day per month. The mean participation was around 2.5 shows on average the sampled household participates on two and above associations and social groups or cooperatives.

Table 4. Descriptive statistics related to honey bee management

Variable	Obs	Mean	Std. Dev.	Min	Max
Dmoder	80	0.4125	0.4953901	0	1
Extension	80	9.225	6.304459	0	27
Partci	80	2.4625	0.7946618	0	5
Dcredit	80	0.7	0.4611488	0	1

Source: Own Computation (2019)

3.2. Econometric Results

The result of the stochastic half normal model estimation is presented in table 5 the first section of the results contains production frontier functions with six parameters. The other part of the result shows the variance parameters the amount of the function of log likelihood and the Log Ratio test

3.2.1 Estimation of the Cobb-Douglas Stochastic Production Frontier

From the stochastic frontier production function number of traditional hive, number of modern hive and value of expenditure were found to significantly affect at 1% level and forest coverage in three kilo meter radius was significantly affect honey production at 5% level.

The log likelihood for fitted model was -51.93 and the chi-square was 155.2 which is strongly significant at 1% level. Thus the overall model was significant and the explanatory variables used in the model were collectively able to explain the variations in honey production. The model result further show that the variance of technical inefficiency parameter γ is $\gamma = \delta u^2{}_{/}\ \delta^2$ (0.937) is significantly different from zero which shows that 93.7 percent of the variation in honey production output were due to technical inefficiency. The value of γ is significantly different from one indicating that random shocks are playing a significant role in explaining the variation in honey productivity, which is expected in agricultural production where uncertainty is assumed to be the main source of variation. This implies why ordinary least square (OLS) or an average production function was not a suitable specification for sampled honey producer farmers.

The following elasticity's were generated from the stochastic production frontier estimation: Labor (-0.248), traditional hive (0.125), modern hive (0.398), expenditure on bee forage (0.383), land (-0.031) and forest coverage (0.263). Hence the resulting returns to scale parameter obtained by summing these input elasticity's 0.89. This indicates that honey production in the study area exhibits decreasing returns to scale, implying that honey producers in the study area use traditional honey production techniques which have become redundant and not effective.

Modern beehive has the largest elasticity followed by bee forage and forest coverage. The result showed modern hive had a strongly positive significant effect on honey productivity at 1% level. This shows that a 1% increase in the number of modern beehive significantly increase honey yields by 39.8%.

This finding conformed to those by Kaleb and Birhanu (2016) who found that use of improved technologies particularly uses of improved hive found to have a significant positive effect on technical efficiency.

Expenditure on bee forage also showed a positive effect on honey productivity according to the finding. It was established that bee forage had a significant influence on honey yields at 1% level. Since a 1% increase in value of expenditure on bee forage then increases honey yield by 38.2 %.

It was further found that forest coverage showed a positive significant effect at 5% level. The result reveled that a 1% increase in forest coverage, significantly honey productivity increases by 26.3%.

The findings also showed a positive coefficient for traditional hive has a strongly significant influence on honey production at 1% level. According to the results an increase the traditional hive by 1% significantly increased the household honey productivity by 12.4%. This suggests the more traditional hive a household have the higher honey yield obtained. The variables labor and land were found to be insignificant. However negative sign of labor might be due to the reason that sampled honey producer farmers use more family labors than the recommended level or at marginal productivity level. In addition, the negative sign of land coefficient showed that a household who had large plot of land might give more emphasis to other agricultural product which is land based and do not care about honey productivity.

Table 5. Estimation result of Cobb- Douglas stochastic production Frontier

Wald chi2(6) = 155.20 Number of obs = 80

Log likelihood = -51.92684 Prob> chi2 = 0.0000

Likelihood-ratio test of sigma_ u=0: chibar2(01) = 8.71 Prob>=chibar2 = 0.002

lnout	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
lntradhiv	0.1245999***	0.0187154	6.66	0.000	0.0879184	0.1612815
lnmodhiv	0.3985397***	0.1048524	3.80	0.000	0.1930329	0.6040466
lnlabor	-0.2482073	0.1703803	-1.46	0.145	-0.5821465	0.085732
lnbeforg	0.3826292***	0.0744603	5.14	0.000	0.2366898	0.5285687
lnland	-0.0309475	0.0899302	-0.34	0.731	-0.2072076	0.1453125
lnfors	0.2638677***	0.0915292	2.88	0.004	0.0844737	0.4432616
_cons	2.575435	0.2964538	8.69	0.000	1.994396	3.156474
/lnsig2v	-3.281473	0.6012556	-5.46	0.000	-4.459912	-2.103034
/lnsig2u	-0.5763618	0.2515173	-2.29	0.022	-1.069327	-.083397
sigma_v	0.1938372	0.0582729			0.1075331	.3494074
sigma_u	0.749626	0.0942719			0.5858665	0.9591589
sigma2	0.599512	0.1299434			0.3448275	0.8541965
lambda	3.867296	0.1359376			3.600863	4.133729

Note: ***, **and * indicate significance at 1, 5 and 10 % level, respectively

Source: Own Computation (2019)

3.2.2. Frequency distribution of technical efficiency of honey producers

The firm specific technical efficiency varied between 0.19 and 0.92 with mean technical efficiency 0.6051 as shown from Appendix 2. This implies that in the short run it is possible to increase honey yield in the study area on average by 39.49 % by using existing inputs technology of best performers.

Table 5 Frequency distribution of technical efficiency of honey producers

Efficiency Level	frequency	percentage	Cumulative percentage
≤0.25	6	7.5	7.5
0.25 ≤ 0.50	18	22.5	30
0.50 ≤ 0.65	13	16.25	46.25
0.65 ≤ 0.75	23	28.75	75
0.75 ≤ 0.85	10	12.5	87.5
> 0.85	10	12.5	100
Total	80	100	

Source: Own Computation (2019)

3.2.2. Factors affecting technical inefficiency

The estimate of the Tobit regression coefficients and the effects of explanatory variables on technical inefficiency are shown in table 4.5. It is important to note that the dependant variable in the model is obtained from FRONTIER41 software and computed by (technical inefficiency index = 1- technical efficiency index) gives us technical inefficiency index. A positive coefficient implies efficiency decrease where as a negative coefficient means an association with technical efficiency increases. The results from the two-limit Tobit regression of selected socio-economic and institutional support factors against computed technical inefficiency scores. The model was correctly estimated since the model chi-square was 43.95 and it was significant at 1% level. In addition, the pseudo R^2 was -0.783 against the recommended level of 0.20. Thus it is evident that the explanatory variables chosen for the model were able to explain 78.3% of the variation in technical inefficiency level.

Based on the result of the inefficiency model three farm specific factors had a significant coefficient: namely age of household head, education level, usage of modern technology and extension contact.

Coefficients associated with other income, family size, credit access, sex of household head,distance to town and marital status have positive signs; that increases technical inefficiency (decreases efficiency) but not statistically significant. Besides experience, other income and participation in cooperatives and associations were affect technical inefficiency negatively (promotes efficiency). Since these were not having statistical significant effect on honey producers technical in efficiency, so no further discussion is made concerning the above factors.

Age of the household head showed a positive effect on technical inefficiency of honey producer farmers and it was significant at 10% level. The results revealed that an increase in the farmer's age by one year increases the level of technical inefficiency by 0.33%. This means that older farmers were less technical efficient in honey production than their younger counterparts. This finding was consistent with findings by Abdul- Malik (2012) in Ghana. The result is attributed to the fact that as a farmer becomes more aged in life it becomes practically difficult if not impossible for him/her to take care of the honey bees and there for becomes more inefficient. The finding also attributed to the fact that older honey producer farmers in the study area were relatively more reluctant to take up better technologies instead they prefer to hold traditional methods. Thus they become more inefficient as compared to their younger counterparts. This reluctance to accept or use innovative farming methods is also responsible for decreasing returns to scale realized earlier.

Tobit regression Number of obs = 80

LR chi2(12) = 43.95Prob> chi2 = 0.0000

Log likelihood = 34.299985 Pseudo R2 = -1.7829

tineff	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
age	0.0033439*	0.0019393	1.72	0.089	-0.0005259	0.0072137
expirince	-0.0031012	0.0028652	-1.08	0.283	-0.0088187	0.0026163
educat	-0.0282263**	0.0109879	-2.57	0.012	-0.0501523	-0.0063004

extension	-0.0079352**	0.003157	-2.51	0.014	-0.0142349	-0.0016355
disttwon	0.0084179	0.00848	0.99	0.324	-0.0085036	0.0253393
convfmsz	0.013703	0.0117505	1.17	0.248	-0.0097447	0.0371507
incother	-1.07e-06	3.12e-06	-0.34	0.732	-7.30e-06	5.16e-06
partci	-0.0076415	0.0235493	-0.32	0.747	-0.0546334	0.0393504
dcredit	0.0373479	0.0426629	0.88	0.384	-0.0477845	0.1224803
dmoder	-0.0771965*	0.0428776	-1.80	0.076	-0.1627574	0.0083645
dsex	0.1562204	0.127133	1.23	0.223	-0.0974696	0.4099104
dmarital	0.2104674	0.1700444	1.24	0.220	-0.128851	0.5497858
_cons	-0.0150355	0.2401405	-0.06	0.950	-0.4942283	0.4641574
/sigma	0.1576011	0.0124595			0.1327386	0.1824635

Note: ***, **and * indicate significance at 1, 5 and 10 % level, respectively

Source: Own Computation (2019)

Education level in years showed a negative effect on technical inefficiency can be argued that farmers with better level of education are assumed to have less inefficiency. In line with this, education was found to have negative and significant effect on honey production technical inefficiency (5% level). The result is consistent with other studies by Batteseand COelli(1995), Getahun G. (2014). In fact, education usually considered as an indication for higher possibilities of literate household in having better managerial skills, access and understanding of information on improved methods to their operations. From the result an increase in education level by one year decreases technical inefficiency by 2.8%.

Extension services provided to households plays crucial role in creating capacities to improve overall performance of farm productions through access to better information on new technologies. The estimated coefficient of extension services in this study also conforms the negative impact on technical inefficiency of honey producer farmers and significant at 1% level. This shows that farmers who had access to more extension service either in form of literature or contact exhibited improved efficiency.

This could be because such farmers have easier access to market information and best available practices from which they can make informed market choices and adopt efficiency enhancing technologies. The estimated result shows that an increase the extension contact with experts by one day then technical inefficiency decreases by 0.8%.

Using modern beehive with bee forage as a proxy for modern technology; improves honey productivity and has a negative significant effect on technical inefficiency. Households who used modern technology are more technical efficient than otherwise.

Besides estimating stochastic production frontier and technical efficiency scores another key propos of analysis was to explain possible sources of honey production and inefficiency commonly known as production effect and inefficiency effect (Coelli et al., 2005). In this study possible determinants of honey output and technical efficiency were investigated by inclusion of various inputs, socio-economic and institutional related variables in the estimation. The selected variables for production and inefficiency model have made test the data against different possible econometric problems. Accordingly, the data was checked for heteroscedasticity using Breusch-Pagan test and the result showed that there was no serious problem of heteroscedasticity. Multi-collinearity test was done using Variance Inflation Factor (VIF) conformed as there is no serious linear relation among explanatory variables.

4. CONCLUSION AND RECOMMENDATION

4.1. Conclusions

This study presents descriptive statistics about honey producers and determinants of honey production and technical efficiency for a sample of 80 honey producer farmers in Bibugn District of Amhara Region, Ethiopia.

The result from descriptive statistics showed that most (97.5%) of honey producers were male headed. The mean age was 47.3 years and there is no any honey producer below 25 years' age. Regarding years of experience honey producers had a mean of 12 years.

The summary statistics showed that the mean honey yield was 69 Kilo Gram and on average owns around 7.9 hives. By considering transitional hive as modern only 41.25% of the sampled households were used modern beehive.

Maximum likelihood techniques were used to estimate a Cobb-Douglas production frontier which was used to drive farm level technical efficiency measures by using FRONTIER4.1and STATA13 software. The results of stochastic frontier model show that the number of hives a household owns whether traditional or modern, a household uses value of purchased bee forage and availability of natural forest and vegetation within three kilo meter radius determine the amount of honey produced by honey producers in Bibugn District. This result is consistent with other research in Ethiopia (Kaleb and Birhanu, 2016)

The analysis reveals that the mean level of technical efficiency equal to 60.51% which shows, by using the existing inputs with best performer's technology it is possible to increase honey yield by 39.49% in the study area. The distribution of the farm level measures of technical efficiency shows that 30% of honey producer farmers have efficiency score that less than or equal to 50% and with only 12.5% were having technical efficiency score above 85%. The firm specific efficiency varied between 0.19 and 0.92, this explains there is no any honey producer scores technical efficiency above 92% level in the study area.

The result from inefficiency model examines that education level, usage of modern technology and extension services have a statistically significant negative influence on technical inefficiency but age of the household head has a statistically significant positive (negative) influence on technical inefficiency (efficiency).

In addition to this the study result conforms that in conceptual framework, honey production is affected from internal and external factors. From external factor policies and institutional factors like extension service and training is significantly affects the technical efficiency of honey producers.

Whereas on side internal factor both technical inputs and producer characteristics such as number of hives, bee forage, forest coverage, age of a household head, modern hive usage and educational background have a significant effect on honey production and technical inefficiency. Standing from this result the following recommendations have been given to farmers, Government organs and non- governmental organization.

4.2. Recommendations

The most important policy implications drawn from this study include, major determinants of the Cobb Douglas stochastic production frontier among honey producers are modern hive, traditional hive, bee forage and forest coverage attributed by the large coefficient values as compared to those of other variables in the model.

There for the study recommends policies that will lead to increased number of modern bee hives and traditional hives, which the former could be supplied by the government or by non-governmental organizations with considerable cost by subsiding. It also recommends increase investment on supply of bee forage and expands forest coverage through planting non farmed lands and expands vegetation through increasing irrigation to increase honey production yield in the study area.

From the analysis it is evident that honey producers in the sample are far from being technically efficient. There is evidence that honey producers could improve their technical efficiency by being less technical inefficient which entails choosing inputs and use them efficiently.

Policies to decrease technical inefficiency can be prioritized on several factors. Firstly, expand spatial extension services to honey producers. In this context Government and other non-government organizations can provide extension contact about honey production in the study area.

Since extension service has a significant positive effect on efficiency level, any organizations or individuals who had an interest to improve the technical efficiency of honey producers could invest on extra extension contact days with effective extension service for honey producer farmers.

Second, improve education level of honey producers is necessary for increasing knowledge on various information and technologies relating to agricultural practices in general and honey production in particular and encourage to use improved technology. In addition to this the government should encourage educated farmers to engage in honey production to have technical efficient honey producer and to increase honey output in the study area.

Finally, the result shows that inefficiency was positively affected by honey producer age. Regarding this result, the government should encourage young farmers to participate in honey production or educate and give special extension contact to older honey producers to improve their technical efficiency.

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