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ADOPTION OF IMPROVED BEEHIVE TECHNOLOGY IN ETHIOPIA: EVIDENCE FROM KAFFA, SHEKA AND BENCH-MAJI ZONES

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Abstract

Even though Southwestern zones of Southern Ethiopia have favorable climatic condition for honey production; productivity is low as compared to its potential due to low level of improved beehive technology utilization. Different organizations strive to increase the production by dissemination of these technologies. However, adopters of the technology are not comparable with what efforts have been done due to institutional, socioeconomic and technology related factors. This study has identified the determinants of improved beehives technology adoption in Kaffa, Sheka and Benchi Maji zones of Southern Ethiopia using a data collected from 360 households. The collected data was analyzed by using both descriptive statistics and econometric model. For econometric analysis, double hurdle model was used to estimate the decision to adopt improved beehive technology and its intensity. The results of the study have indicates that adoption education level, distance from farmers training center, total annual income, extension contact, perception towards hive price and participation in demonstration of the technology influences the adoption of improved beehives technology. Therefore, these decision variables should be addressed to improve the adoption of improved beehive technology.

Key words: *Adoption, double hurdle, intensity, technology*
Jel Codes: *O33, Q16, Q55*

1. Introduction

Ethiopia has huge potential of the apiculture sub-sector, which holds a key position for poverty reduction and natural resource conservation in the country (MoA and ILRI, 2013). Owing to its varied ecological and climatic conditions, the country is among the major producer of honey both in Africa and in the world. For instance in 2013 the country produced about 45 thousand tones which accounted about 27% and 3% of African and World honey production, respectively and makes the country the largest producers in Africa and the tenth in the world (FAOSTAT, 2015).

Despite of its contribution for smallholder households' income in particular and nation's economy in general, honey production system is very traditional which results in low productivity and poor quality. For example, the 96% of the hives are reported to be traditional and 91% of the total honey produced come from traditional hives (CSA, 2015). Thus, the government of Ethiopia has increased its attention to develop the apiculture sub-sector as one of its strategies for poverty reduction and different NGOs have been intervening to assist the poor smallholder farmers through introduction and promotion of improved beehives technologies to obtain higher production and good quality that can enable the smallholder farmers to be benefited from the sub-sector (GDS, 2009).

SNNPR (Southern nation nationalities peoples region) is one of the potential areas in honey production which accounts 15% of the total bee colonies and 17% of the total honey production in Ethiopia. According the report of CSA (2015), annually the region produces 5,724,001 kg honey with average production capacity of 7 kg per hive. Southwestern part of SNNPR contains many nectar and pollen producing plants suitable for bees. As the result, large volume of honey is produced annually based on traditional beekeeping technique (Awraris *et al*., 2012). Although Kaffa, Sheka and Benchi Maji zones have huge potential in number of bee colony and flora, the production from the sector is still low as compared to its potential.

SNNPR government under its agricultural led development policy gave due attention to apiculture development in selected areas of the region based on their prioritized potential. To develop this potential and to increase production from the sector, different improved beekeeping technologies have been introduced (SNNPRBA, 2015). Some of the technologies are transitional bee hive, modern bee hive, honey presser, honey extractor, veil and improved bee forages. To this effect, different governmental and non-governmental organizations have been involved in technology demonstrations and dissemination (Yiyi *eta l.,* 2016).

Likewise in the last 5-10 years, great effort has been made by government extension package and different NGOs to promote improved hive technology in the region to increase honey production (SNNPRBA, 2015). In line with this, Kaffa, Sheka and Benchi Maji zones livestock and fishery departments demonstrate and disseminate improved beekeeping technologies solely and in collaboration with projects like AGP (Agricultural Growth Program), ASPIRE (Apiculture Scale-up Programme for Income and Rural Employment) and EWNRA (Ethio-Wetlands and Natural Resources Association). In addition, different private companies like Sheka nordic honey development industry and Apinec agro-industry demonstrated by dissemination of improved box beehives in these zones (Kassa *et al*., 2017a).

Through different organizations strive to demonstrate improved beehives in Kaffa Sheka and Bench-Maji zones, the adopters are not comparable with what efforts have been excreted. This might be due to institutional, socioeconomic, biophysical and technology related factors. Different researches have been carried out concerning honey production and marketing system, comparative analysis of colony performance, value chain and market supply of homey in the study area (Awraris *et al*., 2012; Gallmann and Thomas, 2012; Awraris *et al*., 2015; Kassa *et al*., 2017; and Kassa *et al*., 2018). However, there is no compiled and tangible information regarding to adoption of improved beehive technology in these zones. Therefore, the aim of this study to identify the determinants of improved beehive technology adoption decision and its intensity.

2. Research Methodology

2.1. Sampling Technique and Sample Size

Sampled beekeepers was selected by multi-stage sampling procedure for the interview. Gesha and Chena districts from Kaffa zone; Masha and Anderacha districts from Sheka zone and Sheko and Debubi Benchi districts from Benchi-Maji zone were selected purposively based on their potentiality honey production and improved box hive promotion. Secondly, based on honey production, kebeles[i] in each district was grouped into medium and high producer. Thirdly, one from medium and high honey producing kebeles of each district was selected randomly. The households were stratified into honey producers and non-producers and listed in selected kebeles. Finally, from the honey producers group, 30 households were selected randomly with total sample size of 360.

2.2. Methods of Data Collection

Primary data was collected by enumerators who are working as development agents in the selected kebeles with aid of districts livestock and fishery development office. Before data collection, the enumerators were trained on the techniques of data collection and the questionnaire was pre-tested. Hence, appropriate modifications were made on the questionnaire based on pretest result prior to conducting the survey. In addition to the questionnaire, an informal survey in the form of focus group discussion and key informants' interview was employed using checklists to obtain additional supporting information for the study.

2.3. Method of Data Analysis

2.3.1. Descriptive Statistics

Mean, standard deviation, percentages and frequency are of the descriptive statistics used to examine the demographic, socioeconomic and institutional characteristics of sample respondents. Furthermore, mean differences of both discrete and continuous variables among adopters and non-adopters were computed using χ^2 and *t*-tests, respectively.

2.3.2. Econometric Analysis

Numerous econometric models have been applied to analyze the determinants of technology adoption. However, the econometric specification largely depends on the purpose of the study and the type of data available. One of the most used methods for modeling technology adoption behavior is the censored regression model, also called the tobit model. The key underlying assumption for the model specification is that farmers demanding improved technology it's have unconstrained by access (Wooldridge, 2010). In line with this, tobit model specification has no mechanism to distinguish households with a constrained positive demand for the new technology from those with unconstrained positive demand, and assumes that a household not adopting the technology is making a rational decision. Hence, for access constraints to technology, tobet model yields inconsistent parameter estimates (Bingxin *et al*., 2011).

Double hurdle is the model introduced as a more flexible and alternative to tobit model (Cragg, 1971). The modeling approach assumes a two-step decision process based on the assumption that household makes two separate decisions; the first step involves the decision whether to adopt certain technology or not and secondly the intensity of adoption. The model estimation involves a probit regression to identify factors affecting the decision to adopt improved beehive technology by using all sample households in the first stage, and in the second stage, the intensity of the adoption was analyzed by truncated regression model.

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[i] Kebele is the lowest administrative unit under Ethiopian condition.

Heckman two-stage model has been used extensively to correct for bias arising from sample selection (Heckman, 1979). In this model, the decision to adopt is sequential two-stage decision making process. In the first-stage, farmers make a discrete decision whether to adopt or not. In the second-stage, conditional on their decision to adopt the technology, farmers make continuous decision on how much to use. One problem with the two equations is that the two-stage decision making processes are not separable due to unmeasured variables determining both the discrete and continuous decision thereby leading to the correlation between the errors of the equations. If the two errors are correlated, the estimated parameter values on the variables determining the intensity is biased (Woodridge, 2010). Besides, there were many zeros in the dependent variable of second stage, OLS estimation was biased because of duplications of many zero's which results no variability.

To capture the above problems, the double hurdle procedure with probit and truncation regressions were used separately. The model is a parametric generalization of the tobit and heckman model, in which two separate stochastic processes determine the decision to adopt and the level of adoption (Bingxin *et al.*, 2011). In addition, using double hurdle model provides consistent and asymptotically efficient estimates for all the parameters. Thus, double hurdle model was used analyze decision to adopt and intensity of adoption, the with tobit model result for comparison.

2.3.3. Specification of Double Hurdle Model

The model involves two-step estimation procedure. In the first stage, probit regression was used to identify factors affecting adoption decision. The model takes a value 1 and 0 that are assigned to represent the choice whether a producer decides to adopt or not. The standard probit model that assesses the household adoption decision is described as follows:

$$D_i = \alpha' Z_i + V_i \text{ (Adoption decisions equation)} \quad (1)$$
$$D_i = 1, \text{ if } D_i * > 0 \text{ and 0 if } D_i * \leq 0$$

Where, D_i is a dummy variable that takes the value 1 if the producer adopts improved box hive and 0 otherwise, Z is a vector of independent variables hypothesized to influence adoption decision and α is a vector of parameter to be estimated and V_i error term.

In the second stage, truncated regression that excludes part of sampled observation based on the value of the dependent variable was used (Wooldridge, 2010). The regression considers the observations that takes 1 for adoption decision or only that adopts improved box hive technology. Therefore, the second hurdle represents the actual level of adoption, expressed by the number of improved beehives owned. Thus, the truncated regression model with the lower left truncation equal to 0 was used to determine factors affecting the intensity of adoption.

$$y_i = \beta_i x_i + \mu\lambda_i + \eta_i \quad (2)$$
$$y_i^* = \beta' x_i + u_i \quad \text{(Equation for intensity of adoption)} \quad (3)$$
$$y_i = y_i^* \text{ if } y_i^* > 0 \text{ and } D_i^* > 0$$
$$y_i = 0 \quad \text{otherwise}$$

Where, y_i^* and y_i are latent and the observed intensity of adoption respectively, x_i is a vector of variables influencing intensity of adoption and β is a vector of parameters to be estimated. The error terms are assumed to be independently and normally distributed as both decisions made by the individual producer independently which is as:

$$v_i \sim N(0, 1) \text{ and } u_i \sim N(0, \sigma^2),$$

The log-likelihood function for the double-hurdle model that nests probit model and a truncated regression model is given following Christoph and Peter (2014) as:

$$LogL = \sum \ln\left[1-\Phi(Z_i{'}\alpha)\left(\frac{x_i{'}\beta}{\sigma}\right)\right] + \sum_{+} \ln\left[\Phi(z_i{'}\alpha)\frac{1}{\sigma}\phi\left(\frac{y_i - x_i{'}\beta}{\sigma}\right)\right] \quad (4)$$

Where, Φ and ϕ refer to the standard normal probability and density functions respectively, Z_i' and X_i' represent independent variables for the Probit model and the Truncated model respectively, α, σ, and β are parameters to be estimated for each model.

The result of double-hurdle model was also compared with the alternative tobit model separately. Tobit model supposes that there is a latent unobservable variable y_i* which depends linearly on x_i via a parameter vector β. In addition, there is a normally distributed error term u_i to capture random influence on this relationship. The observable variable y_i is defined as being equal to the latent variable whenever the latent variable is above zero and to be equal to zero otherwise. According to Tobin (1958), tobit model is expressed as:-

$$y_i = \begin{cases} y_i * if y_i *> 0 \\ 0 \quad if y_i * \leq 0 \end{cases} \quad \text{and} \quad (5)$$

$$y_i* = \beta x_i + u_i, u_i N(0, \sigma^2) \quad (6)$$

Where y_i* *is* a latent variable, β is a vector of unknown coefficients and X is a vector of independent variables

The log-likelihood function verify the equality of the coefficients in the adoption decision equation with the level of adoption equation is given as:

$$LnL_T = \sum_{y_i = y_i^*} -\frac{1}{2}\left[\ln(2\pi) + \ln\sigma^2 + \frac{(y_i - x_i\beta)^2}{\sigma^2}\right] + \sum_{y_i=0} \ln\left[1-\Phi\left(\frac{x_i\beta}{\sigma}\right)\right] \quad (7)$$

A test for the tobit model against the double-hurdle model comes from the fact that the hurdle model log likelihood can always be written as the sum of the log likelihoods of the two separate models: a probit and a truncated model (Hailemariam *et al.*, 2006). As such the hurdle model likelihood function can always be maximized, without loss of information, by maximizing the two components separately (Genanew & Alemu, 2010). Therefore, whether a tobit or a double hurdle model is more appropriate can be determined by estimating the Tobit and the double hurdle models (the truncated regression model and the probit model) separately. After estimation, conducting a likelihood ratio test that compares the tobit with the sum of the log likelihood functions of the probit and truncated regression models (Genanew & Alemu, 2010). The likelihood ratio test statistics Γ can be computed (Greene 2012) as:

$$\Gamma = -2\left[\ln L_{Tobit} - (\ln L_{Probit} + \ln L_{Truncated})\right] \sim \chi_k^2 \quad (8)$$

Where, Γ is likelihood ratio statistic, *ln* is natural logarithm, L_{Tobit},is likelihood values for Tobit, L_{Probit} is likelihood values for Probit is $L_{Truncated}$ is likelihood values for Truncated regression, χ^2 is chi-square and k is the number of independent variables in the equations.

The null hypothesis is rejected when the likelihood ratio statistic (Γ) exceeds the value of the chi-square statistic (χ^2_k). For good measure, Akakie's Information Criterion (AIC) is also included as a model selection criterion. According to Akaike (1974), AIC serving as a measure of goodness of fit for individual models by:

$$AIC = 2K - 2\ln(L) \tag{9}$$

Where, k is number of parameters in the model, $L$is the likelihood function. The AIC method helps to know that the specified model best explains the data and the preferred model is the one with the lowest AIC value, compared to its alternative model (Hailemariam *et al.*, 2006; Adam, 2010).

2.4. Hypotheses of Variables

Adoption is viewed as a variable representing behavioral changes that farmers undergo in accepting new ideas and innovations. The term behavioral change refers to desirable change in knowledge, understanding and ability to apply technological information, changes in feeling behavior such as changes in interest, attitudes, aspirations, values and changes in overt abilities and skills (Rogers, 2003). The term improved beehives in this study refers to Zender, Kenya top bar, Chefeka beehives. Based on theory and previous study the following variables were hypothesized.

Table 1. Summary Of Variables Hypothesized For Econometric Analysis.

Variables	Type	Measurements	Expected sign
Adoption decision of improved beehives technology (D)	Dummy	Adopter=1, Non-adopter=0	
Number of improved beehives owned (y)	Continuous	Number	
Sex of household head (x1)	Dummy	Male=1, Female=0	+
Educational level of household head (x2)	Continuous	Grade	+
Household size (x3)	Continuous	Man equivalent	+
Total income in 1000 (x4)	Continuous	ETB	+
Beekeeping experience (x5)	Continuous	Year	-
Number of local beehive owned (x6)	Continuous	Number	-
Participation in demonstration of improved beehives (x7)	Dummy	1= Yes, 0=No	+
Perception towards price of improved beehives (x8)	Categorical	1=High, 2=Medium, 3=Low	-
Frequency of extension contact per year (x9)	Continuous	Number	+
Distance from farmers training center (x10)	Continuous	Kilometer	+
Cooperative membership (x11)	Dummy	Yes=1, No=0	+
Credit utilization (x12)	Dummy	1=User 0=Non-user	+

3. Result and Discussions

3.1. Descriptive statistics

The study involved 360 smallholder farmers who engaged in beekeeping which 56.25% were adopters [ii] and 43.75% were non-adopters of improved beehive technology. The sample was composed of 85 % male headed and remaining 15% female headed households. However, x^2 test for this variable shows that there was statistically insignificant differences between adopters and non-adopters. From the total respondents only about 36% were participated in demonstrations of improved beekeeping technology while the majority (64%) will not. The x^2 test confirms that there was statistically significant difference in adoption of improved beehive technology between the two groups (Table 2).

Farmers were asked to compare their perception about price risk of improved beehives and other required beekeeping technologies with traditional hives, ignoring other parameters. The result revealed that majority (40%) respondent perception about expensiveness of the technology was high; while about 38% of respondents' perception about the price was medium. The difference in perception about the high prices of the technology is significantly different among adopters and non-adopters.

Table 2. Respondent distribution with dummy and categorical variables

Categorical Variables	**Non-adopters (159)**		**Adopters N=(201)**		**Combined (360)**		**χ2 value**
	№	%	№	%	№	%	
Sex of respondents							
Male	140	86.67	141	83.70	281	85.00	2.5104
Female	19	13.33	60	16.30	79	15.00	
Participation on improved beehives technology demonstration							
Yes	17	10.69	113	56.22	130	36.11	79.75***
No	142	89.31	88	43.78	230	63.99	
Cooperative membership							
Yes	91	57.23	188	93.53	279	77.5	67.011 ***
No	68	42.77	13	6.47	81	22.5	
Credit use							
User	58	36.48	46	22.89	104	28.89	4.523*
Non-user	101	63.52	155	77.11	256	71.11	
Perception in the price of box hives (Attitude of farmers to high price risk)							
High	104	65.41	40	19.90	144	40	58.9276***
Medium	40	25.16	96	47.76	136	37.78	
Low	15	9.43	65	32.34	80	22.22	

Note: ***, ** and * refers significant at 1%, 5% and 10% probability level, respectively.

With regards to cooperative membership, the descriptive statistic result shows that 77.5% of the respondents from the total sample were members, while the rest 22.5% were not. The x^2 test statistic revealed that there was statistically significant difference between the two

[ii] Adopters are those beekeepers who used minimum of three improved box hive for at least two years and non-adopters are beekeepers who did not use improved box hives during the study period.

groups in terms of adoption decision (Table 2). From the total respondents, only 28.89 % of them utilize credit during the survey season, while the rest majority could not. With regard to adoption decision, difference between credit user and non-users was statistically significant.

The mean household size was 5.86 for adopters and 5.06 non-adopters which is not statistically significant difference (Table 3). The mean educational level attended class by sample households was 6.841 for adopters and 4.083 non-adopters. The two-group t-test result revealed that there is statistically significant difference between adopters and non-adopters with regards to level of education.

The mean annually income, proxy for wealth status was 20955 ETB for adopters and 18723 ETB non-adopters which is statistically significant difference (Table 3). With regards to beekeeping experience, the average year of beekeeping was 9 and 7 years for adopters and non-adopters, respectively. The average number of local beehives holding was 15.432 and 9.896 hives for adopters and non-adopters, respectively; which is not statistically significant.

Finally with regards to frequency of extension contact, the non- adopter and adopter respondents had mean extension contact of 4.76 and 8.485 times per year, respectively in 2016/17 production year. This difference is statistically significant as two sample t-test result revealed. The distance from farmers training center was 3.485 kilometers for non- adopters, while 2.037 kilometers for adopters which is statistically significant difference (Table 3).

Table 3. Summary Statistics: Mean Of Continuous Variables by Adoption Decision

Continuous variables	**Non – adopters (159)**		**Adopters (201)**		**Combined (360)**		**t-value**
	Mean	Std	Mean	Std	Mean	Std	
Education level	4.083	2.613	6.841	2.231	4.95	2.401	2.086**
Household size	5.062	1.884	5.862	1.998	5.645	1.931	1.386
Total income(1000)	18.723	7.344	20.955	15.321	19.549	12.56	1.673*
Extension contact	4.761	2.128	8.485	3.021	7.625	2.575	1.849*
Distance from FTC	3.485	1.456	2.037	1.105	2.768	1.303	3.187***
Beekeeping experience	7.156	2.945	9.046	2.844	8.081	2.951	1.934
Local beehives owned	15.432	12.937	9.896	11.981	29.084	12.775	0.867

Note: ***, **and * refers significant at 1%, 5% and 10% probability level, respectively

3.2. Econometrics results

The LR –test suggests the rejection of tobit model. The test statistic (Γ = 171.5196) exceeds the tabulated value [$x_K^2(12)$ =74.92] at a 1% level of significance (Table 4).

Table 4.Test-statistics on Double Hurdle (Probit + Truncated Model) Vs Tobit model.

Indicators	**Probit, D**	**Truncated, y>0**	**Tobit, 0≤y≤1**
Log likelihood	-81.375	- 425.4345	-592.569
Number of observation	360	201	360
Test statistics: Γ= 171.5196 > χ^2 (12)=74.92			

From this table computation of test statistics was as follows;

Γ = -2 [-592.5693 – (-81.375 + (-425.4345)]

Γ = -2 [-407.4836)

Γ = 171.5196

Thus, the null that tobit model is best fitted the data compared to double hurdle is rejected at 1% significance level. This implies that the two-stage decision of adoption has been done independently. Thus, in this subsection we will present results from both the probit and truncated regression.

3.2.1. Determinants of Improved Beehive Technology Adoption Decision

The result of probit regression model indicates that education level, distance from farmers training center, total annual income, frequency of extension contact, perception of farmers about high price and participation in demonstration of improved beekeeping technology are statistically significant decision variables that influenced the probability of adopting improved beehives technology in the study area (Table 5). The marginal effects of the model, which was calculated as the partial derivatives of the non-linear probability function evaluated at each variable sample mean was used for interpretations (Greene, 2008).

A result of probit regression on adoption decision of improved beehive technology was positively associated with annual household income and significant at 10% probability level (Table 5). The model result indicates that as the annual household income is increased by one thousand, the likelihood of adopting improved beehive technology will increased by 9.31% holding other variables constant. The positive relationship implies that the decision to use of the technology will require higher income to purchase it. Therefore, farmers with higher income are more likely to adopt it. The result is consistent with Asmiro *et al.* (2017).

Distance from FTC was negatively and significantly associated with improved box hive adoption decision as hypothesized. Holding other variables constant, the beekeepers reside far from the FTC by one kilometer, the probability of adopting improved box hive reduced by 6.1%. FTC is a bridge to transmit extension information through demonstration the technology by development agents to the farmers (Hassen, 2014). As a result, farmers those who reside far apart from FTC have relatively less probability to get information about advantages of improved box hive from providing institutions than their counter parts. The result coincides with the findings of Solomon *et al*. (2012), Bayissa (2014), Hassen (2014) and Asmiro *et al.* (2017).

The extension contact had positive influence on the adoption decision of improved beehive technology at 10 % level of significance. The result of model result indicates that a unit increase in farmer's contact with extension agents per year increased the probability of adoption by 5.7%. The positive relationship may be due to different honey production improvement trainings, workshops and apiary visits played a role in adoption decision the technology. In addition to offering information and creating awareness, extension service also includes advices, demonstrations and timely distribution of inputs. Thus, the farmers who are frequently visited by extension agents tend to be more progressive in adoption of improved beehive technology. The result is consistent with Tadele (2016), Olusegun *et al. (2014)* and Bekele *et al*.(2008).

Participation in demonstration of improved beehive technology had a positive and significant effect on decision to adopt it. As compared to no participants, the probability of adopting the technology increase by 51.7% for those who participated in the demonstrations of improved beehives technology (Table 5). This may be due that beekeepers who participate in demonstrations of improved beehive technology get the chance to exchanges knowledge and experience with fellow experts, researchers and beekeepers themselves that motivates the beekeepers towards adopting the technology. Beekeepers trust information by seeing practical demonstrations by each other more than simply talking. Hence, a demonstration of the technology at farmers' apiary site and FTC is an important mechanism to introduce beekeeping technology and induce adoption. The result coincides with Yishak and Punjabi (2011), Workneh (2011) and Tamrat (2015).

Table 5. Determinants of Adoption Decision

Independent Variables	Coef. (Std. Err.)	Mfx (Std. Err.)
Sex of household head	0.049 (0.031)	0.0135 (0.011)
Education level household head	0.035 (0.048)	0.013 (0.018)
Household size	-0.029 (0.030)	0.012(0.013)
Total annual income(1000)	0.120 (0.054)	0.093** (0.041)
Beekeeping experience	0.092 (0.059)	0.034 (0.022)
Distance from FTC	-0.187 (0.108)	-0.069* (0.040)
Extension contact	0.189 (0.112)	0.057*(0.035)
Credit utilization	0.103 (0.106)	0.077 (0 .062)
Perception of high price(low)	0.889 (0.363)	-0.287***(0.093)
Perception of high price(medium)	0.315 (0.143)	-0.123** (0.061)
Participation in demonstration	1.698 (0.2485)	0.271***(0.049)
Cooperative membership	0.137 (0.129)	0.082 (0.074)
Number of local beehive owned	0.014 (0 .012)	0.005 (0.004)
Constant	0.246 (0.205)	
Number of obs = 360 LR chi2 (12)=156.33 *** Prob > chi2 = 0.0000 Correctly classified (83.33%), Sensitivity (83.70%), Specificity (82.86%) gof with Pearson chi2(196) = 199.83 with Prob> chi2 = 0.4106)		

Note: Numbers in parentheses are standard errors;
***, ** and * significant at the 1, 5 and 10% probability levels, respectively.

Farmer's perception on the relative price of improved box hives was found to be negatively associated with decision to adopt the technology. The model result shows that as compared to farmers' who perceive the price of improved box hive price high, the adoption decision of improved box hive increased by 28.70% and 12.37% for those farmers who have low and medium perception on the expensiveness of improved hive, respectively. This could be due to that the price of improved beehives and other accessories is increasing from time to time, thus, the farmer's perceive that it is too expensive which influences the expected utility from investing on the new technologies. The result was supported by Belets and Birahanu (2014); Sisay *et al.* (2013) and Workneh (2011).

3.2.2. Factors affecting intensity of improved beehive technology adoption

The result of truncated regression reveals that from hypothesized 12 decision variables level of education, total annual income, frequency of extension contact, perception of farmers about price, participation in demonstration, credit access and cooperative membership influence adoption intensity of improved beehive technology significantly.

Household head education level influence positively and significantly the intensity of technology adoption at 10% probability level. The model result shows that adopting of improved box hive increased by1.56 hives for those beekeepers with one additional educational level keeping other things constant. This may be due to educated farmers are more proficient in accessing and utilizing improved beehives. These result is consistent with Adgaba *et al*. (2014); Kuti (2015) and Njuguna *et al*. (2017). However, the result is contradicted the result of Mal *et al.* (2012).

The frequency of extension contact shows significant effect with expected positive sign at 5% for intensity of adoption. The result of regression indicates that a unit increase in frequency of extension contact with extension agents per year increased the intensity of improved box hive adoption by 1.212 beehives per household holding other variables constant. The larger effect of extension service on the adoption of improved box hive technology may be explained by the different honey production improvement trainings, workshops and apiary visits played a role in adoption decision and intensity of use of improved box hive technology. This result is well-matched with the reult of Hailemariam *et al*. (2006) and Jebessa (2008).

Table 6. Determinants of Adoption Intensity

Variables	Coefficients	Std. Err.
Sex	0.0915	0.0730
Level of education	1.090*	0.620
Household size	-0.439	0.541
Number of local beehive owned	0.187	1.067
Total income	0.885**	0.392
Beekeeping experience	0.1097	0.095
Distance from FTC	-0.694	0.513
Frequency of extension contact	1.212**	0.089
Credit utilization	0.798*	0.456
Participation in demonstration	3.772**	1.669
Perception of high price(low)	-0.648	0.438
Perception of high price(medium)	-0.4740	0.399
Cooperative membership	2.510*	1.327
Constant	2.180***	1.417
Sigma	10.490***	0.823
Observations	201	

Note: ***, ** and * significant at the 1, 5 and 10% probablity levels, respectively.

As anticipated, credit affects adoption level positively and significantly at 10% probability level. The model result reveals that adopting improved box hive increased by 0.798 for those farmers who utilize credited as compared to credit non-users. In the study area improved box hive was perceived as being costly by the beekeepers. Under such circumstances credit plays a significant role in enhancing technology promotion. This result is consistent with Asmiro *et al.* (2017) and inconsistent with Workneh (2011).

Annually income of households is associated positively with adoption level of improved beehives technology at 1% level of significance. The result of truncated regression as shown in Table 6 depicts that as income of household increases by one thousand, the degree of adoption of improved beehives increases by 0.885 which is about one improved beehive holding others factors constant. This could be explained by the fact that an increase use of improved beehive technology will require additional income to purchase it. Therefore, farmers with higher income are more likely to increase the utilization of improved beehive. The result is consistent with Awotide *et al.* (2016).

Participation on improved beehive technology had a positive and significant effect on the intensity of the technology (Table 6). From truncated regression result, as compared to those non-participants, adoption of improved box hive increased by 3.7723 box beehives for those beekeepers that participated in technology demonstration, This is an implication that demonstration of the technology might help farmers in creating awareness and promote the understanding about the advantages of information on improved beehive technology. Additionally, demonstrations enlightened farmers resulting to more appreciation of the technology and this will increase the level of the technology adoption. The result is similar with the finding of Kuti (2015).

Cooperative membership influences positively the adoption level of improved beehive technology at 1% level of significance. As compared to those households who are not member of cooperative, the adoption of improved beehive increased by 2.5 bee hive for those household who are members of cooperative. This might be due to differences in benefits of being membership of cooperatives in terms of training and technical support which can increases adoption of improved technology. Study by Kassa *et al*. (2018) and Adeoti *et al*. (2014) confirmed that being a member of cooperative motivates farmers to use improved beehives more by giving technical advice, input and up to date information provision to members.

4. Conclusions

This study assessed the adoption of improved beehive technology in Kaffa, Sheka and Benchi-Maji zones of Southern Ethiopia. Among beekeeping technologies, improved box hive was the most widely adopted technology in the study area with 56.25% of the farmers adopting it. Several households are constrained from adopting the technology due to improved box beehives purchase cost that prevent farmer from using of it. The result showed that adoption of improved beehive technology in the study area had significant relationship with education level of household head, distance from farmers training center, total annual income of households, frequency of extension contact, perception of farmers about high price and participation in demonstration of improved beekeeping technology.

The government has to put in place a number of policies in order to improve the adoption of improved beehive technology in study area. In particular, the government should make concerted effort to address all the villages through participatory extension services. In addition, efforts should be made in order to increase access of improved beehives by introducing improved hives. Finally, government will take the lead in technology promotion and dissemination at the initial stages and in creating an enabling environment for effective participation of the private sector.

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