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Full Length Research Paper

Adoption of improved box hive technology: Analysis of smallholder farmers in Northern Ethiopia

Belets Gebremichael[*] and Berhanu Gebremedhin[**]

*Department of Agribusiness and Value Chain Management, Samara University, Ethiopia.
**Post-Doctoral Scientist-Agricultural Economist at the International Livestock Research Institute, Addis Ababa, Ethiopia.

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This study was initiated to analyze factors affecting decision and intensity to adopt improved box hive technology in Ahferom district of northern Ethiopia. Both primary and secondary data sources were utilized. Descriptive analysis and econometric (Double-hurdle) model were employed using SPSS-16 and STATA-11, respectively. Of the 130 sample beekeepers, 54.6% and 45.4% were adopters and non-adopters, respectively. Of the adopters' category 67.6% hold both traditional and improved hives, the rest 32.4% hold only improved box hive. The mean number of improved box hives was 3.10 hives for adopters and 1.69 hives for entire sample with maximum of 11. The first hurdle result indicated that other off/non-farm activity, beekeeping experience, distance to market and frequency of extension contact were significantly affect adoption decision of improved box hive. Moreover, the second hurdle result revealed that other off/non-farm activity, frequency of extension contact, credit access, livestock holding, age, distance to all weather roads were found to be significantly affect intensity of adoption. Therefore, these significant factors in adoption of improved box hive technology should be considered by policy-makers and planners of governmental and NGOs in setting their policies and strategies of honey production improvement interventions.

Key words: Adoption, apiculture, improved box hive, smallholder beekeepers, double-hurdle model.

INTRODUCTION

Apiculture is a promising off-farm enterprise, which directly and indirectly contributes to smallholder's income in particular and nation's economy in general. It has significant role in generating and diversifying the income of subsistence Ethiopian smallholder farmers mainly the small land holders and landless (EARO, 2000; Gezahegn, 2001). In Ethiopia traditional, transitional and improved beehives were recognized for honey production with total of 5.15 million beehives (of 93% traditional) and the farm households keeping bees were 1.4 million. Endowing with diverse agro-climatic zones, the total honey and beeswax production estimates about 39,700 and 3,800 tons per year. Such an amount puts the country 10th in honey and 4th in beeswax production worldwide. Moreover, Ethiopia has the potential to produce up to 500,000 tons of honey and 50,000 tons of beeswax per year (GDS, 2009).

In spite of the contribution and potential of the sub-sector, it is very traditional that the production, productivity and quality of hive produces have been low. Thus, the current Ethiopian government has increased its attention to develop the apiculture sub-sector as one of its strategies for poverty reduction and export diversification and different NGOs have been intervening to assist the poor smallholder farmers through the introduction and promotion of box hive to obtain higher honey production of good quality that can enable the smallholder farmers in particular and the country in general to be benefited from the sub-sector (GDS, 2009). Similarly, great effort has been made by regional government extension package and Relief Society of Tigray to promote improved box hive technology in the region to increase the quantity and quality of honey production and build the capacity of beekeepers for better management of bees and hives for honey and beeswax production (Gidey and Mokenen, 2010).

Even though all the efforts have been made at national

*Corresponding author. E-mail: belets11@yahoo.com

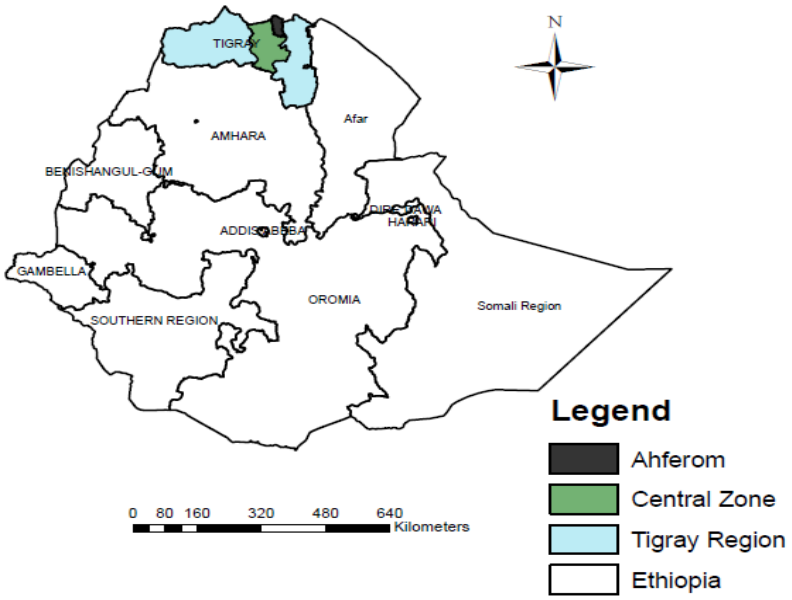

Figure 1. Location map of the study district.

and regional level to introduce improved apiculture technology, there has been no adequate study on addressing the dissemination of adoption of improved box hive technology in the country, particularly, in the study area. Therefore, the primary objective of the study was to analyze the factors affecting adoption decision and intensity of using improved box hive technology by the smallholder beekeepers.

RESEARCH METHODOLOGY

The Study Area

Ahferom district (presented in figure 1) is among the major honey producing districts in Tigray region next to Kilte-Awlaello and Atsbi-Wombert districts and also among potentially the most promising areas for the production of honey next to Tselemti and Medebay-Zana districts. However, up to around a decade back all beekeepers of the district were only engaged in traditional production system (OoARD, 2009) though improved box hive has been introduced and promoted in the country since 1970 to overcome the low production, productivity and quality of honey (HBRC, 1997).

Sampling Technique and Data Collection

Multi-stage sampling procedure was used to select sample smallholder beekeepers for interview. Ahferom district was selected purposively based on the honeybee production potential, availability of bee flora and improved box hive promotion. Excluding five *Tabias* that were affected by the Ethio-Eritrea conflict, four *Tabias* were selected randomly out of the remaining 22 rural *Tabias*. In the selected *Tabias*, the beekeepers were stratified into non-adopters and adopters of improved box hive sub-groups. Having the list of beekeepers from each *Tabia*, 130 sample beekeepers (59 non-adopters and 71 adopters) were selected randomly based on the probability proportional to size sampling technique from the selected *Tabias*.

Both primary and secondary data sources and qualitative and quantitative data types were utilized for this study. Primary data were obtained from sample respondents during March to April 2011 by using semi-structured questionnaire through interview method. Secondary data were gathered from various sources such as reports of MoA at different levels, CSA, district OoARD, NGOs, previous research findings, Internet and other published and unpublished materials.

Method of Data Analysis

Specification of Econometric Models

In principle, the decisions of whether to adopt and how much to adopt can be made jointly or separately. It can be argued that adoption and intensity of use decisions are not necessarily made jointly (Berhanu and Swinton, 2003). The tobit model used to analyze under the assumption that the two decisions are affected by the same set of factors (Green, 1993). In the double-hurdle model, on the other hand, both hurdles have equations associated with them, incorporating the effects of farmer's characteristics and circumstances. Such explanatory vari-

Table 1. Summary of dependent and independent variables used in double-hurdle model.

Variable	Code	Type	Measurement
Adoption decision of improved box hive	D	Dummy	Non-adopter=0, adopter=1
Number of improved box hive	Y	Continuous	Number
Household head sex	SEX	Dummy	Female=0, male=1
Household head age	AGE	Continuous	Years
Household head educational status	EDUC	Dummy	0 = illiterate, 1 = literate
Household head leadership participation	LEADP	Dummy	No=0, Yes=1
Total family size	FAMLYSIZ	Continuous	Number
Working labor force	LABFORC	Continuous	Number
Other off/non-farm activity involvement	OFFACT	Dummy	No=0, Yes=1
Household farm size	FARMSIZ	Continuous	Hectares
Households' livestock holding	TLU	Continuous	TLU
Beekeeping experience	BEEKEEXP	Continuous	Years
Number of bee colonies	BEECOLO	Continuous	Number
Frequency of extension contact	FREQCONT	Continuous	Number per month
Distance to farmers training center	DISTFTC	Continuous	Kilometers
Distance to nearest market	DISTMKT	Continuous	Kilometers
Distance to district town	DISTWRDA	Continuous	Kilometers
Distance to all weathered road	DISTROAD	Continuous	Kilometers
Radio, TV and/or mobile ownership	RTVMOBIL	Dummy	No=0, Yes=1

ables may appear in both equations or in either of one. Most prominently, a variable appearing in both equations may have opposite effects in the two equations. The double-hurdle model, initially due to Cragg (1971), has been extensively applied in several studies such as (Burton et al., 1996; Newman et al., 2001; Mofatt, 2003). Hailemariam et al. (2006) was among those who employed double-hurdle in studying improved poultry breeds adoption in Ethiopia.

The double-hurdle model is a parametric generalization of the tobit model, in which two separate stochastic processes determine the decision to adopt and the level of adoption of technology. The double-hurdle model has an adoption (D) equation:

$$D_i = \alpha Z_i + U_i \quad (1)$$

Where D_i is a dummy variable that takes the value 1 if the farmer adopts improved box hive and zero otherwise, Z is a vector of household characteristics and α is a vector of parameters. The level of adoption (Y) has an equation of the following:

$$Y_i^* = \beta X_i + V_i$$
$$Y_i = Y_i^* if Y_i^* > 0 \,\&\, D_i > 0$$
$$Y_i = 0, otherwise \quad (2)$$

where Y_i is the observed variable to be the proportion of improved box hive, X is a vector of the individual's characteristics and β is a vector of parameters.

The error terms, U_i and V_i are distributed as follows:

$$\left.\begin{matrix} U_i \sim N(0,1) \\ V_i \sim N(0,\sigma^2) \end{matrix}\right\} \quad (3)$$

Finally, the observed variable Y_i in the double-hurdle model is determined by;

$$Y_i = D_i Y_i^* \quad (4)$$

The log-likelihood function for the double-hurdle model is:

$$LogL = \sum_0 \ell n\left[1-\Phi(\alpha Z_i')\left(\frac{\beta X_i'}{\sigma}\right)\right] + \sum_+ \ell n\left[\Phi(\alpha Z_i')\frac{1}{\sigma}\varphi\left(\frac{Y_i-\beta X_i'}{\sigma}\right)\right] \quad (5)$$

Where "0" indicates summation over the zero observations in the sample, while "+" indicates summation over positive observations, and Φ (.) and φ (.) are the standard normal cumulative distribution functions and probability distribution functions, respectively.

Under the assumption of independence between the error terms V_i and U_i, the model as originally proposed by (Cragg, 1971) is equivalent to a combination of a truncated regression model and a univariate Probit model. The tobit model, as presented above, arises if

$$\lambda = \frac{\beta}{\sigma} \text{ and } X = Z$$

.

A simple test for the double-hurdle model against the tobit model can be used. Therefore, one simply has to estimate the truncated regression model; the tobit model and the tobit model separately and use a likelihood ratio (LR) test. The LR-statistic can be computed using (Green, 2000):

$$\Gamma = -2\left[\ell n L_T - (\ell n L_P + \ell n L_{TR})\right] \sim \chi_k^2 \quad (6)$$

Figure 2 (a). Improved box hive.

Figure 2 (b). Traditional beehive.

where L_T - likelihood for the tobit model; L_P - likelihood for the probit model; L_{TR} - likelihood for the truncated regression model and k is the number of independent variables in the equations. If the test hypothesis is written as;

$H_0: \lambda = \frac{\beta}{\sigma}$, and $\lambda \neq \frac{\beta}{\sigma}$. H_0 will be rejected on a pre-specified significance level, if $\Gamma > \chi_k^2$. The dependent and independent variables used in double-hurdle model were defined in table 1.

RESULT AND DISCUSSION

Descriptive Results of the Study

Of 130 smallholder beekeepers included in the survey, 54.6% and 45.4% were adopters and non-adopters, respectively. Besides, within the adopters' category 67.6% owned both traditional (figure 2 (b)) and improved hives (figure 2 (a)) with honeybee colonies whereas the rest 32.4% owned only improved box hive. The mean proportion of improved box hive was 0.70 and 0.38 for adopters and whole sample, respectively with maximum of 13 beehives. Whereas the mean number of improved box hives was 3.10 and 1.69 hives for adopters and entire sample, respectively with maximum of 11 improved box hives. Furthermore, the total number of beehives sample beekeepers hold was 621 (220 improved and 401 traditional) hives with bee colony and 29 (22 improved and 7 traditional) hives without bee colony due to bee colony not being transferred and bee colony absconding. Thus, the occupational rates of the improved and traditional hives were 90.9% and 98.3%, respectively. The average number of beehives with bee colonies for the total sample smallholder beekeepers was around 5 (3 traditional and 2 improved) with minimum of 1 and maximum of 13 beehives.

In the study area, traditional beehive requires a range of accessories, namely, smoker, knife, fork, honey containers, bee brush and queen cage. Some of these accessories (smoker, bee brush and queen cage) were constructed by the beekeepers and the remaining (knife, fork and honey container) were purchased from local markets. All respondents in the study area have never used recommended accessories for traditional honey production. On the other hand, improved box hive demands more additional accessories than traditional beehive. These includes smoker, bee veil, high boots, glove, overalls, bee brush, water sprayer, queen catcher, decapping knife, honey presser, honey extractor, casting mold and uncapping fork. But most of the interviewed respondents were lacking these accessories. It was found during the survey that, apart from the known basic box hive tools, many of the accessories was either non-existent or kept by quite few numbers of respondents. Particularly, the honey extractor and casting mold was reserved at FTC of each *Tabia*.

The productivity of beehive per year varies from location to location, which in most case is determined by the availability of bee flora, the level of management and harvesting system and input technology used. Honey is harvested in the study area from October to November each year (the peak period) and rarely harvested in May (preparation for the next production). The frequency of harvesting honey per hive in the same area and year is also different among beekeepers. About 46.9% of the sample beekeepers harvest twice a year and 48.5% of them harvest

Table 2. Test of double-hurdle model versus tobit model.

	Tobit, 0≤Y≤1	Probit, D	Truncated Regression, (Y>0)
LOG-L	-87.314	-60.689	-116.055
Number of observation (N)	130	130	71
Double-hurdle versus tobit test statistic: Γ = 178.84 > $\chi^2_{0.01,16}$ =32.00			

Source. Model output, 2012.

only once in a year during the study year. Only 4.6% of the beekeepers harvest three times per year. Honey productivity of traditional and improved hives is markedly different; that is, the average honey productivity of traditional beehive per hive per year was 12.56kg with the maximum productivity of 22kg. It was also figured out that the average productivity of improved box hive per hive per year was 26.04kg with the maximum productivity of 48kg. Accordingly, the average annual productivity of improved box hive was more than twice of the average annual productivity of traditional beehive. However, the area has a potential of producing up to 55kg per hive per year.

Honey harvested by the sample farmers in the study area was inevitable for multipurpose. Except for the inconsiderable amount that was extended as a gift, much of the collected honey was consumed and sold during harvesting period. However, the amount of honey sold was much more than the amount of honey consumed by the households. Thus, the total amount of honey produced by the sample beekeepers was around 10,530kg, of which, 998.50, 9292.50 and 239kg was consumed, sold and given as a gift by the sample respondents, respectively. Moreover, sample farmers earned annual income from beekeeping activities by selling honey or both honey and bee colonies. As the result presents, adopters sold significantly larger amount of honey (86.07kg) than non-adopters (53.88kg). As a result, adopters (7910.60ETB) obtained significantly higher beekeeping income than non-adopters (4513.40ETB).

Econometric Models Results

Based on the log-likelihood values of the two models estimated, the LR-test results suggest the rejection of the tobit model. That is, the test statistic Γ = exceeds the critical value of the χ^2 distribution (Table 2).

As Table 3 indicate, regarding age of the farmers, it can be observed that age has a parabolic effect on the level of improved box hive adoption with a turning point of 48 years even though age is insignificant in the decision to adopt. This implies that farmers aged above 48 years are most likely to have lower level of improved box hive. The result supports the hypothesis that with the expectation of risk aversion behavior of aged farmers for fear of absconding and other unexpected events, it is uncertain for these farmers to increase the number of improved box hive as age of the farmers increase beyond the turning point. On the other hand, involvement on off/non-farm activities other than beekeeping passes both hurdles and positively affected the decision to adopt at 5% significant level, but negatively affected intensity of use of improved box hive at 1% significant level. This might be due to farmers participated in other off/non-farm activities earn additional income and purchase improved technologies. As a result, more probably decide to adopt improved box hive. However, this might not be true for intensity of use of improved box hive technology.

Beekeeping experience appears in both hurdles with unexpected negative sign but only significant in decision to adopt improved box hive at 5%. This result implies that more experienced beekeepers in traditional honey production system might be reluctant to accept new ideas and adopt new technologies than less traditionally experienced beekeepers rather they are more immersed to continue with the traditional production system. The variable frequency of extension contact shows significant effect with expected positive sign in each model, that is significant at 1% and 5% for the first and second hurdle, respectively. This result of marginal effect indicates that a unit increase in farmer's contact with extension agents per month increased the probability of adoption by 45.8%, intensity of use of improved box hive by one box hive per household. The larger effect of apiculture 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.

As expected, the distance of farmers' residence from the nearest market center was negatively and significantly associated with improved box hive adoption decision. The marginal effect of this variable indicated that, other variables being constant, as the distance of the farmers' residence from the nearest market far by one kilometer, the probability of farmers to adopt improved box hive decreased by 5.1%. This is due to the fact that as the farmers reside far from the nearest market, the transport cost for selling their output would be high which, in turns, to reduce farmers' decision to adopt improved

Table 3. Maximum likelihood estimation of double-hurdle model of adoption decision and intensity of use of improved box hive technology.

Probit model result				Truncated regression result	
Variables	**Coefficients**	**Robust Std.Err.**	**Marginal effect**	**Coefficients**	**Robust Std.Err.**
SEX	.7289999	.5989064	.2837713	-.3239236	.5697839
AGE	-.0855817	.2115169	-.0333835	-.9397903	.3568755***
AGE2	.001295	.0020047	.0005052	.009118	.0033915***
EDUC	-.02507	.3957653	-.0097673	-.1578531	.550368
LEADP	-.3741634	.2847111	-.1471423	.6595279	.4657661
FAMYSIZ	.0650109	.1141358	.0253593	.2755782	.1999879
LABFORC	-.1536317	.1713791	-.0598139	.1254812	.2644361
OFFACT	.8296531	.3750348**	.2918408	-2.110087	.4690649***
FARMSIZ	.6116728	.6441683	.2385997	.8206633	.9023955
TLU	.0260519	.092633	.0101623	.1910632	.1140586*
BEEKEEXP	-.0609931	.0254795**	-.023792	-.0209167	.0415058
DISTMKT	-.1304401	.0548701**	-.0508817	.1350793	.0902391
DISTROAD	.0105693	.0712608	.0041229	.3227448	.108426***
RTVMOBIL	-.7168753	.6108945	-.2765653	.1871823	.9879324
FREQCONT^{P}	1.174034	.4157339***	.457964	.9699343	.497843*
SERV^{2P}	.127536	.7681176	.0497489	7.259355	1.890195***
_CONS	.9683512	5.502815		12.98404	8.263312
/SIGMA				1.490647	.2493354***
Log-L = -60.688591 Number of obs. = 130				Truncated regression	
Wald chi^2(16) = 54.86 Prob>chi^2 = 0.0000				^{P} = predicted value	
Correctly predicted = 58.4%^{P} = predicted value				Limit: lower=0, upper = +inf	
				Number of obs = 71	
				Wald chi2(16) = 46.84	
				Log-L = -116.05481	
				Prob> chi^2 = 0.0000	

*, ** and *** refers statistically significant at 10%, 5% and 1% respectively.
Source. model output, 2012.

box hive. However, distance to all weather roads positively and significantly affect the intensity of use of improved box hive technology. This might be as residences of beekeepers far from all weather roads there is the probability that the vicinities densely covered with different vegetations which are sources of honeybee feeds. As the same time honeybees are highly sensitive to car sound disturbance in which results in bee colonies absconding. With this observation, beekeepers resides far from the main roads substantially intensify their improved honey production.

Although, access to credit insignificant in influencing decision to adopt, turned out to be significant in the intensity of use of improved box hive. As the credit condition of smallholder farmers changes, the intensity of use of improved box hive increased by seven box hive per household. The implication of this result clarifies that availability of credit service would be expected to minimize liquidity constraint, as a result, promotes the increase in the number of improved box hive. Similarly, other livestock holding significantly affect intensity of use of improved box hive at 10%. Under the ceteris paribus condition, as the farmer increases his/her livestock holding by one TLU the number of improved box hive increased by 0.2 box hive. As the livestock holding was considered as a proxy for farmers' wealth status, highly wealthy status farmers can earn more cash-income that might enable them to intensify improved apiculture.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study, the following recommendations are suggested to be considered by

Governmental and Non-governmental Organizations in their future intervention strategies aimed at introducing of improved box hive technology to improve honey production in the study area in particular and other areas with similar settings.

- Frequent follow-up by the extension agents should be given to reach the technology to every smallholder beekeeper and to increase the number of improved box hive by adopters. This implies, for an effective information communication, the relationship between farmers and extension agents must be improved, encourage farmers to participate in different extension programs regarding apiculture improvement.
- Credit service must be offered to adopters in order to intensify the technology and counsel the development of rural micro-finance to promote not only to provide credit at reasonable terms of repayment and interest rate but also savings.
- Strengthening rural-urban road network and transport facilities to promote adoption of improved honey production is recommended. However, apiary site should not be near to road sides as much as possible to protect absconding.
- Targeting young farmers for intervention of improved box hive technology intensification is probably advisable.
- More attention must be given to less traditionally experienced beekeepers for rapid decision to adopt improved box hive and great effort should be made by the concerned bodies to traditionally experienced beekeepers to utilize new ideas which helps them in adoption decision.
- Priority must be given for other off/non-farm activities involved farmers to adopt rapidly in which they have financial capacity; and the limited resources that were utilized by other off/non-farm activities should be redirected to improved honey production expansion activities even though honey production activity is among the least resource competing off-farm activities.
- Efforts should be made to improve apiculture sub-sector through promoting livestock sub-sector.

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REFERENCES

Berhanu G, Swinton SM (2003). Investment in soil conservation in Northern Ethiopia: the role of land tenure security and public programme. Agricultural Economics. 29: 69-84.

Burton MR, Young T (1996). Changing preferences for meat: evidence from UK household data (1973-1993). European Review of Agricultural Economics. 23(3): 357-370.

Cragg J (1971). Some statistical models for limited dependent variables with application to the demand for durable goods. Econometrics. 39: 829-844.

EARO (Ethiopian Agricultural Research Organization) (2000). Apiculture Research Strategy Document, Addis Ababa, Ethiopia.

GDS (Global Development Solutions) (2009). Integrated value chain analyses for honey and beeswax production in Ethiopia and prospects for exports the Netherlands Development Organization (SNV).

Gezahegn T (2001). Beekeeping (In Amharic), Mega Printer Enterprise, Addis Ababa, Ethiopia.

Gidey Y, Mekonen T (2010). Participatory technology and constraints assessment to improve the livelihood of beekeepers in Tigray region, Northern Ethiopia. Biology Department, College of Natural and Computational Sciences, Mekelle University, Ethiopia. 2(1): 76-92.

Green W (1993). Econometric Analysis, 2nd ed. Macmillan, New York.

Green W (2000). Econometric Analysis, 4th ed. Macmillan, New York.

Hailemariam T, Legesse D, Alemu Y, Negusse D (2006). Determinants of adoption of poultry technology: a double-hurdle approach. Debre-Zeit Agricultural Research Center, Debre Zeit, Ethiopia.

HBRC (Holeta Bee Research Center) (1997). Beekeeping Training Manual. Holeta, Ethiopia.

Mofatt PG (2003). Hurdle models of loan default. School of Economic and Social Studies. University of East Angelia. http://www.crc.ems.ed.ac.uk/Conference/presentations/moffat,pdf.

Newman C, Henchion M, Matthews A (2001). Infrequency of purchase and double-hurdle models of Irish households' meat expenditure. European Review of Agricultural Economics. 28(4): 393-419.

OoARD (Office of Agriculture and Rural Development) (2009). Report of Ahferom district Office of Agriculture and Rural Development.