Factors influencing adoption of dairy technology on small holder dairy farmers in selected zones of Amhara and Oromia National Regional States, Ethiopia

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Abstract

The dairy technology in Ethiopia was promoted and disseminated through both Non-Governmental and Governmental Organization with the aim of improving output, increasing incomes and consequently improving the livelihoods of the small holder farmers. This paper used the Heckman two-stage model to identify the factors that influence adoption of the technology and level of adoption. Farm and household level data were obtained from 384 farmers consisting of 192 adopters and 192 non-adopters. The results demonstrated that family size, farming experience, availability of dairy production extension services, availability of cross breed cows, accessibility of saving institutions, total income from milk and milk products, availability of training on livestock, age of household head and off-farm activity participation played significant roles on both the probability of dairy technology adoption and its level of adoption.

Keywords: dairy technology; smallholder farmers; determinants; Ethiopia

INTRODUCTION

In Ethiopia, dairy production is mainly of subsistent type largely based on indigenous breeds of cattle. Milk production from this system is low to support the demand for the continuously increasing human population, particularly in urban centers (Azage and Alemu, 1998). There is also a large demand-supply variance for milk and milk products especially in urban centers indicating the untapped potential for development of market oriented urban and peri-urban dairy production systems, which play a significant role in minimizing the acute shortage of milk and dairy products in urban centers.

A rough estimation which was done by Getachew and Gashaw (2001) indicated that milk produced from rural small-scale mixed farms in the highlands, small urban/peri-urban farms in the highlands, pastoral/agro-pastoral producers in the lowlands and large private and state farms in the decreasing order of their importance. This shows that intensification and commercialization of smallholder farm households used to improve the dairy production and the living standard of smallholder farmers. Intensification of smallholder dairy production typically involves the adoption of a combination of cattle breeds with increased genetic potential for milk production and other complementary inputs.

Even though large efforts have been made to disseminate dairy technologies through the support of governmental and non-governmental organizations in different parts of the country, the adoption of dairy technologies by farm households varies widely across different agro-ecologies and within the same agro-ecology based on various technical and non-technical factors. On the other hand, for policy design and effective management of extension programmes, information on the extent of adoption of disseminated technologies, understanding of socio-economic and institutional
determinants of adoption of such practices in the study area would help to come up with workable recommendations to improve the performance of the sector. However, little is known about the level of adoption and the determinants of adoption of dairy technologies in the country. Therefore, this study was undertaken to identify the determinants of the dairy technology adoption and to investigate the extent of adoption level in the study areas.

MATERIALS AND METHODS

Study area description

This study was carried out in six selected areas from two National Regional States (Amhara and Oromia), Ethiopia. Amhara National Regional State (ANRS) is located in the north-western part of the country which is found between 90-130 45°North Latitude and 350-400 30°East longitude. The total area of the region is approximately 170,752 Sq.Km whereas Oromia National Regional State (ONRS) lies in the central part of the country with larger protrusions towards the south and west directions. It has an area of 353,690 km² (OPEDB, 2000). The region has 17 administrative zones and 251 districts. Totally, six cooperative centers namely Shemeshengo and Yetenora from ANRS and Godino, Babogaya, Debretsigie and Torbenashie from ONRS were selected.

Sampling Procedure and Sample Size

Multistage sampling procedure was used to select farm households for this study. During the first stage, study Regions (Oromia and Amhara) were selected purposively based on dairy technology adoption which was delivered by SDDP (Smallholder Dairy Development Programme), milk production potential and number of crossbred cows distributed. During the second stage, one zone from Amhara National Region State (East Gojjam Zone) and two zones from Oromia National Regional State (North Showa and East Showa zones) were selected based on the dairy potential of the area. During the third stage, six cooperative center areas (two from each zone) were selected randomly from others. During fourth stage, farm households in the selected sites were categorized into dairy technology adopters and non-adopters and then 384 smallholder farmers were selected by systematic random sampling by considering the proportionality of the number of farm households in each cooperative center areas.

These total sample size (384 smallholder farmers) were determined according to the following formula at 95% confidence Interval, Fox et al. (2007). Prior to farm household sampling, an initial complete listing (census) of all the farm households in the selected area was obtained from Woreda Agriculture and Rural Development Office.

\[ N - P (100\% - P)/(SE)^2; \ SE = MRE/1.96 \]

Where;

**N** - Sample size;

**P** - Proportion of dairy technology adopter smallholder farmers;

**SE** - Standard error;

**MRE** - Margin for random error (5%) and 1.96 is tabular value for 95% confidence interval.

Data collection

Primary data were collected through personal interviews by trained enumerators using a pre-tested semi-structured survey questionnaire from respondents who has at least one lactating cow at the time of survey. The questionnaire was used to collect information on farmer-household socio-economic characteristics, technical, institutional and environmental points. The socio-economic characteristics include the following amongst others: farmers’ age, gender, educational status, land size, farm experience, off-farm income and family size.

Statistical Analysis

Theoretical Framework

Methodological framework and selection of econometric model depended on the objectives and hypotheses to be tested and verified. In order to identify determinants of dairy technology adoption decision and level of adoption, a Heckman
two-stage selection model was used. In selectivity models, the decision to adopt and adoption level can be seen as a sequential two-stage decision making process. In the first-stage, smallholder farmers make a discrete value decision whether or not to adopt the dairy technology. In the second-stage, conditional on their decision to adopt dairy technology, farmers make continuous decision on the intensity of adoption. In the first-stage, standard probit model was used. Prior to the models were analyzed, the explanatory variables were checked for being of multicollinearity. This situation occurs when the explanatory variables display little variation and/or high inter-correlation (Maddala, 1992). Heteroskedasticity- robust test was used for exclusion Restrictions condition, Wooldridge (2002).

Variance Inflation Factor (VIF) for association between the continuous explanatory variables and Contingency Coefficients (CC) for dummy explanatory variables were used to measure multicollinearity. The highest the value of VIF (X_i) the more difficult or collinear the variable X_i is. As a rule of thumb, if the VIF of an explanatory variable greater than 10, there is a multicollinearity problem. Similarly the decision rule for contingency coefficients states that values less than 0.75 mean there is no problem of multicollinearity whereas when the contingency coefficient approaches 1, it indicates that there is a problem of multicollinearity between the discrete variables (Gujarati, 2004; Berhanu, 2012).

Analytical Framework

There was a hypothesis related to dairy technology adoption (cross breed cows). The hypothesis was that different socio-economic characteristics may affect both the decision making of dairy technology (cross breed cows) adoption and then intensity of adoption (number of cross breed cows), in this case both the decision making of dairy technology adoption and intensity of adoption were endogenous.

Variable Definition and Hypotheses

The data were cover information necessary to make farm level indices of social-economic characteristics and factors of dairy technology adoption and its intensity in the study area. Both continuous and discrete variables were used on economic theories and findings of different empirical studies. Accordingly, in order to investigate the research questions of this study, the following variables were constructed.

Dependent variables: A bundle or package of different technological elements such as forage seed, bull service, AI services, and veterinary services, feed supply and crossbred heifer (CB), was transferred to smallholder farmers. For the household who adopts dairy technology the variable takes on the value of one and value of zero for the household who does not adopt. However, cross breed heifer/cattle adoption was taken as a proxy for this study.

Adoption of Crossbred heifer/cattle (ACBC) representing the decision to adopt: Is modeled as a dummy variable that represents the probability of the household adopting crossbred heifer or not. For the household who adopts at least one cross breed heifer, the variable takes the value of one, otherwise zero.

Number of crossbred cattle (NCBC) representing the intensity of adoption: It is the continuous variable which represents the intensity of adoption of dairy technologies (cross breed heifer/cattle).

Independent (Explanatory) Variables: Independent variables are variables that stand alone and are not changed by the other variables but cause change in Dependent Variable/s. some of the independent variables used in this study were described as follow.

Sex of the household head (GENDER): This was a dummy variable that took a value of one if the household head was male and zero otherwise. Gender was expected to affect dairy technology adoption. Male farmer heads were expected to adopt dairy technology more than female headed. Male farmers had more access and exposure to get the information about the dairy technology and they were making decision to adopt than what female farmers were doing.

Family size (FS): It is a continuous variable. As dairying was/is labor intensive: dairy production, in general and marketable surplus of dairy products in particular, is a function of labor. Accordingly, household with more family members tended to have more labor and to adopt dairy technology than household with less family members which in turn increased milk production and then milk market participation of the households.
Distance to Market Center (DMC): Is location of the farm household from the nearest milk market and was measured in kilometer. Distance to market center was expected to affect the dairy technology adoption. The farther the market distance the least the dairy technology could be happened because the closer the milk market to farm household, the lesser would be the transportation charges and loss due to spoilage, and better access to market information and facilities. This improved return to labor and capital; increased farm-gate price and incentive to participate in dairy technology adoption.

Distance from Agricultural Development Center (DADC): It is a continuous variable and measured in kilometer. Distance from agricultural development center was expected to affect the dairy technology adoption. The Agricultural Development Center (ADC) was/is usually strategically located within the farming areas and it is the place where the local extension worker was/is stationed. As distance from the agricultural development center (DADC) increases, livestock technology adoption decreases because this causes transport cost incurred in obtaining information on technologies and inputs to increase. Farmers were/are less likely to adopt the livestock technologies as the distance increases from the ADC.

Education Level of the Household Head (ELHH): It was a dummy variable that took a value of one if the household head was educated and zero otherwise. Education plays an important role in the adoption of innovations/new dairy technologies. Further, education was/is believed to improve the readiness of the household to accept new ideas and innovations, and get updated demand and supply price information which in turn enhances producers’ willingness to produce more and increase milk market entry decision and volume of sale. Therefore, the more educated the household head, the higher the likelihood to decide for dairy technology adoption.

Age of the Household Head (AHH): It is a continuous variable and measured in years. AHH also was expected to affect the dairy technology adoption. It was hypothesized that there was/is an indirect relationship between age of household heads and dairy technology adoption. As the age of the household head increased, the probability of adoption decreased because they were/are inactive to participate in the new technology dissemination process, most likely due to being more influenced by culture.

Off-farm activity participation (OFAP): It is a dummy variable that took a value of one if the household head participated in an off-farm activity and zero otherwise. OFAP was/is expected to affect dairy technology adoption. A household head farmer who has an access to off-farm employment has a positive effect on adoption of dairy technologies. This entails that increased access to off-farm employment can lead to increased adoption of dairy technologies. One explanation for this result was/is that income from off-farm activities provides supplemental income to finance technology expenditures, for example: purchase of salt block, urea, mineral lick, hay and small tools for dehorning and castration and even to the extent of buying crossbred heifers.

Land holding (LH): It is a continuous variable and measured in hectares. It was hypothesized that there was/is a direct relationship between the size of land held by farm households and dairy technology adoption. Farmers with less land were expected not to be willing to adopt a dairy technology since they were thinking that the technology needs more land for forage production.

Access to credit service (ACS): Access to credit was measured as a dummy variable taking a value of one if the household has access to credit and zero otherwise. This variable was/is expected to influence the dairy technology adoption because of the very high initial investment cost which households may not afford easily. Credit relaxes the financial constraint of the household to invest on dairying.

Access to Dairy Production Extension Service (ADPES): This variable was measured as a dummy variable taking a value of one if the farm household had access to dairy production extension service and zero otherwise. It was/is expected that ADPES affect dairy technology adoption. A household head who had/has access to dairy production extension service was/is more prone for technology adoption than those who had/ have no access. Extension service widens the household’s knowledge with regard to the use of improved dairy production technologies which leads to adopt more.

Farming experience: It is a continuous variable and measured in years. It refers to the number of years that the smallholder farmer practiced farming activity after the dairy technology transferred to the area. It was hypothesized that there was/is a direct relationship between the farming experience and dairy technology adoption. Farmers with high farming experience were expected to be willing to adopt a dairy technology since they were getting information about the
advantages of dairy technology through different ways. Both determinants of dairy technology adoption and intensity of adoption were analyzed by using survey data. The specifications of the empirical models used to identify these determinants follow the selectivity models widely discussed in (Bellemare and Barrett, 2006; Berihanu, 2012). In selectivity models, the decision to dairy technology adoption can be seen as a sequential two-stage decision making process. In the first-stage, smallholder farmers make a discrete decision whether or not to adopt the dairy technology. In the second-stage, conditional on their decision to adopt, smallholder farmers make continuous decision on the level of adoption.

In the first-stage, the standard probit model was used, which follows random utility model and specified as Wooldridge (2002):

\[ Y^* = Z'\alpha + \varepsilon_1 \]
\[ Y = 1 \text{ if } Y^* > 0 \]
\[ Y = 0 \text{ if } Y^* \leq 0 \]  

Where,
- \( Y^* \) is a latent (unobservable) variable representing farmer’s discrete decision whether to adopt or not
- \( Z^* \) is a vector of independent variables hypothesized to affect farmer’s decision to adopt dairy technology
- \( \alpha \) is a vector of parameters to be estimated which measures the effects of explanatory variables on the farmer’s decision
- \( \varepsilon_1 \) is normally distributed disturbance with mean (0) and standard deviation of \( \delta_1 \), and captures all unmeasured variables
- \( Y \) is a dependent variable which takes on the value of 1 if the farmers adopt a dairy technology and 0 otherwise.

Since the probit parameter estimate does not show by how much a particular variable increases or decreases the likelihood of adoption of dairy technology, marginal effects of the independent variables on the probability of a smallholder farmer to adopt dairy technology was considered. For continuous independent variables, the marginal effect was calculated by multiplying the coefficient estimate \( \alpha \) by the standard probability density function by holding the other independent variables at their mean values. The marginal effect of dummy independent variables was analyzed by comparing the probabilities of that result when the dummy variables take their two different values (1 if adopt dairy and 0 otherwise) while holding all other independent variables at their sample mean values (Wooldridge, 2002).

Finally, the log likelihood function which is maximized to obtain parameter estimates and corresponding marginal effects is given as:

\[ \ln L (\alpha, Z) = \sum_{y=1} \ln (\Phi(Z'\alpha)) + \sum_{y=0} \ln(1 - \Phi(Z'\alpha)) \]  

Conditional on adoption decision, the variables determining intensity of adoption are modeled using the second-stage Heckman selection model (Heckman, 1979). The Heckman selection equation is specified as:

\[ Z_i^* = W_i\alpha + \varepsilon_2 \]
\[ Z_i = Z_i^* \text{ if } Z_i^* > 0 \]
\[ Z_i = 0 \text{ if } Z_i^* \leq 0 \]  

Where,
- \( Z_i^* \) is latent variable representing the desired or optimal level of adoption which is observed if \( Z_i^* > 0 \) and unobserved otherwise
- \( Z_i \) is the observed level of adoption
- \( W_i \) = vector of covariates for unit i for selection equation which is a subset of \( Z^* \)
- \( \alpha \) = vector of coefficients for selection equation
- \( \varepsilon_2 \) = random disturbance for unit i for selection equation

One problem with the two equations (1 and 3) is that the two-stage decision making processes are not separable due to unmeasured farmer 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 level of adoption is biased (Wooldridge, 2002). Thus, we need to specify a model that corrects for
Table 1. Definition of variables and their descriptive statistics

<table>
<thead>
<tr>
<th>Variable definition</th>
<th>Symbol</th>
<th>Mean (STD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender of the household head(0= female, 1= male)</td>
<td>GENDER</td>
<td>0.72(.45)</td>
</tr>
<tr>
<td>Age of the household head (years)</td>
<td>AHH</td>
<td>45.87(12.25)</td>
</tr>
<tr>
<td>Family size (number)</td>
<td>FS</td>
<td>6.10(2.27)</td>
</tr>
<tr>
<td>Educational status (0 = non-educated, 1= educated)</td>
<td>ELHH</td>
<td>0.53(.50)</td>
</tr>
<tr>
<td>Farming experience (Years)</td>
<td>FE</td>
<td>22.61(11.58)</td>
</tr>
<tr>
<td>Total land holding (hector)</td>
<td>LH</td>
<td>1.76(1.20)</td>
</tr>
<tr>
<td>Total income from milk and milk products per year (Birr)</td>
<td>TIMMP</td>
<td>15748 (21788)</td>
</tr>
<tr>
<td>Off-farm activity participation(0 = not accessible, 1 = accessible)</td>
<td>OFAP</td>
<td>0.30 (.46)</td>
</tr>
<tr>
<td>Distance from Agricultural Development Center (kms)</td>
<td>DADC</td>
<td>4.83(3.66)</td>
</tr>
<tr>
<td>Are extension services on livestock available? (0 = no, 1= yes)</td>
<td>ADPES</td>
<td>0.66(.48)</td>
</tr>
<tr>
<td>Availability of veterinarian /animal health service services? (0 = no, 1= yes)</td>
<td>AVS</td>
<td>0.94(.24)</td>
</tr>
<tr>
<td>Availability training services on livestock? (0 = no, 1= yes)</td>
<td>ATL</td>
<td>0.38(.49)</td>
</tr>
<tr>
<td>Have you used saving service intuitions? (0 = no, 1= yes)</td>
<td>USS</td>
<td>0.47(.50)</td>
</tr>
<tr>
<td>Have you used credit service intuitions? (0 = no, 1= yes)</td>
<td>UCS</td>
<td>0.34(.48)</td>
</tr>
<tr>
<td>Is cross breed cattle available? (0 = no, 1= yes)</td>
<td>CBCA</td>
<td>0.70(.46)</td>
</tr>
<tr>
<td>Adoption of crossbred cattle(0 = no, 1= yes)</td>
<td>ACBC</td>
<td>0.50(.50)</td>
</tr>
<tr>
<td>Number cross breed cows</td>
<td>NCBC</td>
<td>0.99(1.35)</td>
</tr>
<tr>
<td>Total cattle in TLU (Tropical Livestock Unit)</td>
<td>TCTLU</td>
<td>5.13(2.63)</td>
</tr>
</tbody>
</table>

selectivity bias while estimating the determinants of the level of adoption. For this purpose, in the first-step, Mills ratio is created using predicted probability values obtained from the first-stage probit regression of the adoption decision. Then, in the second-step, we include the Mills ratio as one of the independent variables in the level of adoption regression. Thus, the level of adoption equation with correction for sample selection bias becomes:

\[ V = W_i \alpha + \lambda (\Phi (W_i \beta)) + \varepsilon_3 \]

Where,
\( \Phi (\cdot) / \Phi (\cdot) = \) is the Mills ratio
\( \lambda = \) is the coefficient on the Mills ratio
\( \Phi = \) denotes standard normal probability density function
\( \Phi = \) denotes the standard cumulative distribution function
\( \varepsilon_3 = \) is not correlated with \( \varepsilon_1, \varepsilon_2 \) and other independent variables. Under the null hypothesis no sample selection bias \( \lambda \) is not significantly different from zero.
\( V = \) is the level of adoption (number of cross breed cows)

RESULTS

Definition of variables and their descriptive statistics

The characteristics of the households and other exogenous variables are described in Table 1. The average household age was 46 years and the mean number of family members was 6. The proportion of male-headed households was 72% and the mean value of cattle in the study area was 5.13 in TLU. However, the mean number of cross breed cows was 0.99.

Seventy percent of the respondents said that there was cross breed availability in their proximity. The majority of the respondents (94%) also indicated availability of animal health services in the study areas. Availability of training on livestock in the study areas was indicated by only 38% of the respondents. Thirty percent of the households were participated in the off farm activities and the average farming experience of the households was 22.6 years.

Before running the Heckman two stage models, the exogenous variables were checked for existence of multicollinearity and heteroscedasticity problem. A technique of Variance Inflation Factor (VIF) and Breusch-Pagan / Cook-Weisberg test
were used to detect the problem of multicollinearity and heteroscedasticity among exogenous variables, respectively. Accordingly, the VIF (Xi) result showed that the data had no serious problem of multicollinearity (Table 2). This was because, for all exogenous variables, the values of VIF were less than 10. Therefore, all the exogenous variables were included in the model. On top of this, the heteroscedasticity test P-value was 0.9744 which was insignificant implying that there was no problem of heteroscedasticity.

Probit model estimation of the determinants of dairy technology adoption and the values of marginal effects which were evaluated in first-stage Heckman selection at the means of all other independent variables are shown in Table 3. The probit model estimation gave a Pseudo-$R^2$ of 0.46 which implied that the variables included in the model were able
### Table 4. Results of second-stage Heckman selection estimation of determinants of intensity of dairy technology adoption

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Coefficient</th>
<th>P&gt;</th>
<th>Z/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-3.304(.699)</td>
<td>0.000**</td>
<td></td>
</tr>
<tr>
<td>GENDER</td>
<td>0.278(.211)</td>
<td>0.188</td>
<td></td>
</tr>
<tr>
<td>AHH</td>
<td>-0.035(.014)</td>
<td>0.012**</td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td>0.049(.042)</td>
<td>0.247</td>
<td></td>
</tr>
<tr>
<td>ELHH</td>
<td>0.042(.198)</td>
<td>0.834</td>
<td></td>
</tr>
<tr>
<td>FE</td>
<td>0.045(.016)</td>
<td>0.005***</td>
<td></td>
</tr>
<tr>
<td>LH</td>
<td>0.005(.092)</td>
<td>0.957</td>
<td></td>
</tr>
<tr>
<td>TIMMP</td>
<td>0.00008(.00001)</td>
<td>0.000***</td>
<td></td>
</tr>
<tr>
<td>OFAP</td>
<td>-0.451(.222)</td>
<td>0.042**</td>
<td></td>
</tr>
<tr>
<td>DADC</td>
<td>-0.016(.028)</td>
<td>0.580</td>
<td></td>
</tr>
<tr>
<td>ADPES</td>
<td>0.834(.215)</td>
<td>0.000***</td>
<td></td>
</tr>
<tr>
<td>AVS</td>
<td>0.827(.413)</td>
<td>0.045**</td>
<td></td>
</tr>
<tr>
<td>ATL</td>
<td>0.711(.185)</td>
<td>0.000***</td>
<td></td>
</tr>
<tr>
<td>USS</td>
<td>0.587(.197)</td>
<td>0.003***</td>
<td></td>
</tr>
<tr>
<td>UCS</td>
<td>-0.019(.227)</td>
<td>0.934</td>
<td></td>
</tr>
<tr>
<td>CBCA</td>
<td>0.662(.227)</td>
<td>0.004***</td>
<td></td>
</tr>
<tr>
<td>TCTLU</td>
<td>0.038(.047)</td>
<td>0.414</td>
<td></td>
</tr>
<tr>
<td>LAMBDA</td>
<td>0.239(.046)</td>
<td>0.000***</td>
<td></td>
</tr>
</tbody>
</table>

Number of observations = 384, Wald chi2 (16) = 1884.78, Prob >chi2 = 0.000, Rho = 1.000, Sigma = 0.23936308, Censored observations = 195, Uncensored observations = 189. Numbers in bracket show Heckman two-stage Robust standard error. *** and ** indicate statistical significance at 1% and 5%, respectively.

**Source:** Compiled by researcher

to explain about 46 percent of the probability of farm households' decisions to adopt or not to adopt dairy technology. The Log-likelihood Ratio (LR) was also found to be significant at the 1% level (Table 3). This means that all the explanatory variables included in the model jointly influenced farmers' probability of adoption of dairy technologies. The model results also gave a predicted probability of adoption of 0.62. This means that there was about 62 percent probability that farm households in the areas were willing to adopt dairy technologies. Given the above mentioned goodness of fit measures, it was concluded that the probit model employed was reliable and appropriate.

Availability of dairy production extension services was positively associated with farmer’s likelihood to adopt dairy technology. This indicated that good availability of dairy production extension services increased the probability of adopting dairy technology by 30.1%. Similarly, utilization of saving institutions and cross breed cow availability were positively associated with farmer’s likelihood to adopt dairy technology. These indicated that utilization of saving institutions and cross breed cow availability increased the probability of adopting dairy technology by 21.2% and 26.2%, respectively. On contrary to prior expectation, off-farm activity participation was negatively associated and statistically significant with farmer’s likelihood to adopt dairy technology. This indicated that off-farm activity participation decreased the probability of adopting dairy technology by 19.6%.

Results of second-stage Heckman selection estimation for the level of participation are shown in Table 4. The coefficient of Mills ratio (Lambda) in the Heckman two-stage estimation was significant at the probability of less than 1%. This indicated sample selection bias, existence of some unobservable farmer characteristics determining farmer’s likelihood to adopt dairy technology and thus affecting the intensity of adoption. The overall joint goodness of fit for the Heckman selection model parameter estimates was assessed based on the log likelihood ratio test. The null hypothesis for the log likelihood ratio test was that all coefficients are jointly zero. The model chi-square tests applying appropriate degrees of freedom indicate that the overall goodness of fit for the Heckman selection model was statistically significant at a probability of less than 1%. This shows that jointly the independent variables included in the selection model regression explained the intensity of adoption.

Age of household head and off-farm activity participation were negatively related and statistically significant (P< 0.05) with the intensity of dairy technology adoption. This indicates that holding other exogenous variables constant, an increase in household head age by a year resulted in 3.5x10^-2 decrease in the intensity of dairy technology adoption.
Similarly, as the off-farm activity participation increased by a unit results in 45.1 x 10^{-2} decreased in the intensity of dairy technology adoption. On the other hand, both farming experience, total income from milk and milk products, availability of dairy production extension service, availability of training on livestock, utilization of saving services and cross breed cow availability were correlated positively and statistically significant (P<0.01) with the intensity of adoption.

Regarding to farming experience, considering other exogenous variables constant, as it increased by a year, intensity of dairy technology adoption increased by 4.5 x 10^{-1}. Holding other exogenous variables constant, as total income from milk and milk products increased by one birr per annum resulted in 8.0 x10^{-5} increase in the intensity of dairy technology adoption. Holding other explanatory variables constant, utilization of saving services and availability of cross breed cow resulted in 58.7 x10^{-5} and 66.2 x10^{-5} increase in intensity of dairy technology adoption, respectively. Availability of veterinary service was also positively related and statistically significant (P< 0.05) with the intensity of dairy technology adoption. This implied that taking other independent variables constant, availability of veterinary service resulted in 82.7 x 10^{-5} increase in intensity of dairy technology adoption.

**DISCUSSION**

The probability of dairy technology adoption and its intensity associated negatively and significantly (P<0.05) with age of household heads. This finding is in line with Quddus (2013) report which stated that the probability of adoption decreased with the increase of age of household heads. It could be hypothesized that more educated and younger farmers are more ready to try the dairy technology but older farmers may be more conservative to participate in the new technology dissemination process and practices. But both family size and farming experience had positive and significant association with the probability of dairy technology adoption. This finding is also in line with the same author Quddus(2013) which stated that Adoption of dairy technology is positively associated with level of farmer’s education and farming experience; household income and earning members.

Household with large family size could have a high probability of dairy technology adoption which is similar with the finding of Howley, et al. (2012). As per the later, farmers with children were much more likely to use AI in a given period. This justifies that dairy technology needs more labor, hence having more family size could alleviate labor scarcity that constitute one of the limitations for technology uptake. The probability of dairy technology adoption and level of use increased with the increase of farmer’s farming experience. Practices and experiences lead the farmers to have a better knowhow to handle technologies and understand their benefits easily.

Availability of dairy production extension services was positively associated with farmer’s probability of dairy technology adoption and use level. This result is in agreement with the finding of Amelaku, et al. (2012). The later reported that the probability of adopting dairy technology increases by 43% for at least a once time visit by the extension service per year. This implies that farmers that have access to extension services could get good information about the technologies that result in a high probability of adoption.

Availability of cross breed cows and accessibility of saving institutions were also positively associated with farmer’s likelihood to adopt dairy technology and level of adoption. As the technology is available in the areas the probability of adopting the technology increases. This is because it reduces the transport cost and farmers may learn more about the technology by observing which initiate them to adopt. This is consistent with the report of Akudugu et al. (2012). As per the later, the availability of modern agricultural production technologies to end users, and the capacities of end users to adopt and utilize these technologies are critical. Having access to formal (bank and microfinance) and informal (Iquib) saving institutions create a good opportunity for farmers to have an asset and to purchase different agricultural technologies including cross breed cows. On contrary to our prior hypothesis, off-farm activity participation is negatively associated and statistically significant with both farmer’s likelihood to adopt dairy technology and level of adoption. This result is in line with the finding of (Howley, et al., 2012) stated that off-farm job much less likely to adopt AI. This could be due to time constraints of the individual to adopt the dairy technology.

Total income from milk and milk products and availability of training on livestock production are positively and significantly (P<0.01) correlated with the intensity of adoption of dairy technologies. Getting high income from milk empowered farmers economically and triggered them to get more dairy technologies. Muzari et al. (2012) stated that the major option for increased adoption of technology is to overcome the income/ capital constraint through increased credit provision. The availability of livestock training also increases the level of dairy technology adoption through creating awareness on the advantages of the technology and then improving the farm management skill. Therefore, farmers in the areas of training availability could adopt more and owned more dairy technology than non-training areas’ farmers. This is in agreement with Quddus (2013) report that indicated more knowledge on improved technologies through training, availability of reliable and continuous technical assistance, availability and low price of concentrate feeds, increased and timely provision of medicine, increasing AI facilities, providing pure breed and strengthening extension services as the main suggestions from farmers.
CONCLUSIONS AND RECOMMENDATIONS

Regardless of significance variations across physical location; family size, farming experience, availability of dairy production extension services, availability of cross breed cows, accessibility of saving institutions, total income from milk and milk products, availability of training on livestock, age of household head and off-farm activity participation played significant roles on both the probability of dairy technology adoption and its level of adoption. The last two factors (age of household head and off-farm activity participation) have negative significant association with the probability of dairy adoption and level of adoption. Hence, the following recommendations were forwarded.

1. Introducing different dairy technologies should be supported with a continuous training or technical backup on how to manage and utilize the technology as well.
2. Dairy technology input and/or service providers should undertake follow ups to identify possible problems and/or evaluate the use and benefits of the interventions.
3. There should be provision of continuous trainings for aged smallholder farmers in order to enable them to adopt more dairy technologies.

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