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DETERMINANTS OF MILK COOLING PLANT ADOPTION AND INTENSITY OF USE BY SMALL HOLDER FARMERS IN NANDI COUNTY, KENYA: A BI-PROBIT ANALYSIS

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ABSTRACT

Agricultural growth is considered a very close link to rural development and hence poverty alleviation. There's therefore an urgent need for sustainable increase in agricultural productivity through adoption of new and efficient technologies to improve food security, alleviate poverty and stimulate economic growth. Efforts have been made by the Kenyan government and other developing countries such as Rwanda together with Non-governmental organizations such as Heifer International to introduce and disseminate new farming technologies by alleviating economic constraints of technology adoption with the aim of increasing agricultural productivity and increasing farmers' incomes. The study empirically determined the factors that affected adoption of milk cooling plants in Nandi County. The study utilized cross-sectional farm household data which was collected from a sample size of 1662 randomly selected farmers from the dairy population of Nandi County using a structured questionnaire and through face-to-face interviews. Multi-stage sampling procedure involving a combination of purposeful and random sampling procedures was used to draw a representative sample. The results from individual probit, heteroskedastic and Biprobit models showed that farmer characteristics such as age, education level and gender significantly affected the decision to adopt milk cooling plants with p-value of < 0.05. Institutional and economic factors such as access to credit, extension visits, income from milk sales and transport cost and distance to cooling plants also had a significant effect on adoption of MCP. It was concluded that farmers characteristics, institutional and socio-economic factors determine the adoption of milk cooling plants in Nandi county.

INTRODUCTION

Agriculture is an important sector of the economy, constituting about 27% of GDP. Seventy percent of population is rural areas and over 50% is classified as agriculturally self-employed. Within agriculture, dairy industry plays an important role as a contributor to GDP and an important source of livelihood for a huge portion of Kenyan rural population. Calculated at international prices, cow milk is the most significant agricultural commodity for Kenya (FAOSTAT, 2006). Estimating the size of the dairy industry, however, is a challenge. Most of the sector is informal, and the official statistics capture only a small portion that is formal (KDB, 2007 and KDB, 2012). The industry is also a major source of livelihood to a large majority of Kenyans and contributes approximately 4% of Kenya's GDP (though recent studies indicate 8%) and acts as a source of income and employment to over 1.5 million smallholder dairy farmers in addition to 500,000 direct jobs in milk transportation, processing and distribution and a further 750,000 in related support services (KDB, 2012). The history of the dairy industry in Kenya dates back to 1902 when the first exotic dairy cows were introduced by the European settlers. The first crops of the introduced animals were cross-bred with the indigenous cattle over time. The first creamery was established in Naivasha in 1922. In 1946, the first Artificial Insemination (AI) service was introduced. The station provided AI services at a highly subsidized price and this led to the rapid multiplication of the country's dairy herd. As of now, Kenya hosts about 3.35 million heads of dairy cattle (KDB, 2012).

Milk should be cooled within 2-4 hours from the moment it is milked. The main objective of chilling is to preserve the quality of raw milk and reduce spoilage before milk is subjected to further processing. If they are not established by processors, chilling plants are most often owned in at least some percentage by producers, and sometimes they are donor funded.

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Problem statement

Since raw milk is a highly perishable product, it has to be preserved awaiting processing or consumption. Many famers in Nandi County dwell in areas with poor roads, lack electricity or where cooling is uneconomical. Often, milk collected from areas with poor infrastructure cannot reach processing plants within the recommended time of four hours culminating in spoilage. In some inaccessible areas, afternoon milk is not collected because doing so is unprofitable. In some of these areas, farmers cope with the lack of preservation facilities by prolonging the duration before milking by up to 16-18 hours.

The use of the udder as storage for milk has high negative impacts on milk production. Furthermore, plenty of milk goes to waste in dairy farms, especially during the flush rainy season. Heifer International and its partners from 2008 has assisted farmers organize into dairy farmer business associations (DFBA), such as Kabiyet dairy plants where farmers co- own the plant with the donor organizations. However not all the farmers have readily adopted the use of the cooling plant. The research sought to find out the factors that determine adoption and usability of the cooling plants

Specific Objectives

The study's specific objectives were as follows;-

- To determine the effect of institutional factors on adoption and intensity of using milk cooling plants in Nandi County.
- To determine the effect of farmer characteristics on adoption and intensity of use of milk cooling plants in Nandi County.
- To determine the effect of economic factors on adoption and intensity of using milk cooling plants in Nandi County;

Hypotheses

- Institutional factors do not affect adoption and intensity of use of milk cooling plants in Nandi County.
- Farmer characteristics do not affect adoption and intensity of use of milk cooling plants in Nandi County.
- Economic factors do not affect adoption and intensity of use of milk cooling plants in Nandi County

MATERIALS AND METHODS

Individual Probit Equations

Four statistical functional forms are generally used in empirical researches to analyze binary choice problems such as technology adoption, (Greene, 2008 and Gujarati, 2007). These models are Linear Probability Model (LPM), Probit Model, Tobit Model and the Logit Model. Both the Probit and Logit Models are Cumulative Probability Distribution Models (CPDM) models. The limiting factor for linear probability models is that the predictions may lie outside the limiting interval of 0 - 1 imposed by law of probability (Gujarati, 2007; Long and Freese, 2003 and Long and Freese, 2006). The probit model postulated that the probability (P) of a farmer adopting MCP technology was a function of some socio-economic characteristics (X_i). The model used a normal curve to transform the binary responses into probabilities within the 0 - 1 interval. Greene (2008) showed that the Probit Model was an extension of Linear Probability Model (LPM) given as:

$$P_{ij} = E(A=1 \mid X_i) = \alpha_0 + \alpha_i X_i \text{ ....(1.1)}$$

In Equation 1.1 P_i is the probability that the farmer took the decision to adopt the technology, $A=1$ means the farmer adopted the technology, X_i were the decision variables, α_0 is the intercept and α_i are the regression coefficients for $i=1,2,\cdots,n$ and n was the number of decision variables $j=1,2,......,m$ where m was the number of decision makers (Greene, 2008). Probit model is a normal distribution bound between 0 and 1 (Agresti, 2002; and Agresti 2005). Greene, (2008) showed that the LPM (Equation 1.1) above may be represented in the following form;

$$P_i = E(Y_i = 1 \mid X_i) = \frac{1}{1+e^{-(\alpha_1 + \alpha_i X_i)}} \text{ .... (1.2)}$$

This equation represents normal distribution function (Baum, 2006; Cameron and Trivedi, 1998 Cameron and Trivedi, 2005 and Cameron and Trivedi, 2009). Where, Y_i was the observed response for the i^{th} observation (binary variable, $Y_i = 1$ for an adopter, $Y_i = 0$ for non-adopter) Abou, 1992; Adesina and Baidu-Forson, 1995 and Aksoy *et al.,* 2011). Following Yamano (2009) equation 1.2 was equivalently written as:

$$P_i = \frac{1}{1+e^{-Z_I}} = \frac{e^z}{1+e^z} \text{ .... (1.3)}$$

In equation 1.3 P_i represents the probability that a farmer adopts the technology. Therefore the probability of not adopting the technology was $1-P_i$. Greene (2008) showed that:

$$1-P_i = \frac{1}{1+e^{z_i}} \text{ .... (1.4)}$$

Greene (2008) also showed that equation 1.4 was equivalent to;

$$\frac{P_i}{1-P_i} = \frac{1+e^{Z_i}}{1+e^{-z_i}} = e^{z_i} \text{ .... (1.5)}$$

In Equation 1.5 $P_i/(1-P_i)$ represented the odds ratio. This was interpreted as the ratio of a farmer adopting the MCP technology to the ratio of not adopting. This was not estimated because probit model was used.

RESULTS AND DISCUSION

In computation of the separate probit models, the potential relationship between adoption decisions of using cooling technology and extent of using cooling technology was disregarded. Each probit equation had 1,662 observations and 16 parameters. In the first probit equation, access to credit, form of land ownership, education level of the farmer, other occupations, and distance to cooling plant were very significant (p- values < 0.0001). It has been demonstrated that proximity to a milk collection centre was significantly associated with an increased probability of house hold successfully entering or increasing dairy production (Baltenweck, 2000).

Access to credit had a positive and very significant effect on adoption of milk cooling plant p – value 4.44 e-09 < 0.001. Extension visits had a positive and significant effect on adoption of cooling technology p – value 0.0264 < 0.05. Visits from extension staff were found to be positively related to adoption by exposing farmers to new information (Adesina and Baidu-Forson (1995).

Membership to cooperative was positive and significant determinant of adoption of milk cooling plant p - value 0.0095 < 0.01. Membership to cooperatives is a social participation and meant many actions such as people's connection with some foundations which have social and economic aims or their membership to them.

Table 1.0 Regression Results for Adoption Milk Cooling Plant
Deviance Residuals

Min	1Q	Median	3Q	Max
-2.5632	-0.8378	-0.3352	0.9415	2.1979

Variables	Coefficients	Std. Error	Z Value	Pr > |Z|
Intercept	28.383921	9.799374	2.897	0.00377 **
Extension visits	0.009435	0.004248	2.221	0.02635 *
Access to credit	0.849358	0.144775	5.867	4.44e-09 ***
Membership to cooperatives	0.383101	0.147646	2.595	0.00947 **
Membership to cooling plants	-0.254408	0.101849	-2.498	0.01249 *
Land ownership	0.476271	0.109954	4.332	1.48e-05 ***
Education level of the farmer	0.349792	0.028681	12.196	< 2e-16 ***
Gender of the household head	0.209486	0.079169	2.646	0.00814 **
Transport cost	-0.031601	0.011190	-2.824	0.00474 **
Land size in acres	0.038048	0.012745	2.985	0.00283 **
Other occupations	-0.262233	0.031970	-8.202	2.36e-16 ***
Ratio of milk consumed	-0.779942	0.276536	-2.820	0.00480 **
Income from milk sales	0.202354	0.096212	2.103	0.03545 *
Family size	-0.002387	0.004468	-0.534	0.59321
Distance to cooling plant	-0.044929	0.006073	-7.398	1.38e-13 ***
Off-farm income	0.096180	0.038219	2.517	0.01185 *
Age of the household head	-16.414964	6.750404	-2.432	0.01503 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1; (Dispersion parameter for binomial family taken to be 1), Null deviance: 2292.5 on 1661 degrees of freedom Residual deviance: 1758.5 on 1645 degrees of freedom AIC: 1792.5, Number of Fisher Scoring iterations: 6
Source: Data Analysis Results using R, 2014

Table 2.0: Regression Results for Intensity of using Milk Cooling Plants
Deviance Residuals

Min	1Q	Median	3Q	Max
-0.9487	-0.3959	-0.3041	-0.2222	3.0357

Coefficient	Estimate	Std. Error	z value	Pr(>|z|)
Intercept	-8.915209	14.125101	-0.631	0.527935
Extension visits	0.002989	0.005634	0.531	0.595729
Access to credit	-0.459284	0.204794	-2.243	0.024919 *
Membership to cooperatives	-0.118990	0.211895	-0.562	0.574420
Member of cooling plant	-0.407233	0.135169	-3.013	0.002589 **
Land ownership	-0.380819	0.148909	-2.557	0.010546 *
Gender	-0.060515	0.042022	-1.440	0.149849
Education Level	-0.156511	0.111107	-1.409	0.158937
Transport Cost	0.041445	0.015277	2.713	0.006671 **
Land Size	-0.015275	0.017429	-0.876	0.380790
Other Occupations	0.165171	0.04553	3.628	0.000286 ***
Ratio of Milk Consumed	-1.640606	0.418341	-3.922	8.79e-05 ***
Income from Milk Sales	-0.662826	0.139091	-4.765	1.88e-06 ***
Family Size	-0.006555	0.006527	-1.004	0.315184
Distance to MCP	0.005655	0.006564	0.861	0.388986
Off-farm income	-0.026884	0.055027	-0.489	0.625147
Age	4.858251	9.725515	0.500	0.617401

Significant Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1; (Dispersion parameter for binomial family taken to be 1), Null deviance: 799.29 on 1661 degrees of freedom, Residual deviance: 733.27 on 1645 degrees of freedom; AIC: 767.27; Number of Fisher Scoring iterations: 7 Source: Authors Data Analysis Results using R, 2014

The results meant that, the producers who participated in these kinds of activities were more successful in receiving information, learning the details and practicing the innovations. The fact that all of the enterprises involved in the research were the members of milk cooling plants, was an important factor for their being innovator. Dairy producers received some help from their MCPs in learning and practicing some of the innovations. The importance of the level of social participation in learning innovations was also stated by Abou (1992) and Salama (2009). Membership to cooling had negative and significant effect on adoption cooling plant p - value 0.0125 < 0.01. This was attributed to the fact that milk cooling plants dictated the price of selling milk.

The first objective of the study stated that institutional factors such extension visits, access to credit, membership to cooperatives and membership to cooling plant do not determine adoption of cooling plant by farmers in Nandi County. The results from the first probit regression showed that institutional factors such extension visits, access to credit, membership to cooperatives and membership to cooling plant were significantly determined adoption of cooling plants by farmers in Nandi County. Based on the above results the first hypothesis was rejected.

Land tenure had positive and very significant effect on adoption of cooling plant p – value 1.48e-05. The coefficient of transport cost was negative and significant p – value 0.0047 < 0.01. Land size in acres was also a significant determinant of adoption of cooling plant with a p – value 0.0028 < 0.01. This result is consistent with theory because it was hypothesized that size of the land was positively related to the adoption of cooling plant. According to Brush (1997) farms that adopt tend to be larger in size, while the non-adopters have smaller, sub family plots. It was hypothesized that households with larger parcel of land were more likely to adopt new technology as they have additional land on which to experiment and they are less risk averse (World Bank, 1990). Other occupations had a negative and very significant effect on adoption of cooling plant p – value 2.36e-16. This result was consistent with El-Osta and Morehart, (2000) who found that the Likelihood of being a top producer increased with specialization of the farm. Shahin (2004) showed that the main occupation of the producers was of great importance in terms of economic improvement and specialization in production. Also in Turkey it was found that specialization in livestock sector was rare and this affected economic improvement negatively (State Planning Organization, 2001).

Ratio of milk consumed by the household had negative and significant coefficient p – value 0.0048 < 0.01. As it was hypothesized income from milk sales had positive and significant effect on adoption of cooling plant p – value 0.0355 < 0.05. Distance to cooling plant had negative and very significant effect on adoption of cooling plant p – value 1.38e-13. Off-farm income had positive and significant effect p – value 0.0119 < 0.05. The second hypothesis of this study stated that economic factors such land ownership, transport cost, size of the land in acres, other occupations, ratio of milk consumed by the household, income from sale of milk, distance to cooling plant and off-farm income do not determine adoption of cooling plant technology by farmers in Nandi County. The results in table 1.0 showed that economic factors such land ownership, transport cost, size of the land in acres, other occupations, ratio of milk consumed by the household, income from sale of milk, distance to cooling plant and off-farm income determined adoption of cooling plant technology by farmers in Nandi County. Therefore based on the results this hypothesis was rejected.

Education level of the farmer had a positive and very significant effect on adoption of milk cooling plant technology (p – value < 2e-16 < 0.001). This result is consistent with Aksoy *et al.,* (2011) who showed that there was a strong and positive correlation between the level of education and the level of adoption of dairy innovations in Turkey. The education level of a community is the most important indicator of social change. Similarly, Weir (2000) found that education level was effective in adopting and practicing the innovations in rural areas in Ethiopia. It was statistically found out that the increase in education level affects innovations in Turkey. The positive influence of the educational level on adopting innovations was also reported by Salama (2001), Shahin (2004) and Singh and Sharma (1995). This result is parallel to Abou (1992) and Madhukar and Ram (1996) works that found that education had no role in adoption of innovations. The results also showed that gender of the household head had a positive and significant coefficient (p – value 0.0081 < 0.005). The size of the family had negative and insignificant effect on adoption of milk cooling plant (p – value 0.5932 > 0.05). These results supported the findings of Turkyilmaz (2003) and Simsek (1996), who found that the family size of the producer did not determine or oppose adoption of innovations.

The age of the farmer had a negative and significant effect on adoption of cooling plant (p – value 0.0150 < 0.05). Probability of adoption decreased with the increase of age of the household head because older farmers may be more reluctant to adopt new technologies or practices (Feder *et al.,* 1985). Similarly Quddus (2012) found that age of the farmer was negatively interrelated with technology adoption. Simsek (1996) noted that the age of the producer was one of the factors which determined the decisions and actions made in the enterprises, because people's thoughts, behaviors and needs were primarily related to their ages. In some researches it was stated that age affected innovations Madhukar (1996), while in others not (Salama (2001) and Singh and Sharma (1995). Age has also been found to be either negatively correlated with adoption, or not significant in farmers' adoption decisions. In studies on adoption of land conservation practices in Niger (Baidu-Forson, 1999), rice in Guinea (Adesiina and Baidu-Forson, 1995), fertilizer in Malawi (Green and Ng'ong'ola, 1993), IPM sweep nets in Texas (Harper *et al.,* 1990), Hybrid Cocoa in Ghana (Boahene *et al.,* 1999), age was either not significant or was negatively related to adoption.

The third hypothesis of this study stated that farmer's characteristics such as education, gender, family size and age do not significantly determine adoption of cooling plant technology by farmers in Nandi County. The results in table 1.0 showed that farmer's characteristic such as education, gender and age significantly determined adoption of cooling plant technology by farmers in Nandi County. Therefore based on this finding the hypothesis was rejected.

In addition, operator membership to cooling plants, transport cost, other occupations, ratio of milk consumed by the household, distance to cooling plants and age of the household head were negatively and significant at 5% (P - values < 0,005). The result further showed that the size of the family was not significant at 5% (P – value 0.722 > 0.005).

Individual Probit Regression Results on Intensity of Using MCPs

The results for the second probit equation are reported in table 2.0. The results for the second equation showed that transport cost and other occupations had a positive and significant relationship on the intensity of using cooling technology by farmers in Nandi County. Results suggested that the intensity of using milk cooling plants was significantly affected by access to credit (p – value 0.0249 < 0.05) Land tenure negatively determined the intensity of using MCP by farmers in Nandi county (p – value 0.0105 < 0.05). Contrary to approri expectations transport cost had positive and significant effect on intensity of usings MCPs by farmers (p – value < 0.0067 < 0.05) and other occupations (p –value 0.0003 < 0.05). The ratio of milk consumed and income from milk sales significantly determined the intensity of using MCPs (p – value 0.0000 < 0.05).

model with selection (STATA 10.0). To obtain efficient estimators accounting for heteroskedasticity in the data, robust standard errors were computed. "Robust" computed a weighted covariance matrix as a sandwich between standard errors. Table 5.0 shows the estimated coefficients of estimates and standard errors from the bivariate probit with selection model.

The results of biprobit regression are reported in table 5.0. Fitting comparison equation 1 reached convergence after four iterations with a log likelihood -879.26376. Fitting comparison equation 2 reached convergence after four iterations with a log likelihood -366.633316. The comparison log likelihood was -1245.8969. Fitting Comparison equation of the overall model reached convergence after five iterations with a log likelihood of -1179.7673. The results of bivariate probit model showed that there was a significant relationship between the decision to adopt cooling plant and intensity of using cooling plant (p – value of /athro was significant 0.009 < 0.05). The likelihood ratio test for rho = 0, was 0.000 < 0.005. Therefore it was concluded that there was significant relationship between the decision to adopt milk cooling plant technology and intensity of using milk cooling plants hence the factors that determined adoption had an effect on the intensity of use once a farmer had adopted the technology.

3.0. Individual Heteroskedastic Probit Regression Results for Adoption of Cooling Technology

Heteroskedastic Probit Model				Number of observation = 1662
				Zero Outcomes = 900
				Nonzero Outcomes = 762
$PROB > \chi^2 = 0.0000$				$Wald\chi^2(16) = 378.08$
Log Likelihood = -876.9803				$Pseudo\ R^2 = 0.0826$
Adoption	Coefficient	Std. Error	Z	Prob >|Z|
Extension visits	0.0098	0.0045	2.16	0.030
Access to credit	0.8204	0.1495	5.49	0.000
Membership to cooperatives	0.3934	0.1489	2.64	0.008
Membership to cooling plant	-0.2847	0.1062	-2.68	0.007
Land ownership	0.4741	0.1143	4.15	0.000
Education level	0.3686	0.0292	12.61	0.000
Gender of the household head	0.2055	0.0815	2.52	0.012
Transport cost	-0.0322	0.0116	-2.79	0.005
Land Size	0.0400	0.0130	3.07	0.002
Other occupations	-0.2615	0.0331	-7.91	0.000
Ratio of milk consumed	-0.9364	0.2923	-3.20	0.001
Income from milk sales	0.1981	0.0993	2.00	0.046
Family size	-0.0025	0.0046	-0.53	0.593
Distance to cooling plant	-0.0469	0.0065	-7.18	0.000
Off- farm income	0.0993	0.0406	2.44	0.015
Age of the household head	-16.8592	7.2255	-2.33	0.020
Insigma Intensity	0.5120	0.2904	1.76	0.078
Likelihood- Ratio test of Insigma2 = 0: $\chi^2(1) = 0 \quad PROB > \chi^2 = 0.0326$				

Source: Authors Data Analysis Results 2014

The results of heteroskedastic probit regression in Table 3.0 and 4.0 above confirmed heteroscedasticity in the independent variables used in the analysis. Bi-variate Probit Regression Results on Adoption and Intensity of using Cooling Technology Full information maximum likelihood estimates were computed for the bi-variate probit with selection model. Estimates were based on 1,662 observations with 16 parameters. Since adopters of cooling technology select the intensity of using cooling technology in dairy farms, bi-probit model was formulated with selection model based on STATA command bi-probit with "selection" set the model to be fitted for the Van de Ven and Van Praag (1981) bi-variate probit

Findings on Farmer Institutional Factors on Adoption and Intensity of Milk Cooling Plants. Extension visit for example had a positive impact in that extension officers provided information and aided in exposing farmers to the benefits of new technologies. It is therefore important that the ministry of livestock development increase the number of extension agents so as to reach as many small holder farmers as possible. Access to credit, membership to cooling plants and other farmer cooperatives affected adoption and use of MCPs because increased funds meant high investment in dairy hence high productivity while membership to cooling plant and

Table 4.0. Individual Heteroskedastic Probit Regression Results for Intensity of Use of Cooling Technology

Heteroskedastic Probit Model				Number of observation = 1662
				Zero Outcomes = 900
				Nonzero Outcomes = 762
$PROB > \chi^2 = 0.0000$				$Wald\chi^2(16) = 378.08$
Log Likelihood = -876.9803				$Pseudo\ R^2 = 0.0826$
Adoption	Coefficient	Std. Error	Z	Prob >|Z|
Extension visits	0.066075	0.0037963	1.74	- .0008331
Access to credit	0.2323101	0.2398302	-0.97	-.7023687
Membership to cooperatives	0.0649468	0.240148	0.27	-.4057347
Membership to cooling plant	-0.538698	0.1475362	-3.65*	-.8278636
Land ownership	-0.2307516	0.1639405	-1.41	-.5520691
Education level	0.0544215	0.0407411	1.34	-.0254296
Gender of the household head	-0.1041772	0.1205529	-0.86	-.3404565
Transport cost	0.0300597	0..0163816	1.83	-.0020477
Land Size	0.0001957	0.0205305	0.01	-.0400433
Other occupations	0.0890698	0.00527481	1.69	-.0143146
Ratio of milk consumed	-1.928468	0.4199199	-4.59*	-2.751496
Income from milk sales	-0.6786726	0.1216241	-5.58*	-.9170515
Family size	-0.0077623	0.0072077	-1.08	-.0218892
Distance to cooling plant	-0.0037159	0.0067055	-0.55	-.0168585
Off- farm income	0.0239718	0.0008994	2.67*	.0063439
Age of the household head	-4.616663	0.5472591	-8.44*	-5.689271
Likelihood- Ratio test of Insigma2 = 0: $\chi^2(1) = 0$ $PROB > \chi^2 = 0.0326$				

Source: Authors Data Analysis Results 2014

Table 5.0. Bi-variate Probit Regression Results on Adoption and Intensity of Using Cooling Technology

Fourth Iteration Eq. 1 log likelihood = -879.26376				
Fourth Iteration Eq. 2 log likelihood = -366.63333				
Comparison Equation log likelihood = -1245.8969				
Overall Comparison Eq log likelihood = -1179.7673				
Bi-Probit Regression with selection				Number of observation = 1662
$PROB > \chi^2 = 0.0000$				$LR\ \chi^2(16) = 66.03$
Log Likelihood = -879.26376				$Pseudo\ R^2 = 0.0826$
First Hurdle: Adoption	Coefficient	Std. Error	Z	Prob >|Z|
Extension visits	0.0093	0.0043	2.14*	0.032
Access to credit	0.7709	0.1439	5.36*	0.000
Membership to cooperatives	0.3828	0.1433	2.67*	0.008
Membership to cooling plant	-0.2449	0.1003	-2.44*	0.015
Land ownership	0.4686	0.1089	4.30*	0.000
Education level	0.3410	0.0272	12.54*	0.000
Gender of the household head	0.1923	0.0781	2.46*	0.014
Transport cost	-0.0345	0.0112	-3.09*	0.002
Land Size	0.0396	0.0126	3.15*	0.002
Other occupations	-0.2528	0.0317	-7.96*	0.000
Ratio of milk consumed	-0.7937	0.2736	-2.90*	0.004
Income from milk sales	0.2414	0.0960	2.52*	0.012
Family size	-0.0016	0.0044	-0.36	0.722
Distance to cooling plant	-0.0434	0.0062	-7.03*	0.000
Off- farm income	0.1004	0.0391	2.57*	0.010
Age of the household head	-17.1629	6.9293	-2.48*	0.013
Intercept	29.2169	10.0601	2.90*	0.004
Second Hurdle: Intensity	Coefficient	Std. Error	Z	Pro > |Z|
Extension visits	0.0055	0.0056	1.00	0.319
Access to credit	-0.5860	0.2083	-2.81*	0.005
Membership to cooperatives	-0.0749	0.2051	-0.37	0.715
Membership to cooling plant	-0.4225	0.1338	-3.16*	0.002
Land ownership	-0.4269	0.1502	-2.84*	0.004
Education level	-0.1156	0.0340	-3.40*	0.001
Gender of the household head	-0.1865	0.1099	-1.70	0.090
Transport cost	0.0333	0.0152	2.20*	0.028
Land Size	-0.0089	0.0178	-0.50	0.618
Other occupations	0.1886	0.0478	3.95*	0.000
Ratio of milk consumed	-1.4793	0.3920	-3.77*	0.000
Income from milk sales	-0.6758	0.1404	-4.81*	0.000
Family size	-0.0061	0.0064	-0.96	0.340
Distance to cooling plant	0.0066	0.0063	1.05	0.292
Off- farm income	-0.0151	0.0540	-0.28	0.780
Age of the household head	2.6184	9.4774	0.28	0.782
Intercept	-5.8749	13.7931	-0.43	0.670
/athro	-1.7366	0.6643	-2.61*	0.009
Rho	-0.9398	0.0775		
Likelihood-Ratio test of rho=0				0.000 132.259

Source: Data Analysis Results 2014 using R co-operatives encouraged cohesion hence high bargaining power by farmers who now get better milk prices compared to when individual farmers sold their own raw milk at farm gate. As shown by the results, more support in terms of credit facilities from local banks and development partners should be given to smallholder dairy farmers so that they can increase productivity hence get higher incomes and better living standards. There is also need to encourage participation by farmers in cooling plants and co-operatives as they assist them get better milk prices because of high volumes sold.

Findings on Farmer Economic factors on Adoption and Intensity of Milk Cooling Plants. Objective two of the study on economic characteristic's effect on adoption indicated that land tenure, transport cost, ratio of milk consumed, income from milk sales and off-farm income significantly affected adoption of MCP. Research findings showed that land tenure and land size were positively significant in adoption so that farmers who have large tracks of land and those who owned farms easily adopted the technology because the two characteristics allowed them to take risks without taking much time because they can act as collateral security in getting funds to implement new technology. Additional income from off farm activities was a positive significant factor showing that farmers who had extra incomes were better adoptees that those who relied purely on farm incomes. The government should therefore subsidize most of the costs associated with technology adoption to ensure that its uptake is quick. From the results, other occupations that farmers participated in other than dairy production was negatively significant meaning that farmers attention is diverted to other activities instead of specializing in dairy hence reduced production and returns its therefore urgent to sensitize farmers who are able to specialize in dairy and reduce other occupations so that they can realize the benefits of dairy and participation in cooling plants.

More accurate assessment found out that the longer the distance from farm to milk cooling plant prevented most milk farmers from participating or using the cooling plant as they spent more time and high costs of transportation to get to the facility. The study shows the necessity of cooling plant sub stations be developed in villages that are far from the main stream MCP to allow all the willing farmers access the facility so that they are not discriminated because of distance and the associated costs.

Since some of the milk produced by farmers is consumed by the household it was found that the ratio of milk consumed negatively but significantly affected adoption .From our regression results the average age of dairy farmers was 36 - 40 years and at that age it was expected that they have families (children and spouses) who consumed part of the milk that would otherwise be taken to cooling plants. High income from milk sales encouraged adoption of cooling plants in that milk now was sold in bulk and therefore the cooling plant has a higher bargaining power than individual farmers. Results on farmers' characteristics showed that age, education level, gender of household head and family size had an impact on adoption of the milk cooling plant technology. Education level and gender for instance had a positive effect on adoption and use of MCP'S. Farmers who were more educated were better adopters and users of MCP'S than illiterate farmers. These was because educated farmers could analyze the benefits and were better risk takers than the less educated who were always late adopters of any technology. Farmers should be exposed to more dairy technologies and information on the same so that their attitude on new technology may change.

Findings on Farmer Characteristics on Adoption and Intensity of Milk Cooling Plants. On gender both men and women as household heads adopted technology. The statistic on more men in the results is because there are more male headed households compared to female headed ones. Gender therefore in our results did not oppose or negatively affect adoption or its use. Study findings on age of farm households head had a negative but significant effect on adoption and use of milk cooling plants technology. As farmers age they become rigid to new technologies and therefore the rate of adoption goes down. Our analysis showed that the prime age for technology adoption is between 36-40 years. Family sizes on the other hand had a negative and insignificant effect on adoption and use of cooling plant. It was assumed that the impact is insignificant because the family's milk consumption forms a very small portion of the household's total daily basket of goods consumed and therefore adoption is done irrespective of the size of family.

Conclusion

The level of Milk Cooling Plant technology adoption by small holder dairy farmers in Nandi County is highly dependent on farmer's education level, farmer's characteristics, their economic status and the institutional factors. The study confirmed that the farmer education levels, land tenure, distance and access to the nearest cooling plant, access to credit, extension visits and other occupations were the main determinants that affected the adoption and use of Milk Cooling Plant's. This showed that training programs should be conducted to improve knowledge of the farmers about the merits of adopting and using MCP's so that they can improve their productivity hence high milk sales that in turn lead to increased farm incomes.

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