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Analysis of Market Participation Behavior Among Smallholder Dairy Farmers in Uganda

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Abstract

Market participation of smallholder farming has gained priority in the policy agenda of many developing countries as an engine for economic growth. In Uganda, smallholder dairy farming has been adopted as a strategy for the country's economic transformation through commercialization but efforts to improve dairy market sales have not been successful. Without appropriate interventions, Uganda may fail to take advantage of the anticipated increase in demand for livestock products. A study to analyze determinants of dairy farmers' market participation and percentage of milk sales was therefore undertaken in Uganda's three main milk producing regions. Multistage sampling and purposive sampling procedures were used to select a study sample of 171 representative dairy farming households, with at least one milking cow based on data derived from the REPEAT Survey of 2012. Data was analyzed by descriptive statistics and Heckman two-stage selection econometric model. Results show that milk market entry decision was significantly influenced by improved lactating cows (1%), number of lactating cows (1%), milk yield (1%), information access (5%), access to veterinary services (5%) and children less than 6 years (10%). Percentage of milk sales was influenced by information access (1%), number of lactating cows (5%), improved milking breeds (5%) and quantity of milk consumed. Three variables critical to policy intervention in enhancing smallholder dairy farmer participation and intensification are number of lactating cows, improved lactating cows and information access. Quantity of milk consumed suggests supplementation of milk with other protein foods among dairy farmers in Uganda.

Keywords: smallholder, milk, market participation, 2 stage-heckman model

1. Introduction

Market participation of smallholder farming has gained priority in the developing world as an engine for economic growth. This prioritization of smallholder farming has been reflected in the policy agenda of many developing countries (Demeke & Haji, 2014). This could be a result of the anticipated increase in demand for livestock products as Ehui et al. (2002) projected total consumption of meat and milk in Sub-Saharan Africa (SSA) to more than double, from 11.3 to 35.4 million tons between 1997 and 2020. Moreover, Delgado et al. (1999) had earlier projected a 50% increase in per capita consumption of livestock products from 1993 to 2020. Such increases are attributed to population growth, urbanization and rising incomes in developing countries, which cause an outward shift in the demand for livestock especially dairy products. As Heltberg and Tarp (2001) observed, this rising demand presents expanding market opportunities among rural people in SSA (in particular, increased milk sales, market information, market entry, entrepreneurships and incomes). Accordingly, increased participation in markets by smallholder farming households is an important strategy for better incomes and possibly poverty escape and spells food security in developing countries (Heltberg & Tarp, 2001). Besides, increasing market participation was earlier underscored by Delgado (1998) as a key factor to lifting households out of poverty in African countries.

Developing country governments are directing effort to improve market access, expecting significant return in meeting Sustainable Development Goals (SDGs) of poverty reduction and zero hunger anticipated by 2030 (MFPED, 2016). Interventions aimed to increase market participation and product sales in Sub Saharan African countries are therefore major strategies that need to be addressed to take advantage of the projected increase in demand for agricultural products, especially livestock. For agro-based economies such as Uganda (80% agrarian), market development is crucial for the increasing population and urbanization. However, many households face a major constraint of inability to participate in markets, which makes it impossible to combat poverty. Despite Uganda government efforts to transform the agriculture sector, many farmers remain largely in subsistence farming with little level of commercialization. Lack of smallholder dairy market participation has been reported a major constraint to poverty reduction in Uganda (UBOS, 2016). Efforts to improve livestock products market sales are therefore paramount to the Ugandan economy as they lead to increases in productivity and sale (supply) of agricultural (livestock) products. Without the stated interventions, Uganda may fail to take advantage of the anticipated increase in demand for livestock products.

There is almost exhaustive literature on market participation in decades before 2010 including that by Woldemichael (2008), Bellemare and Barrett (2006), Staal and Ehui (2004), Ahmed et al. (2004), Ehui (2003), Muriuki and Thorpe (2001), Delgado (1998), Goetz (1992), Key et al. (2000), Holloway et al. (2005), Yigezu (2000), Muriuki and Thorpe (2001), Redda (2002), and Sadoulet and De Janvry (2000). These studies do not address dairy technology (type of breed) as an independent variable influencing market participation. However, technology (type of dairy breed) is a major influencing factor to participation decision and sales. Studies on relationships between dairy technology and participation are almost non exixtent. There are few studies in the decade after 2010, including; Chamboko et al. (2017) in Zimbabwe; Benyam et.al. (2016), and Berhanu et al. (2014) in Ethiopia, which have applied Heckman econometric models to address market participation objectives, these studies focus on volume and not on proportion or percentage sales, which affects intensity of participation somewhat differently. This study on milk market participation and technology relationships addresses the stated information gaps in order to contribute to the development policy interventions aimed to enhance smallholder farmers' milk market participation and improvement in the percentage of milk sales.

2. Methodology

2.1 Description of the Study Area

Uganda lies between latitude 4°12′ N and 1°29′ S; longitude 29°34′ E and 35°0′ N. It has a total land area of 241,551 square kilometers with a population of approximately 42.8 million (PRB, 2017). The average daily temperature ranges from 15-31 °C and an average annual rainfall range from 735-1863 mm/year. This type of climate allows generally good rains in most parts of the country that permit plenty of forage and water for livestock, which enables relatively high milk yield for much of the year. Seasonality in milk supply however, still occurs. The country's climate permits production of mixed breeds including locals and the high yielding breeds (crosses and exotics). The study was carried out in Uganda's three main milk producing regions (Southwestern, Central and Eastern).

2.2 Sampling Techniques

The study uses a secondary data set of Research on Poverty, Environment and Agricultural Technologies (REPEAT) household level survey project of National Graduate Institute for Policy Studies (GRIPS) and Makerere Uiversity for the year 2012. The survey aimed to identify agricultural technologies and farming systems with potential to contribute to increased agricultural productivity and reduced poverty in Uganda. The survey involved 91 communities (LC1s, which is the country's lowest administrative unit). Multistage sampling and purposive sampling procedures were used to select representative households for analysis. The dataset consisted of 916 households from which 282 households were purposively selected on the criterion that they had at least one milking cow per household, at the time of the survey (2012). The study further purposively selected five districts from each of the 3 milk producing regions (Southwestern, Central and Eastern) having the highest number of milk producing households out of six milk shades (regions). Households with missing information on variables of interest for this study were dropped to remain with a complete data set of 171 households for study. They included 61 h/h from eastern region, 55 h/h from south western and 51 h/h from central region.

2.3 Methods of Data Analysis

Data was analyzed using the Statistical Package for Social Sciences (SPSS) and STATA (Version 14) software. Two types of data analysis, namely descriptive and econometric (quantitative) statistics were used to analyze the data. Descriptive methods of data analysis included percentages, means, t-tests and chi-square tests. These statistics first examined and compared smallholder characteristics of milk market participants and non-market participants of selected dairy households. Econometric analysis applied the Heckman two-step selection model to examine the determinants of milk market participation and percentage of milk sales.

2.3.1 Theoretical Framework of the Heckman Model

An econometric model known as Heckman two-step estimation procedure was developed by Heckman (1979) to specifically correct for sample selectivity bias, in cases that would involve two decisions such as participation and intensity or degree of participation. In the case of the present study the decision to participate in milk markets can be seen as a sequential two-stage decision making process. Households make a discrete choice on whether to participate in milk markets or not, in the first stage. In the second stage, these households make continuous decisions on how much sell or what percentage or proportion of milk should be sold, based on the first decision to sell milk. This means that the first stage of the Heckman two-stage model is a 'participation equation', which attempts to capture factors that affect one's decision to participate in a given activity. This equation is then used to construct a selectivity term or variable known as the 'inverse Mills ratio'. This variable is then added to the second stage equation that explains factors affecting percentage or proportion of milk sales. The inverse Mill's ratio is a variable for controlling bias due to sample selection (Heckman, 1979). This therefore makes the Heckman (1979) two- step estimation procedures most appropriate for the study at hand.

After adding the Mills ratio to the milk sales equation, the equation is then estimated using Ordinary Least Square (OLS). For the participation equation to be confirmed, the coefficient of the 'selectivity' term has to be significant, meaning, the hypothesis that an unobserved selection process governs the participation equation. Moreover, including the said extra term, the coefficient in the second stage 'selectivity corrected' equation is unbiased (Zaman, 2001).

2.3.2 Model Specification

The two-stage Heckman procedure is written in terms of the probability of milk market participation, and marketed milk Percentage. To apply this model to the present study, the researcher tracked literature on empirical studies of selectivity models (Goetz, 1992; Key & Delgado, 1998; Holloway et al., 1999; Sadoulet & De Janvry, 2000; Nicholso, Heltberg, & Tarp, 2001; Staal & Ehui, 2004; Bellemare & Barrett, 2006).

Following procedure by selectivity models, determinants of smallholder dairy farmer decision to participate in milk markets and intensity or percentage of milk sales in Uganda, was considered as a sequential two-stage decision process. Firstly, households make a discrete choice on whether to participate or not (whether to deliver milk or not to milk collection centers). Secondly and conditional on farmer decision to participate, they make continuous decisions on what proportion or percentage of milk should be sold to collection centers.

In the first-stage, the standard probit model is used, following the random utility model as specified by Wooldridge (2002):

$$Y^* = x'\beta + \varepsilon_1$$
$$Y = 1 \text{ if } Y^* > 0$$
$$Y = 0 \text{ if } Y^* \leq 0 \tag{1}$$

Where,

Y^* = is a latent (unobservable) variable representing farmer's discrete decision whether to sell milk or not; x' = is a vector of independent variables hypothesized to affect farmer's decision to participate in the milk market; β = is a vector of parameters to be estimated which measures the effects of explanatory variables on the farmer's decision; ε_1 = is normally distributed disturbance with mean (0) and standard deviation of (δ, 1). It captures all unmeasured variables; Y = is a dependent variable which takes on the value of 1, if the farmers participated in the milk markets and 0 otherwise.

The probit parameter estimates do not show by how much a particular variable increases or decreases the likelihood of farmer market participation. For this reason, this study considered and reported the marginal effects of the independent variables on the probability of a smallholder dairy farming household to participate in milk markets. The variables determining level of participation are estimated using the second-stage Heckman selection model (Heckman, 1979). The Heckman selection equation is specified as:

$$Z_i^* = Wi\alpha + \varepsilon_2$$
$$Z_i = Zi^* \text{ if } Zi^* > 0$$
$$Z_i = 0 \text{ if } Zi^* \leq 0 \tag{2}$$

Where,

Z_i^* = latent variable representing the desired or optimal level of participation which is observed if $Z_i^* > 0$ and unobserved otherwise; Z_i = is the observed level of participation; W_i = vector of covariates for unit i for selection equation which is a subset of Z'; α = vector of coefficients for selection equation; ε_2 = random disturbance for unit i for selection equation.

3.3.3 Correction for Selection Bias in the Second Stage

The two equations (1 and 2) in the two-stage decision process 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. There are unobservable variables in the first stage, which influence occurrence of the second stage, causing correlation in the error terms of the two equations (1 and 2). If the two errors are correlated, the estimated parameter values on the variables determining the level of participation are biased (Wooldridge, 2002). Thus, we need to specify a model that corrects for selectivity bias while estimating the determinants of the level of participation. The analysis therefore needs to create in the first-step, a Mills ratio using predicted probability values obtained from the first-stage probit regression of the participation decision. The Mill's ratio is hence included in the second stage as one of the independent variables postulated to influence the level (percentage) of farmer participation to form a regression equation Thus, the level of participation equation with correction for sample selection bias becomes:

$$V\% = W_i\alpha + \lambda \left[\frac{\phi(W_i\alpha)}{\Phi(W_i\alpha)}\right] + \varepsilon_3 \quad (3)$$

Where,

$\phi(.)/\Phi(.)$ is the Mills ratio; λ is coefficient on the mills ratio; ϕ is the standard normal probability density function; Φ is the standard cumulative distribution function; ε_3 = is not correlated with ε_1, ε_2 and other independent variables. Under the null hypothesis; no sample selection bias; λ is not significantly different from zero; V% = is the level of participation (Percentage of milk sold per day).

Table 1. Description of the variables in the empirical models

Variable name	Description	Variable type	Variable measurement	Expected Sign	
				First stage	Second stage
Dependent variables					
Market participation	Milk market participation decision	Dummy	1 if household participated in the milk market, 0 otherwise	N.A	N.A
Percentages sales	Percentage of milk sale	Continuous	Percentage of milk supplied to the market out of the total household production	N.A	N.A
Explanatory variables					
Sex	Sex of household head	Dummy	1 if household head is male, 0 otherwise	+	+
Age	Age of household head	Continuous	Number of years	+/-	+/-
Education level	Educational level of head of household	Continuous	Number of years in school	+/-	+
Household size	Number of people in a household	Continuous	Number of people	+	+/-
Children less 6 years	Number of children in the household less than 6 years of age	Continuous	Number of children	+/-	-
Milk consumed	Average quantity of milk consumed	Continuous	Litres consumed by household per day	+/-	+/-
Land size	Total size of land holding of the household	Continuous	acres	+/-	+
Milk yield	Milk yield per household	Continuous	litres per household per cow per day	+	+
No. of lactating cows	Number of dairy lactating cows	Continuous	Number of lactating cows	+	+
Only Improved lactating cows	Ownership of improved lactating cows	Dummy	1 if household owned only improved lactating cows, 0 otherwise	+	+
Both local and improved	Ownership of both local and improved breeds	Dummy	1 if household owned both local and improved lactating cows, 0 otherwise	+	+
Access to information	Access to dairy information	Dummy	1 if household information, 0 otherwise	+	+
Bicycle	Ownership of a bicycle	Dummy	1 if household owned a bicycle, 0 otherwise	+	+
Motorcycle	Ownership of a motorcycle	Dummy	1 if household owned a motorcycle, 0 otherwise	+	+
Vet services	Access to veterinary services	Dummy	1 if household accessed veterinary services, 0 otherwise	+	+
Credit access	Access to credit for dairy production improvement	Dummy	1 if household accessed credit services, 0 otherwise	+	+
Nonfarm employment	Household head earning income from other sources	Dummy	1 if household had non-farm income, 0 otherwise	+/-	+/-

Note. Source: Author's definitions, 2018.

3.4 Model Evaluation and Testing for Regression Diagnostics

Regression diagnostics involve a number of tests that is checking the data for; normality, multicollinearity and heteroscedasicity before the model can be run for analysis

3.4.1 Testing for Normality and Log Transformations of Variables

To ensure getting unbiased estimates, continuous variables were tested for normality graphically using a histogram. Gujarati (1995) states that log transformation of numerical variables helps to eliminate skewness and kurtosis. All variables in the study that did not conform to normality assumption were transformed to fit a normal distribution (Appendix A).

3.4.2 Testing for Multicollinearity

Before running the Heckman two stage models, the exogenous variables were checked for existence of multicollinearity problems. A multicollinearity situation occurs when the explanatory variables display little variation and/or high inter-correlation (Maddala, 1992). This implies that if there exists an association between continuous independent variables, then a problem of multicollinearity is likely to occur. The test is done in order to conform to the regression requirement that the errors must be homogenous. Multicollinearity is measured by a value /statistic referred to as the Variance Inflation Factor (VIF). According to Green (1997), the threshold value of the VIF is 10 and that a highly positive value of the VIF indicates that there is significant Multicollinearity in the model. All variables included in the analysis gave values of the VIF less than 10 and tolerance values (1/VIF) greater than 0.1, therefore warranting further investigation. The higher the value of VIF (Xi) the more difficult or collinear the variable Xi is. As a rule, if the VIF of an explanatory variable is greater than 10, then a multicollinearity problem exists. Accordingly, the VIF (Xi) results in 2012 data set showed that the data had no serious problem of multicollinearity. This is because, for all the 17 (seventeen) exogenous variables, the values of VIF were less than 10. Therefore, all the exogenous variables were rightly included in the model (Appendix B).

3.4.3 Testing for Heteroscedasticity

Heteroscedasticity among explanatory variables was tested using Breusch-pagan/Cook-Weisbergin test. The null hypothesis for the test is that there is no heteroscedasticity among the variables (*i.e.* the variance among variables across the sample is constant or Homoskedasticity). If the heteroscedasticity test P-value is not significant, it implies that there is no problem of heteroscedasticity. If the p-value is significant it implies that there is a problem of heteroscedasticity among variables in the sample (*i.e.* variance among variables across the sample are not constant but vary). In this situation robust standard errors of the Huber/White/sandwich estimators of variance can be used to correct for possible heteroscedasticity of unknown form (White, 1980; Vella, 1998) such that the regression requirement that the errors must be homogenous is fullfilled. However, the heteroscedasticity test P-value was found not to be significant (*i.e.* P = 0.3004), implying that there was no problem of heteroscedasticity (Appendix C).

3. Results and Discussion

3.1 Socio-economic and Demographic Characteristics of Milk Market Participants and Non-Participants

Descriptive statistics (mean and t-test) for continuous household variables indicated that market participants and non-market participants had statistical significant differences at 1% level among four variables including milk yield in liters per cow per day, number of improved lactating cows, level of education and number of lactating cows per household. Variables with significant difference at 5% level, between participants and non-participants are; size of land size, quantity of milk consumed in litres per household per day and size of herd per household. The key features of the variables used in the study are shown in the Table 2.

Table 2. Mean Socio-economic characteristics of milk market participants and non-participants, 2012 production year

Variable	Market participants (n = 80)	Non-participants (n = 91)	t-statistic	p-values
Age (number of years)	52.1	53.8	0.705	0.4818
Education (years in school)	7.0	5.5	-2.616	0.0097***
Household size (No. of people in a H/H)	13.3	12.5	-0.923	0.3573
No. of children under 6 years of age	1.5	1.3	0.766	0.4448
Land size (acres)	16	8.8	-2.185	0.0303**
Quantity of milk consumed litres per H/H per day	0.5	0.3	-2.372	0.0188**
Milk yield in liters per cow/day	4.5	2.2	-4.811	0.0000***
No. of local lactating cows per H/H	1.7	1.5	-0.437	0.6629
No. of improved lactating cows per H/H	1.5	0.3	-5.406	0.0000***
No. of lactating cows per H/H	3.1	1.8	-3.003	0.0031***
Herd size per H/H	12.2	6	-2.424	0.0164**

Note. *, ** and *** significant at 10%, 5% and 1% respectively.

The average number of years spent in school by household heads was higher for market participants (7 years) compared to non-participants (5.5 years) and significantly different at 1% level. This implies that education had positive influence in the milk market participation (Benyam Tadesse et al., 2016). This outcome emphasizes the importance of education in enhancing participation decision as it attracts technology acceptance and uptake, which support market participation. Marenya and Barret (2007) found a strong and positive significant association between the education variable and market participation among smallholder farmers in western Kenya. Education increases skill and successful implementation of improved production, processing and marketing practices, which all increase product output and market participation. Significant mean difference in number of years spent in school between market participants and non-participants is reported among smallholder dairy value chain actors in Zimbabwe (Chamboko, 2017) and Benyam et al. (2016) and Berhanu et al. (2014) in Ethiopia.

Size of land in acreage owned by a household was higher for market participants (16 acres) than non-participants (8.8 acres) and registered significant difference between participants and non-participants at 5% level. This could have influenced the size of herd (12.2 heads) which participants had over non-participating households with half the number (6 heads of cattle).

Quantity of milk consumed by households per day was higher for participants (0.5 litres per day) than non-participants (0.3 liters per day) and significantly different at 5% between the two groups. This emphasizes the nutritional effect that households with more milk output (higher yields) consumed more quantities of milk than those with reduced milk yields.

The average milk yield for market participating (4.5 liters per cow) and non-participating (2.2 liters per cow) households was significant at 1% level. Those with higher yields are likely to participate in milk markets implying that milk yield is positively associated with market participation. Depending on the number of lactating cows a household has, a higher yield facilitates higher milk output and marketable surplus. The association could also be that income from sale of milk enables participating households to access yet more yield increasing resources from the market, which further increases production of milk.

The average number of local lactating cows for market participants (1.7 cows) and non-participants (1.5cows) were not significantly different. However, ownership of improved lactating cows associated with milk market participation. Milk participants had more improved lactating cows (1.5) compared to non-participants (0.3) and the difference in average number of lactating cows between the two categories was statistically significant at 1%.

Size of herd was positively associated with participation in that milk participants had more than twice (12.2 heads) than heads of cows owned (6 heads) by non-participants and significantly different at 5% level. Participation yields income which can be re-invested to acquire more assets especially livestock.

These results suggest that milk market participation is directly associated (influenced) by milk yield, number of improved lactating cows, number of lactating cows per household, education of dairy farmer, size of herd per household, quantity of milk consumed by a household per day and size of grazing land a farmer has.

Variables that were not statistically different between the participating and non-participating households were age of household head, household size, number of children less than 6 years of age and number of local lactating cows owned. The average age was 52.1 years for participants and 53.8 years for non-participants, while size of household was averagely 13 for market participants and 12.5 for non-participants. Each category had less than 2 children below 6 years.

The Chi-square test results for categorical variables (Table 3) show that type of milking breeds owned, access to information and access to veterinary services were statistically significant (1%) between market participants and non-market participants. Results show an association between type of breed and participation in that among participants, majority (45%) had improved breeds, followed by those with only local breeds who were 38.75%, whereas majority of households that did not participate in the milk market kept only local breeds (79.12%). The implication of these results is that households that keep improved breeds are more likely to participate in milk marketing than those keeping local or both types of breeds (mixed breed category). Participating households with access to veterinary services were 31.25 % while only 14.29% of non-participating households did not access veterinary services. Those who access veterinary services are more likely to receive technical knowledge for improved productive performance leading to higher yields and hence surplus milk which precipitates participation decision and market sales.

Information access was associated with participation at 1% level. Approximately 94% participants accessed information while non-participants who accessed information were 79.12%. This implies that household with access to information were more likely to participate in the milk market than those without access. Dairy farmers who access information are able to make better marketing arrangements for their products and even reduce on transaction costs in milk marketing.

Table 3. Proportion of socio economic characteristics of participants and non-participants

Variable	Market participants (n = 80)	Non participants (n = 91)	Chi-square value	p-values
Sex				
Male	91.25	93.41	0.2819	0.595
Female	8.75	6.59		
Marital status (Married)	90.00	87.91	0.1879	0.665
Transport assets				
Bicycle (Yes)	71.25	65.93	0.5568	0.456
Motorcycle (Yes)	25.00	10.99	5.7773	0.016**
Moto vehicle (Yes)	7.50	1.10	4.4432	0.035**
Milking breeds				
Only local	38.75	79.12		
Only improved	45.00	16.48	29.1452	0.000***
Both local and improved	16.25	4.40		
Institutional factors				
Access to information (Yes)	93.75	79.12	7.5515	0.006***
Veterinary services (Yes)	31.25	14.29	7.0886	0.008***
Non- farm income (Yes)	48.75	32.97	4.4061	0.036**
Credit (Yes)	77.50	74.73	0.1798	0.672

Note. *, ** and *** significant at 10%, 5% and 1% respectively.

Ownership of a motor vehicle and non-farm income were significantly associated with milk market participation at 5% level. Percentage of households with a motor vehicle was higher for market participants (7.5%) campared to non-participants (1.1%). This shows that a motor vehicle is an important transport asset among households as it facilitates access to various markets and distribution of greater milk sales despite the fact that motor vehicles were owned by very few households (less than10%). Majority of the households owned bicycles (71.25% for participants and 65.93% for non-participants). This shows the importance of bicycles in smallholder dairy farming although the chi-square test shows that bicycle ownership has no significant relationship with market participation.

Other variables with Chi-square values showing no significant difference between participants and non-participants in milk marketing were sex of the household head, marital status and access to credit. Male headed households however, dominate smallholder dairy farming *i.e.* 91.25% among participants and 93.41% among non-participants. Marital status had no significant relationship with milk market participation, although majority of respondents (participants and non-participants) were married.

Table 4. Milk market participation behavior of dairy farming households

Characteristics	**2012(n = 171)**
Milk market Participation	
Yes	46.78%
No	53.22%
Daily production per household	8.2 litres
Daily milk yield per household	3.26 litres
Volume sold by households per day	4.2 litres
Proportion of milk sold per day	0.61
% milk sold per day per household (level of participation)	61%

Out of 171 households, 46.78% of the smallholder dairy producers in 2012 data were classified as market participants and the remaining households (53.22%) did not participate in selling milk. Daily milk yield was 3.26 litres per cow. Daily milk production was 8.2 litres per day on average, market participants sold 4.2 litres of milk per day with percentage participation of 61% of the daily milk production. These results imply that smallholder dairy producers in Uganda still need support to increase their involvement in milk marketing and increase milk market sales for dairy sector development.

3.3 Factors Affecting Milk Market Participation by Household Derived From 1st Stage (Probit) Heckman Model

The analysis first tested for model fitness or reliability and appropriateness whereby the first stage probit model was estimated by maximum likelihood method using data obtained. The Log-likelihood Ratio (LR) for this model was highly significant at the 1% level (Prob > chi2 = 0.0000) (Table 5). This is an indication that all the explanatory variables included in the model jointly influenced households' likelihood to participate in selling milk. A pseudo R^2 of 0.30 shows that the model has a good fit to the data (Table 5). Based on the above measures for model reliability and appropriateness (*i.e.* goodness of model fitness), we conclude that the probit model employed was reliable and appropriate.

Results show six (6) variables that significantly explained the likelihood of milk market participation by households in Uganda's major milk producing regions (Southwestern, Central and Eastern). The most important variables include a household having only improved lactating cows (1%), number of lactating cows owned by a household (1%), milk yield in liters per cow per day (1%), information access (5%), access to veterinary services/animal health (5%) and a family having children less than 6 years (10%).

As hypothesized, household having only improved lactating cows had a significantly higher likelihood to participate in the milk market compared to households with only local lactating cows at 1% level. Households with mixed milking breeds (local and improved breeds) also had a significantly higher likelihood to participate in the milk market compared to households with pure local lactating cows at 10% level. According to Benyam et. al. (2016) and Woldemichael, (2008), improved dairy breeds facilitate market entry decision of a household because they are high yielding compared to local breeds leading to availability of milk marketable surplus. Thus availing improved cows alongside local cows is an important policy relevant variable in stimulating the smallholder to market entry.

Contrary to prior expectations number of children less than 6 years in a household had a positive and significant effect on the households' likelihood to participate in the milk market at 10% level. An increase in number of children in a household is likely to increase household expenditure hence children are a driving factor for a household to participate in the milk market. Berhanu et al. (2014) hypothesized number of children less than six years of age in a household to negatively influence market participation with an argument that there is competition between milk for child requirement and amount needed for market; however the variable was not found significant contrary to findings of this study.

Table 5. Marginal effects for determinants of probability of milk market participation

Variables	Coef. (Std. Err.)	dy/dx (Std. Err.)	P > z
Sex of household head	-0.3342(0.4647)	-0.1314(0.1774)	0.459
Age of household head	0.0019(0.010)	0.0007(0.0040)	0.853
Education level	0.0115(0.0328)	0.0045(0.0131)	0.727
Household size	-0.2723(0.3129)	-0.1086(0.1248)	0.384
Children less 6 years	0.4687(0.2902)	0.1841(0.1107)	0.096*
Milk consumed	0.0121(0.0950)	0.0048(0.0387)	0.901
Total Land size	-0.1074(0.1371)	-0.0429(0.0547)	0.433
Milk yield	0.1812(0.0683)	0.0723(0.0272)	0.008***
No. of lactating cows	0.1955(0.0710)	0.07798(0.0283)	0.006***
Only Improved lactating cows	0.8611(0.2948	0.3261(0.1006)	0.001***
Both local and improved	0.8022(0.5020)	0.2955(0.1568)	0.060*
Access to information	0.8282(0.3932)	0.3080(0.1260)	0.014**
bicycle	0.1394(0.2547)	0.0556(0.1013)	0.583
Motor cycle	0.2156(0.3540)	0.0856(0.1394)	0.539
Veterinary services	0.5642(0.3129)	0.2195(0.1158)	0.058*
Credit access	0.1704(0.2732)	0.0678(0.1083)	0.531
Nonfarm employment	0.1871(0.2549)	0.0745(0.1012)	0.462
Constant	-1.8773(1.0081)		
Number of obs = 171			
LR chi2(17) = 71.80			
Prob > chi2 = 0.0000			
Log likelihood = -82.275563			
Pseudo R2 = 0.3038			

Note. *, ** and *** significant at 10%, 5% and 1% respectively.

Daily milk yield had a positive and significant effect on the household's decision to participate in the milk market at 1% level of significance. An increase in milk yield significantly increased the likelihood of that household to participate in the milk market as hypothesized. According to Berhanu et al. (2014) and Bardhan et al. (2012), a marginal increase in milk yield has an obvious and significant effect in motivating market participation.

Number of lactating cows had a positive and significant effect on a household's decision to participate in the milk market at 1% level, as prior hypothesized. The model output predicts that adding one more milking cow to a household significantly increases the likelihood of that household to participate in the milk market. As number of lactating cows increases, milk production per household increases which in turn increases percentage share of milk sales per household per day (Berhanu et al., 2014; Benyam et al., 2016; Chamboko et al., 2017).

Household access to information positively and significantly influenced the likelihood of a household to participate in the milk market as expected at 5% significance level. Farmers marketing decisions are based on market price information. Access to information leads to understanding of the workings of the market, information on prices, and other market information improves farmer decision to participate (Chamboko et al., 2017). Goetz (1992) showed that better market information significantly raised probability of market.

Access to veterinary services significantly influenced the decision of a household to participate in the milk market at 10% level of significance positively as hypothesized. It is expected that dairy farming households which have access to veterinary services have health sound dairy animals and also widen the household's knowledge with regard to the use of improved dairy production technologies and this is likely to influence milk market participation decision of a household positively. According to Quddus (2013), and Dehinenet (2014) knowledge on improved technologies through training, availability of reliable and continuous technical assistance, increased and timely provision of medicine, increasing A.I facilities and strengthening extension services increased use of improved technologies among dairy households.

Contrary to earlier expectations, sex of the household head, age, household size, education, household size, average quantity of milk consumed per household per day, ownership of a bicycle, access to credit and possession of non-farm employment had no significant influence on the household's decision to participate in the milk market at 1%, 5% and 10% levels of significance.

3.4 Factors Affecting Milk Market Participation by Household Derived From 1st Stage (Probit) Heckman Model

Determinants of percentage of milk sales by smallholder dairy farmers were estimated using the second stage Heckman selection model (Table 6). The overall joint goodness of fit for second stage Heckman selection model parameter estimates was assessed based on Wald chi square test. The null hypothesis for the test is that all coefficients are jointly zero. The test indicates that the overall good fit for the model is statistically significant at 1% level of significance. This shows that jointly independent variables included in the selection model significantly explained the percentage of milk sales by the studied households.

The second stage Heckman model revealed five (5) significant explanatory variables influencing the percentages of milk sales out of 16 variables. The significant explanatory variables are; quantity of milk consumed per day by household (10%), Number of lactating cows (5%), improved lactating cows (5%), access to information (1%) and lamda (5%).

As hypothesized, number of milking had a positive and significant effect on the percentage of milk sales by a household at 5% level. This result suggests that marketable percentage of milk of the household in the study areas are more responsive to number of lactating cows kept by farming household. Studies by Holloway and Ehui, (2002) reported that milk production varies directly with the number of lactating dairy cows, as number of dairy cows increases, milk production also increases and percentage share of consumption declines and milk sales increases. Similarly Benyam et al. (2016), and Chamboko et al. (2017) reported a positive relationship between number of lactating cows and level of milk market participation in terms of volume of milk sold. Bardhan et al. (2012) study in India report that the milk output sold depends on resource ownership like land and animal holding and farmer specific variables.

Quantity of milk consumed per household per day had a negative effect on the percentage of milk sales by a household per day at 10% level. An increase in milk consumption by household significantly reduces marketable surplus and likely to negatively affect percentage sold. Many farmers in Sub-Saharan Africa remain at the subsistence level, with production activities mainly conducted for home consumption (Verheye, 2000). This leaves megre percentage sales hence the negative relationship as hypothesized.

Table 6. Heckman second stage results for percentage of milk sales by household per day

Variables	Coef.	Std. Err.	z	P>z
Sex	-2.9683	11.5766	-0.26	0.798
Age	-0.0226	0.2530	-0.09	0.929
Education	1.1198	0.8503	1.32	0.188
Household size	1.0384	8.5665	0.12	0.904
Children less 6 years	-2.2186	8.3972	-0.26	0.792
Qty of milk consumed	-3.6831	2.6030	-1.91	0.057*
Total land size owned	-3.2744	3.5054	-0.93	0.350
Milk yield	1.0126	0.9732	1.04	0.298
No. of lactating cows	2.8750	1.1356	2.53	0.011**
Improved lactating cows	21.5422	8.9809	2.40	0.016**
Both local and improved cows	10.7621	11.2838	0.95	0.340
Access to information	29.0842	10.4173	2.79	0.005***
Bicycle	7.7592	7.2270	1.07	0.283
Motorcycle	7.9457	8.8683	0.90	0.370
Veterinary services	-6.1328	7.7646	-0.79	0.430
Lambda	23.6122	11.3302	2.08	0.037**
Number of obs = 171				
Censored obs = 91				
Uncensored obs = 80				
Wald chi2(15) = 186.12				
Prob > chi2 = 0.0000				
Rho = 0.82908				
Sigma = 0.28480156				

Note. *, ** and *** significant at 10%, 5% and 1% respectively.

Access to information by household positively influenced the percentage of milk sold by household, at 1% level. Information access enables a famer to reach out to distant markets and locate milk demand areas. It also facilitates linkage with many milk buyers hence higher percentage sales. Goetz (1992) similarly reported a positive relationship between access to information by a household and level of market participation. However several studies: Chamboko et al. (2017); Berhanu et al. (2014); Benyam et al. (2016); and Holloway and Ehui (2002) hypothesized that market information is positively related to marketable surplus (Volume of milk sold) though not found significant.

Ownership of improved milking breeds significantly influenced the percentage of milk sales positively at 5% level. Households with improved breeds sold a higher percentage of milk per day compared to households with only local lactating cows. Improved dairy breeds are high yielding compared to local breeds leading to availability of milk marketable surplus (Woldemichael, 2008). Promotion of improved dairy cows significantly increases the intensity of milk market participation among smallholder dairy farmers.

Lambda coefficient of Mills ratio was positive and significant at 5% level, implying significant correlation of error terms in the 1st and 2nd stage of the heckman selection model. This signifies sample selection bias, existence of some unobservable farmer characteristics affecting likelihood to participate in the milk market and thus affecting percentage of milk sold. The correction for selectivity bias is significant justifying the use of stage 2 heckman selection model for analysis to estimate determinants of the milk participation decision and percentages of milk sales by a dairy household.

4. Recommendations and Conclusion

Smallholder dairy farmer drivers to milk participation include; ownership of improved lactating cows, number of lactating cows, milk yield, information access and access to veterinary services. Children tend to drive up family expenditures and this compels households to commercialize the dairy farming enterprise. Important variables to percentage of milk sales are information access, number of lactating cows and ownership of improved lactating cows but quantity of milk consumed negatively affects milk sales.

The study recommends important policy intervention instruments to enhance both smallholder milk market participation and percentage milk sales in Uganda. The study recommends; improvement of dairy technology in particular upgrading dairy breeds, empowering dairy farmers in accessing and use of more appropriate information and communication technologies. The study also recommends increasing numbers of lactating cows per household per year and improving on lactating intervals among smallholder dairy farming households. A review and extension of support to the existing dairy improvement program is recommended to specifically target the various dairy production systems and provide continuous training, veterinary services/animal health services and market access facilities (transport facilities, information *etc.*). Smallholder dairy producers are not fully commercialized and need increased support to intensify their involvement in milk marketing and milk sales for dairy sector development.

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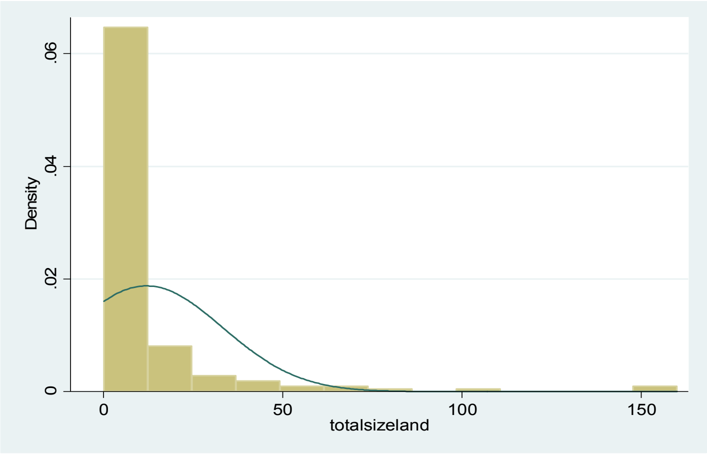
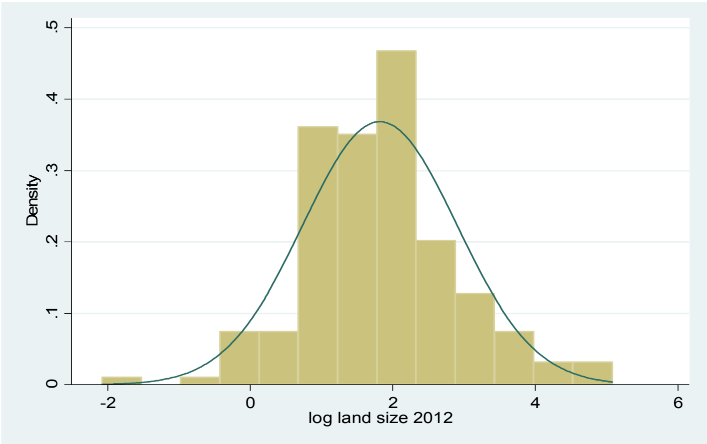
Appendix A

Testing for normality

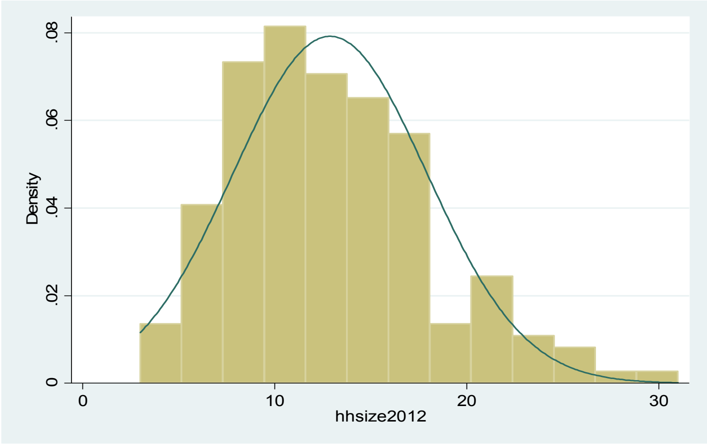
(1) Land Size



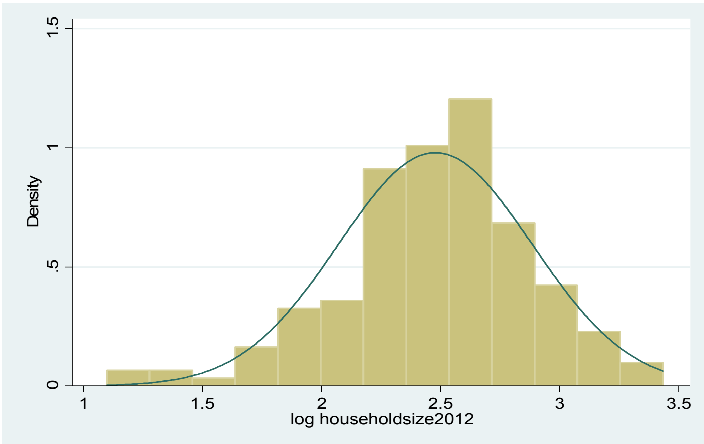
(2) Transformed Log Land Size



(3) Household Size



(4) Transformed Log Household Size



Appendix B

Variance Inflation Factor-STATA 14 results

Variable	VIF	1/VIF
loglandsize	1.79	0.557961
No. milk cows	1.44	0.696173
Age	1.40	0.713882
motocycle	1.38	0.724908
loghhsize	1.31	0.761149
onlyimprov~y	1.31	0.764821
qtymilkcon	1.30	0.769054
milkyield12	1.29	0.776559
veterinary	1.25	0.798067
local&impro	1.24	0.806466
education	1.23	0.814750
nonfarminc~e	1.23	0.814982
childless612	1.23	0.815589
sex2012	1.17	0.853571
information	1.14	0.876699
credit	1.11	0.898580
bicycle	1.11	0.898999
Mean VIF		**1.29**

Appendix C

Heteroskedasticity test

Breusch-Pagan/Cook-Weisberg test for heteroskedasticity-STATA 14 results

Ho: Constant variance

Variables: fitted values of percentage of milk sales

chi2(1) = 1.07

Prob > chi2 = 0.3004

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