Determinants Of Smallholder Dairy Farmers’ Volume Of Milk Sales In Uganda’s Agro-Ecological Zones

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Abstract

The study was undertaken with the objective of assessing determinants of volume of milk sales in Uganda’s agro-ecological zones. Out of the total dataset by the National Graduate Institute for Policy studies (GRIPS) and Makerere University in Uganda of (2005) 519 milk producing households, 271 small holder dairy farmers were purposively selected. Data were analyzed using Heckman two-stage selection econometric model. Major determinants of volume of milk sales were milk production per lactating cow per year (P = 0.000), ownership of transport facility (P = 0.001), distance to nearest market (P = 0.022), farmer living in a bimodal medium rainfall zone (P = 0.026) and presence of livestock improvement programme in area (P = 0.32). The Mill’s ratio was significant (P = 0.001). These variables positively and significantly influenced volume of milk sales and are critical to improved milk market sales.

Key words: Heckman model, milk sales, smallholder

I. Introduction

Improving livestock market sales is paramount to the Ugandan economy as it increases productivity and supply of agricultural (livestock) products, without which the anticipated increase in demand for livestock products may not be met. 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) also projected a 50% increase in per capita consumption of livestock products from 1993 to 2020. Factors leading to these increases are attributed to population growth, urbanization and rising incomes in developing countries. This rise in demand for livestock products has reflective proposition for market sales. The expected rising demand for livestock products especially dairy products, presents expanding market opportunities (including volume of milk sales, increased market information, market entry, entrepreneurship and incomes) among rural people in SSA, Uganda inclusive. This will enable smallholder dairy producers to realise better incomes and possibly escape poverty.

Uganda’s dairy industry is estimated to have contributed to more than 50% of the total output from the livestock sub-sector, making it the second major agricultural activity after cereal products in contributing to national GDP (RoU, 2004; Grimand et al., 2007, DDA, 2010; Balikowa, 2011). The dairy sub-sector is significant to the Ugandan economy contributing up to 45% to the livestock sector, about 9% of total agriculture GDP and about 3% of the country’s overall GDP. Dairying is strongly practiced in 42 districts of Uganda, found in the cattle corridor, which stretches from the South Western region through central to north eastern regions. It is an important source of food, income and
employment having over 2.5 million households (approximately 15 million people) in Uganda engaged in milk production. The dairy value chain employs various actors particularly in milk production, collection, bulking and transportation, processing, distribution and marketing as well as provision of inputs and support services (Balikowa, 2011). Milk production grew at an average rate of 4.9% per annum from 637.8 million liters per annum in 1999 to an estimated 1.08 billion liters per annum in 2010. This growth stems mainly from the increasing demand for milk and other milk products and establishment of milk processing plants in the producing areas, which derives from the increased demand for milk; better herd management and adoption of improved breeds; improved animal health and support services all of which lead to higher yields that in turn precipitate market participation (UBOS, 2008; FAO, 2011).

Smallholder dairy farmers must be enabled to benefit more from efficient markets and be more exposed to competition (World Bank, 2009) mostly through increased milk sales. This will transform the dairy sub-sector from subsistence to commercial production. Despite the rapid expansion of dairy production and inherent potential in the sector, it is still questionable whether smallholder milk producers who are majority (87%) livestock farmers and who characteristically keep low yielding; local cattle will be able to produce significant sales which will enable them take advantage of the high demand emerging marketing opportunities. One of the necessary conditions for the farmers to reap economic benefits from this sector is the availability of assured market outlets, which can only be sustained by large volume of milk sales by market participants and a more modern marketing infrastructure particularly in terms of transport and communications networks.

Inability of smallholder producers in Uganda to participate in markets and meet market demands are major limitations to harnessing opportunities in livestock production and marketing, yet, literature shows deficits in milk supply against surplus milk production in some regions of the country (Balikowa, 2011). Existence of such potential market calls for increased market participation drivers, which are not certain, hence, the need for a study to identify determinants of volume of milk sales. This will enable appropriate policy recommendation measures to be devised for promotion of increased volume of milk sales.

II. Materials and Methods

2.1 Description of the Study Area

Uganda lies between latitude 4 degrees 12’ N and 1 degree 29’ S; longitude 29 degrees 34’ E and 35 degrees 0’N. It has a total land area of 241,551 square kilometres with a population of approximately 31,369,979 (UBOS, 2008). 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 and prices paid to farmers fluctuate. 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 seven agro-ecological zones.

The seven agro ecological zones are broadly grouped according to economic and social backgrounds within them, and in which ecological conditions (soil types, topography, and rainfall), farming systems and practices are fairly homogeneous. These are often further split into sub-zones usually identified by such factors as similar crop combinations, size of holdings, average plot sizes and yields (MFP&ED, 1996, Statistical Abstracts, MFP&ED, June 1997). The zones include bimodal high (BH), bimodal medium (BM) and bimodal low (BL) rainfall zones, south western highlands (SWH) and Eastern highlands (EH), unimodal medium (UM) and unimodal low (UL) rainfall zones. This zoning was based on three main factors namely agricultural potential, rainfall pattern and market access according to Wood et al. (1999). Agro ecological zones (AEZs) provide consolidated information on
climate (including radiation, rainfall, temperature, and humidity), which helps to define the production potential of land for different types of (rain fed) agriculture.

Specifically, AEZs are often used to gauge the suitability of land for rain-fed cultivation, in general, as well as for the production of specific crops and rearing of different types of animals.

2.1.1 Bi-modal High (BH) rainfall Zone

In the BH zone, intensive banana-coffee farming is the dominant farming system. This area receives sufficient and evenly distributed rainfall to support perennial crop production (ranging between 1000 and 1500 mm per annum for 10 to 12 months of the year) and has the most favourable access to infrastructure and markets compared to other regions in Uganda (Deininger and Okidi, 1999). Because of its high population density, high urban population of relatively higher incomes, high market access and high agricultural potential, the BH zone has the highest economic potential among all rural areas in Uganda (Bashaasha, 2001; Sserunkuuma et al., 2001). It was used as a base zone to compare with other agro-ecological zones in economic and dairy market performance. Although livestock is generally not integrated into the system, dairy farming in particular, has gained prominence. Districts that make up the Bimodal High rainfall zone include; Kampala, Masaka, Luwero, Kibale Kiboga, Lyantonde and Sembabule, many of which also fall within the cattle corridor. In this study, this zone is used as a base zone to compare with other six agro-ecological zones in economic (and specifically market) performance.

2.1.2 Bimodal medium (BM) rainfall zone

Rainfall within this system is less stable compared to the BH zone or the banana-coffee system, so there is greater reliance on annual food crops (maize, some banana, millet and sorghum). In the drier areas, livestock is a main activity. The vegetation is moist Combretum/Terminalia/Butyrospernum savanna with moderate biomass production. The western region in particular, has more exotic and cross breed cattle per household than any other region in Uganda. Rainfall patterns are a strong determinant of cattle and dairy production strategies. Bimodal rainfall (October-November, March-May) in this zone allows generally good rains in these parts of the country, which increases output and avails surplus production for the market. The area has medium market opportunity in mostly crop products, but livestock products have gained prominence.

2.1.3 South western highlands (SWH) rainfall zone

The South Western Highlands are high altitude areas in Western Uganda, which receive low to moderate rainfall (600-1000 mm) and low temperature ranging from a minimum of 13-16°C to maximum of 27-28°C. Districts making up the SWH zone include Ibanda, Isingiro, Kiruhura, Part of Bushenyi, Ntungamo, Kisoro, Kabale, Kanungu, and Rukungiri (UBOS 2006; Charles-Lagu 2012). The climate permits mostly communal/pastoral livestock systems of low to medium productivity with a few crossbred animals.

Part of the SWH zone is found within the cattle corridor and has a total human population of 3,085,900 (UBOS, 2006). The cattle population in this zone is 1,689,605, comprising of the Friesian and Friesian crosses 50% (F1) and 75% (F2), Boran and Boran crosses and the Ankole cattle. Although the Ankole cattle are the most predominant breeds in this zone, extensive cross breeding of Ankole with Friesian breeds has taken place (MAAIF, 2009). The area has high - medium market opportunity in mostly livestock products (ghee and milk) due to increased urbanization and a concentration of milk cooling plants.
2.1.4 Eastern highlands (EH) rainfall zone

This zone receives the highest rainfall in the range of 1,229 mm- 1500 mm. Mixed breeds are kept but on a rather lower scale. Districts in EH zone include Mbale, Kapchorwa, the highland areas of Mt. Elgon and part of L. Victoria and Highland areas extending to Kenya. Rainfall in this zone is bimodal but the zone suffers low market opportunity of both crop and livestock products.

2.1.5 Unimodal medium (UM) and Unimodal low (UL) rainfall zones

In this study, the UL and UM zones were combined, because of the similarity in their agro-ecological conditions. The zones generally receive rainfall one season in a year. The lowest precipitation of 600-1,070m is experienced in the northern region. The zone receives about 800 mm annually and it is less pronouncedly bimodal with the far north and northeast of the country (Kotido and Moroto) receiving unimodal rainfall, which is too low (under 800 mm) and erratic to sustain crop (pasture) and milk production. Tobacco and cotton are major crops. Temperatures are quite high ranging from 28-34⁰c and even reaching 37⁰c. Unimodal low rainfall areas can only support low quality natural pastures with short grassland dominated by communal grazing. The dry season can be so severe that only drought tolerant annuals are cultivated, including finger millet (*Eleusine coracana*), simsim, cassava and sorghum (http://www.fao.org/ag/AGP/AGPC/doc. Accessed March 1, 2013). This area is well known for its pastoral system with semi-nomadic cattle herding. Cattle kept are predominantly indigenous and of poor lactation of only 300 liters per lactation on average. Cattle corridor districts with this type of rainfall include Gulu, Kotido, Moroto and North Western districts. Most of the livestock products in this area are for subsistence use due to low market opportunities in the face of an underdeveloped infrastructure (UBOS, 2008).

The West Nile system rainfall pattern resembles that of the northern system, with more rain at higher altitudes. Mixed cropping is common with a wide variety of crops and limited livestock due to the presence of tsetse fly. The system is in the sub-humid zone where the vegetation community is moist *Butyrospermum/Combretum/Terminalia* grassland.

2.2 Study design

This study used secondary data of 2005 obtained from RePEAT household survey data supplemented by review of literature from research reports (RePEAT Study Report, 2010), journal articles and related research and theses. The RePEAT survey data was from the RePEAT (*Research on Poverty, Environment, and Agricultural Technology*) project of the National Graduate Institute for Policy Studies (GRIPS) and the Faculty of Agriculture, Makerere University in Uganda which aimed at identifying agricultural technologies and farming systems with potential to contribute to increased agricultural productivity and reduced poverty in Uganda.

The survey involved 94 communities (LC1s, the lowest administrative unit) covering about two thirds of Uganda and representing seven of the nine major farming systems of the country. Within the study region, LC1s were selected using a stratified random sample, with the stratification based on development domains (16 in number) defined by the different agro-ecological and market access zones and differences in population density as proposed by Pender et al., (2001). From each of the 94 LC1s, 10 households were randomly selected for household surveys to make a total of 940 households. Out of these 519 households kept different breeds of cattle including local breeds, cross breeds and a combination of local and cross breed cows. From the 519 cattle keeping households, this study purposively selected dairy farming households which had at least one milk producing cow at the time of the survey to make a total sample of 271 households, of which, 202 households had local cows, 45 cross and 24 kept both local and cross breed cows.
From each farm of the 271 households, the study obtained information on three categories of variables; (i) household head characteristics (gender, age, education and household size as proxy for family labor); (ii) household head endowment of productive assets (land owned, breed type, credit access, herd size, number of milking cows, quantity of milk produced, ownership of transport) and (iii) community level characteristics (distance to major town, distance to nearest market, presence of livestock program in LC1 area, population density, proportion of market participation and five agro-ecological zones). Additional information was gathered from literature and reports.

2.3 Data Analysis

Data analysis was performed using STATA (Version 12) software. The determinants of milk market volume of sales were estimated using Heckman econometric model. The \( P \) –values at \( 1\% \), \( 5\% \) and \( 10\% \) were considered significant.

2.3.1 Conceptual or Theoretical Framework of the Heckman Model

This study applied the Heckman model to determine factors that affect volume of milk sales or level of participation in the milk markets. Theoretically, Heckman (1976) proposed a two-stage estimation procedure using the Inverse Mills' ratio (IMR) to take account of sample selection bias. In the first step, a regression for observing a positive outcome of the dependent variable (decision to participate) is modelled with a Probit model (equation 1: \( y' = \beta' x + u \)) The Probit model assumes that the error term follows a standard normal distribution. The estimated parameters in the Probit are used to calculate the Inverse Mills Ratio, (IMR), (i.e. the IMR is generated in the process of estimating the probit regression coefficients). The IMR is then included as an additional explanatory variable in the OLS estimation in the second step. A common application of the inverse Mills ratio (sometimes also called 'selection hazard') arises in regression analysis to take account of a possible selection bias. This factor qualified the Probit as opposed to the Logit procedure, which could not be used in the present study (i.e. it cannot take care of or accommodate the bias in sampling).

2.3.2 Estimation of the Heckman model (Two-step Selectivity Procedure)

The sample selection bias, or what Heckman (1979) refers to as the Inverse of Mill’s Ratio, is computed from the parameter estimates of the selection equation for each observation in the selected sample (Greene, 1993), and is represented by the formula below:

\[
\lambda = \frac{\phi(\beta' x)}{\Phi(\beta' x)}
\]

(5)

where \( \phi \) and \( \Phi \) are, respectively, the density and distribution functions

The level of sales, \( z \), specified in equation (6), is observed only if \( \beta' x + u > 0 \), (see equation1) and is estimated by ordinary least squares where the vector of inverse Mill’s ratio (\( \lambda \)) is included as an additional regressor.

\[
z = \gamma' w + \theta \lambda + \varepsilon_i
\]

Where \( \varepsilon_i \sim N(0,1) \)

The error terms of the market participation and the sales equation are correlated as the Heckman procedure assumes that the decisions pertaining to market participation and the amount of sales are interdependent. The correlation coefficient for the error terms \( u_i \) and \( \varepsilon_i \) is represented by \( \rho \) where, \( u_i \) and \( \varepsilon_i \) are bivariate and normally distributed (Greene, 1993).

\[
corr(u_i, \varepsilon_i) = \rho
\]

(7)
By incorporating the inverse Mill’s ratio as an additional explanatory variable in the sales equation, the second stage of the Heckman procedure corrects the sample selection bias.

2.3.3 Specification of the Two-step selectivity Procedure (Heckman Model)

The empirical model is then specified as:

\[ Z = \alpha + \gamma_1w_1 + \gamma_2w_2 + \gamma_3w_3 + \gamma_4w_4 + \gamma_5w_5 + \gamma_6w_6 + \gamma_7w_7 + \gamma_8w_8 + \gamma_9w_9 + \gamma_{10}w_{10} + \gamma_{11}w_{11} + \gamma_{12}w_{12} + \gamma_{13}w_{13} + \gamma_{14}w_{14} + \gamma_{15}w_{15} + \Phi\lambda + \varepsilon \]

Where \( Z \) = the dependent variable, which is quantity of milk sold (i.e. level of participation) and \( w \) are independent variables (determinants of volume of sales).

\( \alpha = \) Constant
\( \alpha \) and \( \beta \) are therefore parameters to be estimated
\( \varepsilon = \) the error term

The independent variables considered and which comprised of the following:

- \( w_1 = \) Gender (1= female, 0 = otherwise)
- \( w_2 = \) Age of household head in years
- \( w_3 = \) Education of household head
- \( w_4 = \) Access to credit (1=Yes, and 0 = otherwise)
- \( w_5 = \) Market distance (in miles)
- \( w_6 = \) Land owned (acres)
- \( w_7 = \) Ownership of transport facility (I= if household owns a bicycle, truck, pick up etc and 0 = otherwise)
- \( w_8 = \) Quantity of milk produced in liters per cow per day
- \( w_9 = \) Presence of livestock improvement breeding program (1 = if cross breed and AI and 0 otherwise)
- \( w_{10} = \) Bimodal Low (BL) rainfall zone (I= if household head lived in that zone and 0 = otherwise)
- \( w_{11} = \) Bimodal Medium (BM) rainfall zone (I= if household head lived in zone and 0 = otherwise)
- \( w_{12} = \) South Western (SWHs) Highlands zone (I= if household head belongs in zone and 0 = otherwise)
- \( w_{13} = \) Eastern Highlands (EHs) zone (I= if household head belongs in zone and 0 = otherwise)
- \( w_{14} = \) Uni-modal Medium (UM) rainfall zones (I= if household head lives zone and 0 = Otherwise)
- \( w_{15} = \) Inverse Mills Ratio (IMR)

\( \varepsilon = \) Error term to cater for variables not included in the model.

\( \phi \) and \( \Phi = \) the density and distribution functions respectively and where, \( \lambda = \frac{\phi(\beta'x)}{\Phi(\beta'x)} \)

To cater for identification of the equations in the second step of the estimation procedure (i.e. volume of milk sales), two variables (mobile phone and other communication equipment) are dropped in the second step of the Heckman model. The two variables theoretically influence the participation decision but not volume of sales. The analysis was performed using STATA (Version 12) software. The determinants of milk market volume of sales estimated using Heckman econometric model, probability values set at 1%, 5% and 10% were considered significant.
2.3.4 Apriori variable expectations on volume of milk sales (Table 1)

Gender of household head carries a negative sign in its expected effect on volume of sales due to the fact that women inherently front the food security objective of sustaining the household. This leaves less milk output for the sale. Makhura (2001) reported related responses about gender effects on market participation.

Age of household head was measured in number of years and was continuous in nature. This variable carries two signs (positive and negative). Older household heads owned improved (cross) breeds, which produced higher yields than local cows that were mostly owned by the majority of young people. Older people were therefore expected to have a surplus for the market. Young people may not have enough capital to invest in advanced technologies. They mostly kept local animals whose yield is characteristically low and diminishes quantity of milk produced and sold.

The level of education of a household head was hypothesized to have either a positive or negative relationship with volume of milk sold; A higher education enables a household head to access market and required technical information, which precipitate productivity, hence positively impact volume of milk sales. Makhura (2001) argues that education compels an educated farmer to access extension services more often than a lesser educated or without adequate training in animal husbandry. Those with advanced level of education (post secondary) however, tend to move out of the milk business into salaried occupations, abandoning the livestock keeping career which, results into a negative effect on volume of milk sales as hypothesized in this study.

Access to credit was hypothesized to positively influence volume of milk sales because credit enhances the household’s capacity to purchase inputs that could be invested in application of productivity enhancing practices such as purchase and use of improved pastures and management of improved breeds. Credit availability helps a household make additional business profit. As an asset credit positively influences volume of sales, which leads to business growth and expansion. Sserunkuuma D, Omiat G and Ainembabazi J.B. 2010 found that lack of credit is a major constraint to sustainable agricultural development because it deters poor farmers from using the needed purchased inputs that could be invested in land improvement that helps to increase yields and therefore profitability.

Land ownership is expected to positively affect volume of sales in that the larger the land owned the bigger is the grazing land and therefore the more the output that would compel farmers to seek market outlets. A hypothesized positive association of land owned and participation was also based on the findings by Ehui et al. (2009), which stated that physical capital including number of producing stock and farmland were the main factors influencing market sales. The variable of ownership of transport facility (bicycles, motorcycles and trucks) was expected to have positive effect on volume of milk sales. Ownership of transportation equipment mitigates transaction costs by reducing travel time to markets as well as the costs of transporting particularly bulky perishable products such as milk and bananas to the market by the farmer. Zaibet and Dunn (1988)

Distance to and from the nearest market is expected to be positively associated with high milk sales. The shorter the distance, the easier it would be for milk sellers to physically transport milk to selling outlets. Availability of market outlets is likely to also attract increased volume of sales. This is true in a study by Mamo et.al.(2014) who found that market distance from a household home in Oroma Regional state of Ethiopia, positively and significantly affected the probability of participation in value addition and volumes 1% level.

Presence of livestock improvement program (AI and Veterinary services) in area was expected to positively influence volume of milk sales. An improved livestock-breeding program is also expected to lead to increased animal productivity leading to surplus milk production and sales Livestock improvement programs (AI and veterinary services) in Uganda are conducted by extension service
providers in the ministry of Agriculture animal industry and fisheries (MAAIF) at district and sub country level or through the NAADS program (NAADS, 2009) in area. It was therefore expected that just as extension services; presence of the livestock improvement program in an area widens the actors (farmers’) knowledge and animal husbandry skills and hence positively impact on volume of sales.

Agro ecological zones and milk sheds in study area were analyzed for their effect on volume of milk sales using six milk-sheds or dairy regions that embody agro-ecological and milk production factors. Climate and technology are together known to positively or negatively affect the productivity of a given production system, which in turn affects market participation and sales (Ehui, 2009). The production potential of different agro –ecological regions has implications on market sales. This means that the effect of studied agro ecological zones on smallholder volume of sales is expected to vary across and within a given agro ecological zone. The Bi-modal Low (BL) rainfall zone was expected to influence sales positively; the Bi-modal Medium (BM) was hypothesized to positively influence volume of milk sales, while the Eastern highlands (EH), the South western highlands (SWH) and the Uni-modal Medium (UM) rainfall zones were expected to have no direction (i.e. positive or negative) in their effect on volume of milk sales.

Unimodal rainfall zone (which combined both Unimodal medium (UM) and low (UL) rainfall zone is at moderate elevation. It is prevalent in the Northern and Northeast region, especially, Kotido and Moroto region. The majority of are smallholder farmers mostly nomadic cattle herders producing milk mainly for household consumption. The proportion of marketed milk is quite low thus negatively impacting on participation and sales. Their negative impact is further constrained by low livestock incomes and poor infrastructure (DDA, 2009). Technologies that could be accessed are limited and this further depresses quantity produced and sold.

Milk producers in the different agro ecological areas use different means of dairy herd management, from pastoral and extensive systems to agro-pastoral and agricultural intensive systems (Grimaud et al., 2007). In the intensive systems, herds often include exotic cows, with a predominance of the Friesian-Holstein breed (Grimaud et al., 2004). The six dairy regions have significant differences in terms of milk production, cattle numbers, market dynamics, and dairy infrastructure, among other factors (DDA, 2004; Balikowa, 2011). These have largely been influenced by the dominant dairy production systems, with the North and Eastern regions (including Karamoja) lagging behind in terms of milk production. A significant share of the national milk production is from the Mbarara area, located in the Southwest milk-shed (DDA, 2004).

III. Results

Heckman’s second stage of estimation identifies the significant factors that affect volume of milk marketed surplus by using the selection model which included the inverse Mill’s ratio calculated from a maximum likelihood probit estimation of cow milk market participation decision. Of sixteen hypothesized variables in the selection equation of the model, seven variables were found to be significant determinants of the level of cow milk volume sales including inverse Mill’s ratio (LMBDA). They included Milk production per lactating cow per year (with P value of 0.000), ownership of transport facility (P = 001), distance to nearest market (miles), having p values = 0.022, household head belonging to the bimodal medium (P = 0.026), presence of livestock program (AI and Veterinary services) in area (P = 0.032) and variable of land owned (P = 0.000). The Inverse Mills ratio was highly significant at P = 0.001. The signs of all significant parameter estimates were positive and are consistent with prior expectations except for land owned variable, which was negative contrarily to the positive expected effect on volume of milk sales (see Table 1).

3.1 Discussion of Results
Milk production per lactating cow per day showed positive and highly significant effect on marketed milk volume (sales) at 1% probability level. Milk production (liters) had positive and highly significant effect on volume of milk sales. The greater the quantities produced per cow per day the greater the marketable surplus. The results are consistent with Kuma et al. (2014) whose findings indicated that the positive and significant relationship between the two variables indicate that milk yield per day per household is a very important variable affecting household’s level of participation (volume of sales). The significant and positive influence of milk production on marketed surplus of milk was also reported by Shah and Sharma (1993) and Omiti et al. (2007; 2009) used total quantity of milk produced per day as one of the determinants of level of participation and found the variable to have a positive influence on percentage sold, but only significant for the pooled sample from both the rural and peri-urban dairy farmers in Kenya.

Other factors kept constant, ownership of transport facility is a major factor which positively affects quantity supply (sales) at 1% significant level. This result is believable and suggests that marketable milk surplus of a household in the study area was more responsive to possession of a transport facility. Owning a transport facility tends to cut down on transaction costs that would be incurred by traders using public means, and it also brings the milk seller nearer to markets. It means that a farmer will load and sell greater volumes of milk to distant and better outlet markets, which are likely to offer a premium for bulk sales (Heltberg and Tarp, 2002). Analyses by Barret, 2008, Alene et al., 2008 and Sserunkuuma et al., 2010 conquer with previous findings that ownership of a transport facility increases quantity of agricultural products (amount of milk) transported to markets and reduces the cost of transporting products (milk) to a collecting centre along a tarred road or the point of sale or town centre. These studies also explain that transactions costs that have attracted most attention by analysts are those associated with transport, implying that ownership of transportation means increases food grains market participation and sales volumes through their effect of reducing travel time to markets to search for information and deliver goods. Sserunkuuma et al. (2010) in particular, report that ownership of transport equipment enhances market participation among female-headed households; recommending support to farmers to acquire transport equipment as a way of enhancing market participation and sales.

The variable of distance to nearest market (miles), had probability value of 0.022, showing a strongly significant and positive effect on milk sales as hypothesized. This stems from the fact that market linkage helps to cut down transaction costs and post harvest loss. Shorter distance to selling points implies that dairy farmers can easily be linked to buyers and processors through closer and regular market interaction, which attracts bulk sales and sale of inputs, increasing productivity in the long run. Closer linkage of farmers with buyers and processors also attracts organized product bulking (selling in bulk). The results concur with Eyoku (2013 and EADD, 2013) study findings that proximity to markets also provides ready market for milk since processors are attracted to come and take all collections from a known place or market. EADD, 2013 study confirms the observation that being close to markets makes it easier for farmers to acquire marketing and post harvest equipment (milk coolers, generators and other equipment) from processors at friendly and also credit terms to ensure increased production and sale of milk, quality and standardization.

The bimodal medium rainfall agro-ecological zone showed positive and strongly significant influence on volume of milk sold at 5% probability value., This zone geographically takes up much of the central and western regions, which have the highest numbers of improved (exotic and cross) breeds of cattle, good rains and are the major source of the surplus milk sold through various outlets in Uganda (DDA, 2008). This is evident in the high milk output, which ranges from 25 to 40 liters per cow per day which precipitate higher volume of milk sales. The bimodal rainfall zone experiences two rain seasons in a year of which the wet season permits plentiful forage, leading to increased production, other factors being constant, the rainfall pattern of this zone positively impacts farmers’ ability to produce a market surplus and the quantities sold.
As hypothesized, presence of livestock program variable had positive and strong effect on volume of cow milk sales. The strongly significant effect at 5% probability level is evidence that the extension services (AI and veterinary services) advice on cow milk production in the study area positively affected cow milk production and sales volume of cow milk marketed. It also stems from the idea that presence of the livestock improvement program in an area is likely to increase productivity and therefore quantity, leaving surplus for the market. These results relate with Holloway et al. (1999) earlier report of a positive and significant impact of extension visits on the percentage of milk output sold. We can here deduce that percentage output sold was probably more responsive to presence of a livestock improvement program in the area meaning that the livestock improvement program (artificial insemination and veterinary services) as a policy instrument could be more effective in increasing the smallholder dairy producers’ level of participation (volume of milk sales) in Uganda. Presence of the livestock program in a producing area can also act as an additional channel of relevant livestock information for increased returns to production and marketing, and as observed, companies often pay a small price premium and incentives for associated members (Duncan et al., 2007), attracting higher volume of milk sales.

The coefficient of the Mills Ratio (Lamda) was highly significant with probability value of 0.001, indicating sample selection bias, existence of some unobservable household characteristics affecting likelihood to participate in milk markets and thereby affecting volume of supply and hence sales. The significance of inverse Mills ratio λ is in the fact that sample selection bias would have resulted if the milk sales equation was estimated without consideration of the market participation decision.

The land owned variable effect on volume of sales contradicts apriori expectations as the sign bears highly significant but negative effect on volume of milk sales at 1% significant level. This finding however, coincides with findings by Staal et al. (2006) that the number of households producing milk for the market have been increasing especially in vicinity of urban areas with aid of purchasing pastures from other households or government holdings implying that the negative relationship could mean that milk market oriented dairy production does not necessarily require large land holdings. This further suggests growing demand for production and marketing of milk in the context of efficient pasture and fodder markets. Hayes et al. (1997), also found that households with security of land tenure invest in production (including marketing) technologies that result in high output and marketable surplus (sales); majority if any smallholder dairy farmers in Uganda do not have this tenure security, implying they cannot make such investments that can lead to surplus production, hence the negative effect by the land variable. Furthermore, Sserunkuuma, 2010 points out those production-enhancing factors such as security of land tenure of a household head were factors found to also have significant negative effects on transacted quantity sales. He suggested that policies that aim at encouraging secure tenure rights through land registration and provision of title deeds may improve the incentives for production of marketed surplus (Sserunkuuma et al. 2010). The negative relationship between land variable and volume of sales could also have stemmed from the probability that the majority of studied households owned local cattle that characteristically graze on communal lands, poor or low quality pastures which cannot yield marketable surplus. In fact Balikowa, (2010) noted that in Uganda, most local cattle keepers characteristically feed their animals on marginal lands, which, significantly reduces marketable surplus and discourages participation (saleable volumes).

IV. Conclusion and Recommendations

Interventions aimed at increased investment in smallholder household acquisition of private assets (own transport facilities, security of land tenure, cost reducing market infrastructure (better road network and markets) are key incentives for stimulating volume of milk sales. The study recommends upgrading of farm-to-market roads and establishes more and better equipped retail market centers in the villages in order to reduce transport costs and encourage distanced (rural) dairy farmers to produce and trade in
milk. A policy supporting dairy farmer tenure security through land registration and provision of title deeds is not far from improving the incentives for production of marketed milk surplus.

Also support toward an active or operational (presence of) livestock improvement programme (AI and veterinary services) through regular extension contact at village or parish level in milk producing zones (the bimodal rainfall zone) is critical to improving milk productivity and sales. The stated variables are policy variables and estimates of their responses in this analysis suggest that they can be used as policy instruments to increase volume of milk sales (i.e. smallholder dairy farmer level of market participation) in Uganda.

V. Acknowledgements

I acknowledge the support and technical input provided by my sponsors and the principal academic advisor (Professor Dick, Sserunkuuma).

Bibliography


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**Table 1: Regression estimates of the determinants of volume of milk sales**

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Expectation</th>
<th>Coefficient</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender of household head (1 = female; 0 = male)</td>
<td>-</td>
<td>-0.129 (0.243)</td>
<td>0.596</td>
</tr>
<tr>
<td>Age of household head</td>
<td>+/ -</td>
<td>-0.004 (0.006)</td>
<td>0.516</td>
</tr>
<tr>
<td>Education of household head</td>
<td>+/ -</td>
<td>0.018 (0.023)</td>
<td>0.439</td>
</tr>
<tr>
<td>Access to credit</td>
<td>+</td>
<td>-0.069 (0.186)</td>
<td>0.709</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Factor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to nearest market (miles)</td>
<td>+</td>
<td>0.308 (0.134)</td>
<td>0.022**</td>
</tr>
<tr>
<td>Ownership of transport facility</td>
<td>+</td>
<td>0.147 (0.194)</td>
<td>0.001***</td>
</tr>
<tr>
<td>Bimodal low rainfall zone</td>
<td>+/-</td>
<td>-0.189 (0.288)</td>
<td>0.512</td>
</tr>
<tr>
<td>Bimodal medium rainfall zone</td>
<td>+</td>
<td>-0.004 (0.241)</td>
<td>0.026**</td>
</tr>
<tr>
<td>Uni- medium/Unimodal low rainfall zone</td>
<td>–</td>
<td>0.003 (0.451)</td>
<td>0.995</td>
</tr>
<tr>
<td>South west highlands rainfall zone</td>
<td>+/-</td>
<td>-0.259 (0.257)</td>
<td>0.315</td>
</tr>
<tr>
<td>Eastern highlands rainfall zone</td>
<td>+</td>
<td>0.289 (0.487)</td>
<td>0.553</td>
</tr>
<tr>
<td>Presence of livestock program (AI and Veterinary services) in area</td>
<td>+</td>
<td>0.509 (0.237)</td>
<td>0.032**</td>
</tr>
<tr>
<td>Land owned</td>
<td>+</td>
<td>-0.371 (0.104)</td>
<td>0.000***</td>
</tr>
<tr>
<td>Milk production per lactating cow per year</td>
<td>+</td>
<td>0.001 (0.001) &amp; 0.000***</td>
<td></td>
</tr>
<tr>
<td>Inverse Mills ratio</td>
<td></td>
<td>0.135 (0.040)</td>
<td>0.001***</td>
</tr>
</tbody>
</table>

Key: +/- implies positive or negative hypothesized effect of the explanatory variable on the dependent variable. N/A: Two variables (ownership of mobile phone and ownership of other communication equipment) are dropped in the second step of the Heckman model.