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Acronym

DA	Development agent
GAC	Global Affairs Canada
LR	Likelihood ratio
PA	Peasant association
TLU	Tropical livestock unit
SNNP	Southern Nations, Nationalities and Peoples

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We are grateful to the Global Affairs Canada (GAC) for the financial support. We are also deeply grateful to the many farmers who patiently and willingly responded to our numerous questions.

Abstract

Smallholder dairy holds significant potential benefits for the rural population as a source of income, nutrients and employment opportunities. Although several studies have been conducted on smallholder dairy in Ethiopia, almost all of these studies focus on fluid milk market participation of rural dairy producers. However, the great majority of rural households involved in dairy production do not sell fluid milk. Butter is the most marketed dairy product. The extant studies are also based on two-step modeling framework, where the first stage is milk market participation followed by the second stage of intensity of milk market participation. Production decision is left out of the analyses. This paper uses two triple-hurdle models to analyse the determinants of Ethiopian rural households' decision in (1) milk production, butter marketing and volume of butter sales; and (2) milk production, purchased input use and intensity of purchased input use. Results are based on data set collected from 5000 households and 497 rural communities in the highlands of Ethiopia. We find that the number of milking cows per households is very small, with an average household engaged in milk production owning 1.40 lactating cows. Use of purchased inputs is low due to limited physical and economic access. Availability of feed stands out as an important factor influencing household decision to engage in milk production, indicating the dire need to develop feed resources in order to promote dairy production in rural Ethiopia. Milk production in rural Ethiopia seems to have an interesting and complex gender dimension. While female-headed households are less likely to be engaged in milk production, perhaps because of resource limitations, they are more likely to manage their dairy farms more intensively conditional on being milk producers. Female-headed households are also more likely to participate in butter selling, although they sell less than their male-headed household counterparts. Household milk consumption needs encourages decision to engage in milk production and input use, but detracts from butter marketing. Opportunity cost of factors of production matter in milk production, suggesting trade-offs between dairy production and some alternative sources of livelihoods. Marketing costs also matter in dairy production and marketing in rural Ethiopia. Distance to butter market discourages participation in butter marketing, while distance to livestock input market decreases probability of input market participation, suggesting for the need to develop market infrastructures for both dairy outputs and inputs. Clearly dairy producers in rural Ethiopia are facing liquidity constraints implying for credit facilities targeted at dairy production. Our results also indicate that market and profit orientation in dairy production in rural Ethiopia is low.

1. Introduction

Smallholder dairying holds significant potential benefit for the rural population as a source of income (Hoorweg et al. 2000; Kidoido and Korir 2015), nutrients (Hoorweg et al. 2000; Fulgoni et al. 2011; FAO 2013), and employment opportunities (Kaitibie et al. 2010; Beyene 2015). The sector also provides opportunities to improve the livelihood options of women (Quisumbing 2013; Johnson et al. 2015) since in most developing countries milking, processing and marketing of milk and milk products are the responsibility of women. For example, a study in Uganda showed that women contributed about 70% of the labour for dairy production (Makoni et al. 2013).

Dairy plays an important role in the Ethiopian agricultural sector and the national economy (Tegegne et. al. 2013). It is a source of livelihoods for a vast majority of the rural population both in terms of income and employment. Recent estimates indicate that there are about 55 million cattle, of which 55.4% are female animals (CSA 2014). The country is endowed with an estimated 12 million cows and favourable environment for dairy production (Tegegne et al. 2013; CSA 2016). The CSA survey further indicates that 2.8 billion litres of milk was produced in 2012/2013, out of which 42.3% was used for household consumption.

Despite its potential, the Ethiopian dairy sector is characterized by a large gap between its actual and potential contributions to national economy and the welfare of rural people in Ethiopia (Yilma et al. 2011). This emanates from a number of interrelated issues that include limited availability and low usage of improved dairy breeds and inputs (Duncan et al. 2013; Kumar et al. 2013; Makoni et al. 2013), low awareness of improved dairy management practices (Duguma et al. 2012; Mekonnen et al. 2010) and weak market linkages (Duncan et al. 2013; Makoni et al. 2013). National estimate shows that average milk yield per cow per day for indigenous breeds in Ethiopia stand at about 1.37 litres (Adane et al. 2015b). About 98.7% of the dairy cows in Ethiopia are local breeds which partly explain the low production and productivity of the sector.

Several studies have been conducted on dairy production and marketing in Ethiopia. To our knowledge, almost all of these studies focus on fluid milk market participation (Ahmed et al. 2004; Francesconi et al. 2010; Holloway et al. 2008; Kumar et al. 2013; Yigrem et al. 2008). Holloway et al. (2008) tried to assess the effect of fixed cost and time required for transporting milk to market on farmers' decision to sell milk. Kumar et al. (2013) posit that poor access to market and lack of improved dairy cows which affect the volume of milk production are important factors that limit farmers' participation in fluid milk market.

However, the great majority of rural households involved in dairy production do not sell fluid milk. More than 75% of milk producers in rural Ethiopia sell butter (Gebremedhin et al. 2014). Tegegne et al. (2013) also argue that attention needs to be given to Ethiopian rural households' behaviour in butter production and marketing. Input use for dairy production has also received inadequate attention in dairy research in Ethiopia. Hence, an understanding of household behaviours in milk production, input use and butter marketing can better inform policy and development practice to develop the Ethiopian rural dairy sector.

The aim of this paper, therefore, is to analyse the determinants of Ethiopian rural households' decision in milk production, input use and butter marketing. The effects of transaction cost factors, household and farm characteristics, institutional and infrastructural services, and prices are analysed. Two triple hurdle models are used. The first triple-hurdle model deals with household decisions to engage in milk production, butter marketing and intensity of butter marketing, while the second model deals with household decision to engage in milk production, input use and intensity of input use.

The paper is organized as follows. The next section presents the conceptual framework. Section three deals with our econometric modelling and estimation approach. Section four discusses households' milk and butter production, and butter marketing behaviour and practices. Section five presents household use of dairy inputs and feeding practices. Section six presents and discusses the econometric results. Section seven concludes the paper and presents implications.

2. Conceptual framework

Despite the multifaceted potential benefits that dairy production offers to smallholders, the sector remains severely underdeveloped, prompting several empirical questions related with feasibility, profitability, input supply and services, and market access conditions. Fueled by rising demand due to population and income growth, urbanization and changing food habits, prices of milk and milk products in Ethiopia have been rising over the last two decades. However, it has been observed that demand outstripped supply at any given price level. This paradox cannot be explained based on price analysis only. A broader look at the various nodes in the dairy value chain is needed. This paper, therefore, tries to answer three important questions in the dairy value chain in rural Ethiopia: (1) What factors determine household decision to engage in milk production? (2) What factors constrain or promote household decisions to engage in butter marketing and the intensity of participation in the butter[1] market? (3) What factors determine household decision to use modern dairy inputs and the intensity of use of those inputs?

Household and farm characteristics, transaction cost factors, community level variables including rainfall shocks, agro-ecological zones, and prices are hypothesized to influence household participation in milk production, butter marketing and the use of purchased dairy inputs. Hence, the triple-hurdle models are specified as functions of access to infrastructures, markets and services (tc), household characteristics (hc), farm characteristics (fc), asset endowment (ae), community level variables (cc), agro-ecological zones (az) and prices (p).

The following models are estimated.

$$milkprod = (\text{tc, hc, fc, ae, cc, az, p}) \quad (1)$$

$$buttermrket = (\text{tc, hc, fc, ae, cc, az, p}) \quad (2)$$

$$buttersuppl = (\text{tc, hc, fc, ae, cc, az, p}) \quad (3)$$

$$inputmarkt = (\text{tc, hc, fc, ae, cc, az, p}) \quad (4)$$

$$inputdemand = (\text{tc, hc, fc, ae, cc, az, p}) \quad (5)$$

Where *milkprod* is a binary indicator of whether a household is involved in milk production, *buttermrkt* is a binary indicator of whether household is involved in selling butter, buttersupply is the volume of butter the household sold, *inputmrkt* is a binary indicator of whether household used purchased inputs, and *inputdemand* is the monetary value of purchased inputs. Exclusion restrictions are possible, so not all explanatory variables may be included in each model (Burke et al. 2015).

The decision on volume of butter supply is preceded by two prior decisions of household's involvement in milk production, and the decision to engage in selling butter. Similarly, the household decision of how much purchased dairy input to use is also preceded by two prior decisions of household's involvement in milk production and the decision of whether to use purchased inputs. Hence, two triple-hurdle models (Burke et al. 2015), are used to estimate the parameters of the determinants of these sequential decisions.

1. We focus on butter marketing because few farmers are involved in fluid milk marketing in rural Ethiopia. Moreover, since almost all milk producers also produce butter, we did not need to estimate an equation for butter production decision.

3. Empirical models and estimation

3.1 Empirical model

Based on the conceptual framework described above, the triple-hurdle models are specified based on the hypotheses that milk production and participation in input/output market are determined by household characteristics ((age of household head ((age_i,agesqi), sex of household head ($hhsex_i$), education of household head[2] (edu_i), number of children less or equal to 5 years old ($childfive_i$)) and (labour supply ($labsup_i$)); asset endowment (physical assets excluding small and large ruminants ($hasst_i$), and non-farm cash income ($cash_i$)); farm characteristics (land ($land_i$), lagged number of small ruminants ($lagnsr_i$), lagged number of crossbred cows ($lagncrcow_i$), amount of crop residue produced ($cropresdu_i$), total milk production ($totmilk_i$) and total number of lactating cows ($nlactcow_i$), proportion of crossbred lactating cows ($prcrslactcw_i$)); household access to infrastructure, services and market (distance to town market ($disttwnm_i$), distance to district market ($distdsrtm_i$), distance to veterinary clinic ($distvc_i$), distance to livestock input market ($dislivinptc_i$), distance to development agent (DA) post ($disdpost_i$), whether the household accessed credit ($crdt_i$), whether there is supplier of bran in the peasant association (PA) ($branseller_i$), whether there is supplier of compound feed in the PA ($cfeedseller_i$), and whether there is supplier of hay in the PA ($hayseller_i$)); community level variables (population density ($popdens_i$), availability of grazing land per tropical livestock unit (TLU) ($tglpltu_i$), wage rate for off-farm employment for both male ($wagemale_i$) and female ($wagefemale_i$)); agro ecological zone of the community[3] ($azzone_i$)); shocks (occurrence of less than average rainfall ($rainshock_i$) and market prices ((lagged district price of small ruminants ($lagdsrpr_i$), lagged district price of butter ($lagdbuttpr_i$), relative price of maize with respect to butter ($pricemazbutr_i$) and relative price of teff with respect to butter ($priceteffbutr_i$)). We used zonal dummies[4] ($zone1_i$ through $zone9_i$) to control for any zone specific unobserved effects. Since specifications may vary by model and exclusion restrictions are possible, not all variables are included in each model.

The specifications of the two triple-hurdle models of milk production, butter market position and volume of butter sale; and milk production, purchased input use and input demand are given in equations 6–10 below. The specification for milk production ($milkprod_i$) equation is given in equation 6 below.

$$milkprod_i = f(age_i, agesq_i, hhsex_i, childfive_i, labsup_i, edu\_1_i, edu\_2_i, edu\_3_i, land_i, hasst_i, cash_i, lagnsr_i, lagncrcow_i, cropresdu_i, disttwnm_i, distdsrtm_i, disdpost_i, distvc_i, crdt_i, popdens_i, tglpltu_i, azzone\_d_i, azzone\_w_i, wagemale_i, wagefemale_i, lagdsrpr_i, lagdbuttpr_i, rainshock_i, zone1_i - zone9_i, u_{1i}) \quad (6)$$

2. Education of household head was classified into illiterate (edu_0i), 1–4 years of schooling (edu_1_i), 5–8 years of schooling (edu_2_i), and above 8 years of schooling (edu_3_i). We used illiterate as a base of comparison in our regression models.

3. We categorized the 10 agro-ecological zones we used for sampling purposes into three broad agro-ecological zones: below 1500 masl ($azzone\_k_i$), above 1500 but below 2300 masl ($azzone\_w_i$), and above 2300 masl ($azzone\_d_i$). We used the lower altitude agro-ecology as a base of comparison in our regression models.

4. Though the number of zones are 10, we only included nine dummy variables to avoid dummy variable trap. We used eastern Tigray as a base of comparison in our regression models.

The specification for butter market participation ($buttermrkt_i$) equation is given in equation 7 below. Amount of crop residue produced by the households ($cropresdu_i$), household access to grazing land ($tglpltu_i$), household access to veterinary clinic ($distvc_i$) and occurrence of negative rainfall shock ($rainshock_i$) are expected to affect household decision to participate in butter market through their effect on total amount of milk produced ($totmilk_i$). After controlling for total amount of milk produced by the household, these variables become conceptually irrelevant for market participation decision as such they are excluded from the model. Wage rate for off farm employment for male ($wagemale_i$) is also excluded from the market participation equation because conceptually it would be irrelevant once milk production decision had been made.

$buttermrkt_i = f(age_i, agesq_i, hhsex_i, chidfive_i, labsup_i, edu\_1_i, edu\_2_i, edu\_3_i, land_i, hasst_i, cash_i, lagnsr_i, lagncrcow_i, totmilk_i, disttwnm_i, distdsrtm_i, disdpost_i, crdt_i, popdens_i, azzone\_d_i, azzone\_w_i, wagefemale_i, lagdsrpr_i, lagdbuttpr_i, zone1_i - zone9_i, u_{2i})$	(7)

The specification for intensity of butter market participation ($buttersupply_i$) equation is given in equation 8 below. Distance to market town ($disttwnm_i$) is used as a proxy for fixed transaction cost and is hypothesized that it only affects the market participation decision but not the volume of sales. Thus, it is excluded from the intensity equation.

$buttersupply_i = f(age_i, agesq_i, hhsex_i, childfive_i, labsup_i, edu\_1_i, edu\_2_i, edu\_3_i, land_i, hasst_i, cash_i, lagnsr_i, lagncrcow_i, totmilk_i, distdsrtm_i, disdpost_i, crdt_i, popdens_i, azzone\_d_i, azzone\_w_i, wagefemale_i, lagdsrpr_i, lagdbuttpr_i, zone1_i - zone9_i, u_{3i})$	(8)

The specification for input market participation ($inputmrkt_i$) model is given in equation 9 below. Similar to butter market participation model above, wage rate for off farm employment for male ($wagemale_i$) is also excluded from the input market participation equation since conceptually it would be irrelevant once milk production decision had been made.

$inputmrkt_i = f(age_i, agesq_i, hhsex_i, childfive_i, labsup_i, edu\_1_i, edu\_2_i, edu\_3_i, land_i, hasst_i, cash_i, lagnsr_i, nlactcow_i, prcrslactcw_i, cropresdu_i, disttwnm_i, distdsrtm_i, disdpost_i, dislivinptc_i, distvc_i, branseller_i, cfeedseller_i, hayseller_i, crdt_i, popdens_i, tglpltu_i, azzone\_d_i, azzone\_w_i, wagefemale_i, lagdsrpr_i, lagdbuttpr_i, pricemazbutr_i, pricemazbutr_i, rainshock_i, zone1_i - zone9_i, u_{4i})$	(9)

The specification for intensity of input market participation ($inputdemand_i$) equation is given in equation 10 below. Distance to livestock input centre ($dislivinptc_i$) and availability of dairy input sellers ($branseller_i$, $cfeeddseller_i$ and $hayseller_i$) are used as a proxy for fixed transaction cost and are hypothesized that they affect only the market participation decision but not the volume of purchases. Thus, these variables are excluded from the intensity equation.

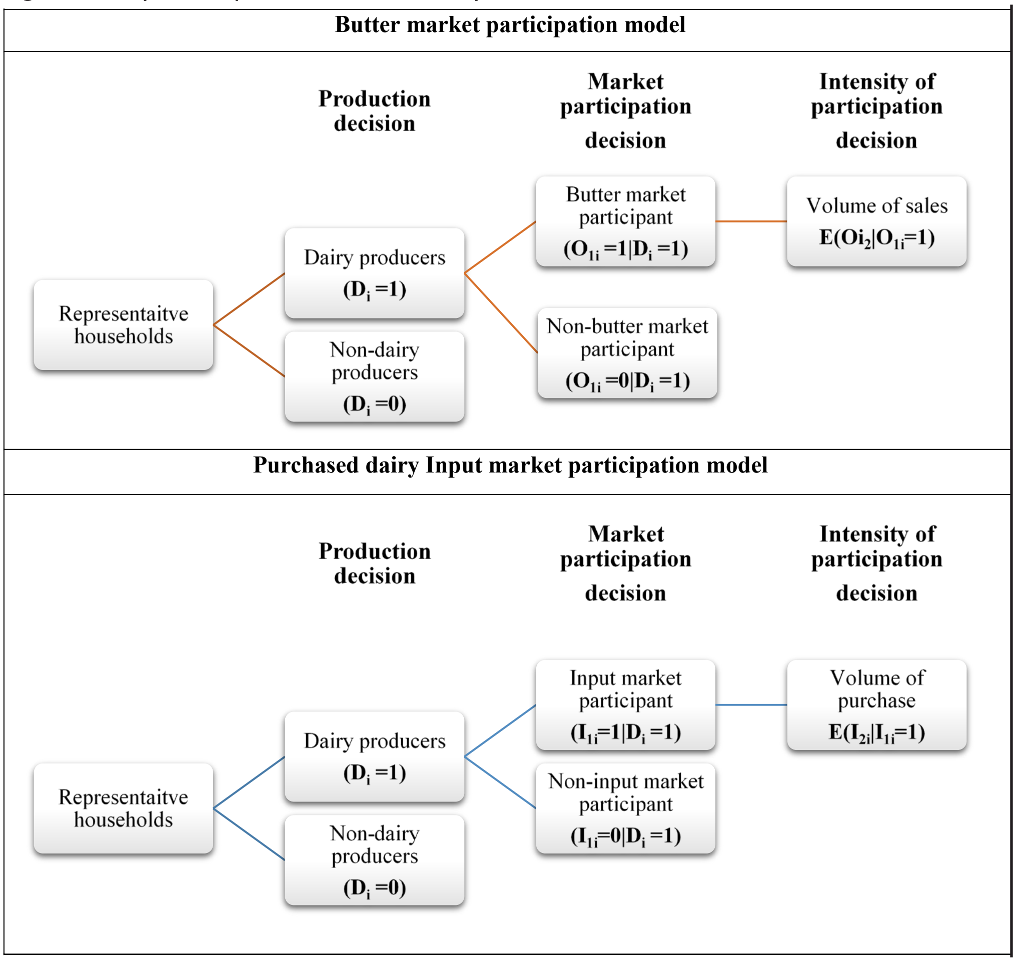
$inputdemand_i = f(age_i, agesq_i, hhsex_i, childfive_i, labsup_i, edu\_1_i, edu\_2_i, edu\_3_i, land_i, hasst_i, cash_i, lagnsr_i, nlactcow_i, prcrslactcw_i, cropresdu_i, disttwnm_i, distdsrtm_i, disdpost_i, distvc_i, crdt_i, popdens_i, tglpltu_i, azzone\_d_i, azzone\_w_i, wagefemale_i, lagdsrpr_i, lagdbuttpr_i, pricemazbutr_i, pricemazbutr_i, rainshock_i, zone1_i - zone9_i, u_{5i})$	(10)

3.2 Estimation

We develop two triple-hurdle models, one for household decision to engage in milk production and butter marketing, and another one for household decision to engage in milk production and input use. Input or output market participation decisions have traditionally been modeled as two-stage decision models, the first stage being decision on whether to participate in the market and the second stage on how much to participate (Goetz 1992; Bellemare and Barret 2006; Burke et al. 2015). Such modelling approach leaves out household decision to engage in the production of the commodity in the first place. The two-step models are, therefore, appropriate only if all households in the study population are involved in the production of the commodity. In the context where significant number of households do not produce the commodity, as is the case for dairy production in our study area, policies to influence market participation among producers may result in non-producers joining the producer set, thus rendering generalizations of results from the two-step models difficult to the whole population (Burke et al. 2015). Hence to analyse the determinants of household decision in the production and marketing of butter, and the decision of milk production and purchased input use, instead of the usual 'two-step' modelling framework including that of Cragg's (1971) double-hurdle model, triple hurdle approach as developed and elaborated by Burke et al. (2015) is used.

Market participation and intensity of participation in dairy output or purchased input use decision can be thought of as three-stage decision problem where clearance from the previous stage is required for each successive stages. The first stage is production decision (i.e. whether to engage in dairy production or not), followed by market participation decision (the decisions of dairy producers to participate or not participate in marketing the output or purchasing the input). Conditional on being a market participating producer, the third stage is the decision on intensity of participation (i.e. how much dairy output to sell or how much external input to purchase). The following graph summarizes the sequential decisions.

Figure 1: Graphical representation of the triple hurdle models.



The three-stage decision problem has three possible outcomes. Not engaging in dairy production (D_i=0), engaging in dairy production but not participating in input (output) market (I_{1i}=0|D_i=1 (O_{1i}=0|D_i=1)) and for market participating producers, the intensity of participation ($I_{2i}(O_{2i})$). Let W be explanatory variables and β be the respective coefficients, then the probabilities for the three possible outcomes are.

- $Pr(D_i=0) = 1-\Phi(W_{1i}\beta_1)$
- $Pr(I_{1i}(0_{1i})=0|D_i=1) = \Phi(W_{1i}\beta_1)-\Phi(W_{1i}\beta_1,W_{2i}\beta_2)$
- $E(I_{2i}(O_{2i}))$ =E(volume of purchase(sell)) $=\Phi(W_{1i}\beta_1)\Phi(W_{1i}\beta_1,W_{2i}\beta_2)*\exp(W_{3i}\beta_3+\sigma_3^2/2)$

Combining these outcomes and their respective probabilities gives the following likelihood function

$$\boldsymbol{l_i(\theta)}=1[D_i=0]\log[1-\Phi(W_{1i}\beta_1)]$$

$$+1[D_i=1]\,1[I_{1i}(O_{1i})=0]\{\log[\Phi(W_{1i}\beta_1)]-\log[\Phi(W_{1i}\beta_1,W_{2i}\beta_2)]\}$$

$$+1[D_i=1]1[I_{1i}(O_{1i})=1]\left\{\begin{matrix}\log[\Phi(W_{1i}\beta_1)]+\log[\Phi(W_{1i}\beta_1,W_{2i}\beta_2)]\\ +\log(\phi\left[\frac{\log(I_{2i}(O_{2i}))-W_{3i}\beta_3}{\sigma_3}\right])-\log\sigma_3-\log(I_{2i}(O_{2i}))\end{matrix}\right\}$$

Where, Ø(.) is the standard normal density function, Φ(.) is standard normal cumulative distribution function, β_1 are the parameters on W_1 in the first stage, β_2 are the second stage parameters on W_2, and β_3 are the third stage parameters on W_3. Finally, σ_3 is error variance parameter.

The models can be estimated simultaneously via maximum likelihood method or separately using Heckman's (1979) method. However simultaneously estimating the model would allow us to easily calculate the predictive margins and partial effects of explanatory variables. Stata 14 (Stata Corp. 2015) is used to estimate the model coefficients and parameters.

We used wage rate for off-farm employment, which measures alternative use of households' labour time to identify the butter market participation equation, because alternative use of time only affects the decision of whether or not to engage in dairy production, and becomes conceptually irrelevant after the production decision has been made. Distance to market town is used to identify the butter market participation intensity equation since distance to market measures fixed transaction costs which should not affect volume of sales.

Similarly, wage rate for off-farm employment was used to identify the input market participation equation for the same reason given above. Distance to livestock input supply centres and availability of input supplier in the village are used to identify the input market participation intensity equation, since these variables measure fixed transaction costs of accessing markets and are expected to affect the decision on market participation, but not the intensity of participation (Goetz 1992).

4. Butter production and marketing practices

4.1 Milk production and marketing

The number of milking cows per households is very small. In our sample the average number of lactating cows is 0.44 ± 0.77 cows (0.03±0.22 for crossbreeds and 0.47±0.79 for locals). Among those who have lactating cows, a typical household owns 1.40± 0.76 cows (0.09±0.38 crossbreeds and 1.31±0.78 locals).

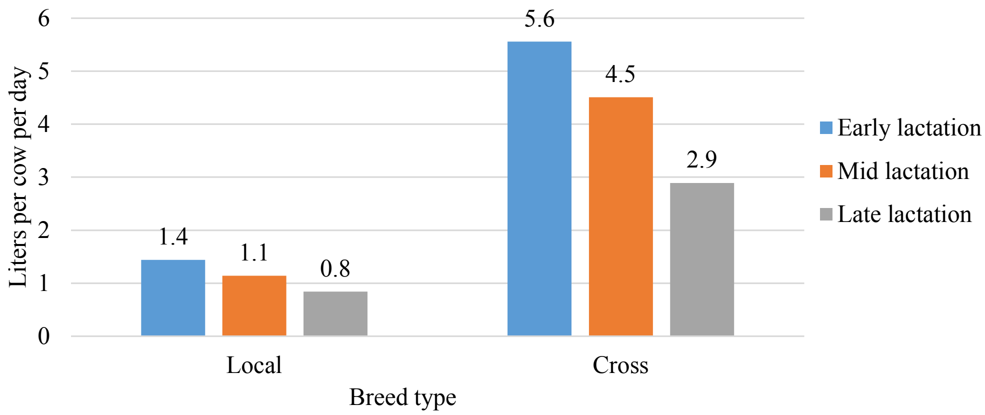
Table 1: Number of lactating cows per household

	Breed type	Mean	Std. dev.	Quartiles		
				P25	Median	P75
Total sample (N=5004)	Local	0.44	0.77	0	0	1
	Crossbreed	0.03	0.22	0	0	0
	Total	0.47	0.79	0	0	1
Milk producers (N=1669)	Local	1.31	0.78	1	1	2
	Crossbreed	0.09	0.38	0	0	0
	Total	1.4	0.76	1	1	2

Source: LIVES baseline data 2014.

As expected milk yield from crossbred cows is higher than that of local breeds. For example during the early lactation, milk yield from crossbred cows is about four times that of local cows. As expected, milk yields decreases with lactation period, with the highest during the early lactation period (birth to 3 months) and the lowest during the late lactation period (6–9 months) (Figure 2.).

Figure 2: Milk yield by lactation seasons.



Source: LIVES baseline data 2014.

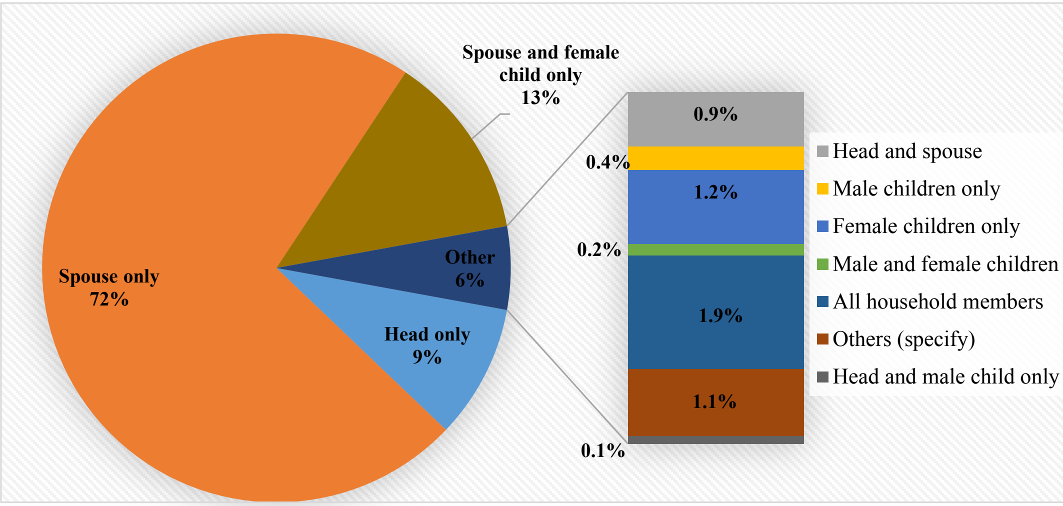
On average, a household with lactating cows produces about 325 litres of milk per year. Among those household who keep local lactating cows more than 60% reported that spouses are responsible of milking, while 15% of households reported that household heads are responsible for the milking. Similar overall trend is observed in households with crossbred cows, although smaller proportion of households reported that spouse are responsible for milking crossbred cows (40% compared to 61%). The proportion of household heads, in the households with crossbred cows, involved in milking was the same (15%) as in the households with local cows. Crossbred cows yield significantly more milk which increase milking time and it seems that other household members tend to share the responsibility.

About 68% of the milk produced by sample households is processed into butter, while only about 2% is sold as fluid milk. Interestingly, about 29% of the milk is consumed in the household. Since butter has longer shelf life, processing milk into butter is a rational response for households with market access difficulties. Only about 4.1% of milk producing households sold fluid milk.

4.2 Butter production and marketing

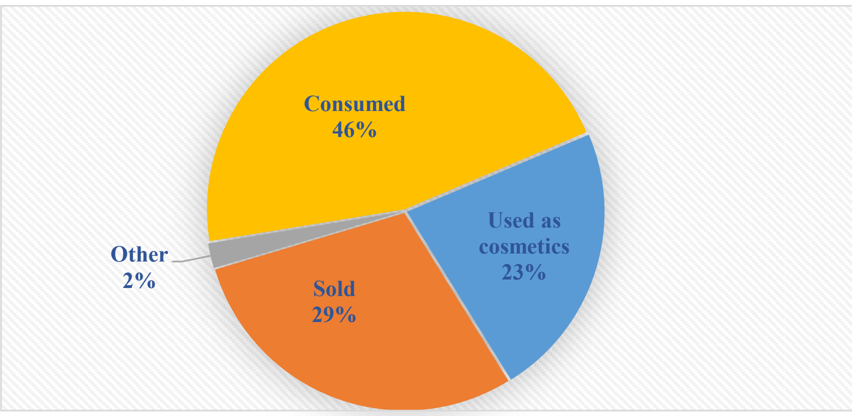
About 94% of milk producers produce butter. Butter production primarily the responsibility of female household members. Our data show that either spouses only or spouses and female children are responsible for processing milk in 85% of butter producing households, using traditional method and equipment.

Figure 3: Responsibility of processing milk into butter.



Butter producing household on average produced 8.9 ±10.12 kg of butter during the production year and about 46% and 23% is consumed at home and used for cosmetics, respectively. Only about 29% of butter produced is sold.

Figure 4: Butter use pattern.



Source: LIVES baseline data 2014.

The majority of butter producers (52.8%) participate in butter market. On average, butter selling household earns about ETB 639.82±816.9 by selling 6.11±7.2 kg of butter (Table 1).

Table 2: Income from butter sales (ETB)[5]

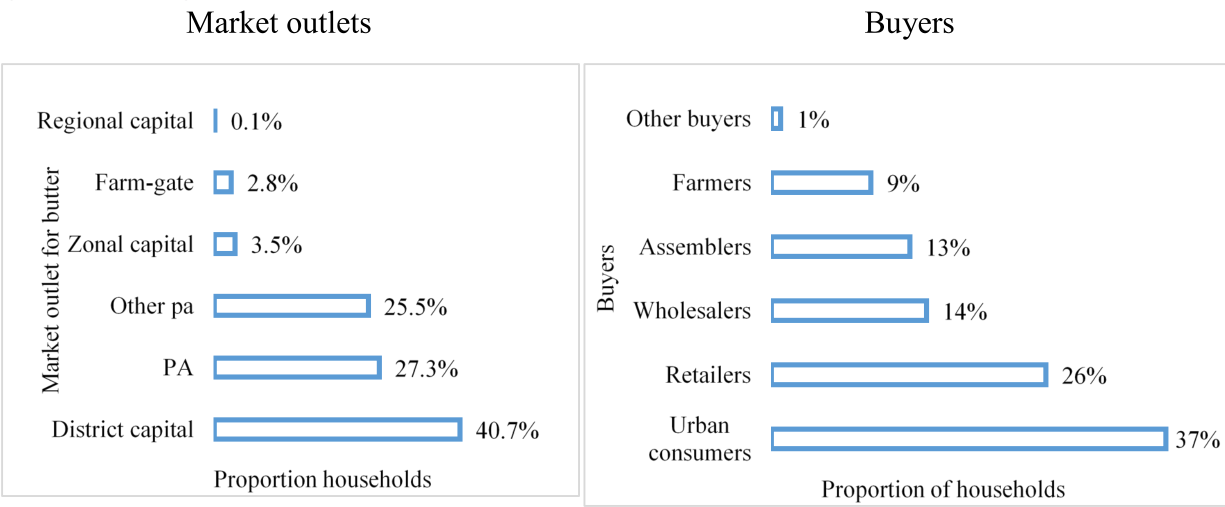
Butter marketing	N	Mean	Std. dev.	Quartiles		
				P25	Median	P75
Total amount of butter sold (kg.)	827	6.11	7.2	2	4	7.36
Price of butter (ETB/kg.)	827	103.38	24.7	85	100	120
Total revenue from selling of butter (ETB)	827	639.82	816.9	202.5	388.2	720

Source: LIVES baseline data 2014.

As expected butter selling is mainly the responsibility of women. About 82% of butter selling households reported that only spouses are responsible for selling butter. About 13% reported that household heads are responsible for selling butter. Interestingly, however, only 57% of butter selling households reported that spouses control income generated from butter sales. About 29% reported that income is controlled jointly by the husband and the wife, while 14% reported that only the household head controls the income. This results show that women have fair amount of control on income from butter sales.

District capitals followed by markets in the PA (rural kebeles) are important market outlets for butter, accounting for about 40.7% and 27.3% of the total butter sold respectively (Figure 5). Results also show that urban consumers are the primary buyers, which account for about 37% of the total butter sold followed by retailers (26%) (Figure 2).

Figure 5: Marketing of butter.



Source: LIVES baseline data 2014.

Farmers commonly produce local cheese (ayib) from butter milk. Our data show that out of those who process milk into butter, about 57% (891 out of 1566) produce local cheese. These households, on average, produced 17.7 ± 19.9 kg of local cheese. It seems that the local cheese is mainly produced for home consumption as almost, 93% of the produced, is consumed at home. Only about 4% of the local cheese produce is sold.

4.3. Extension services on improved dairy production

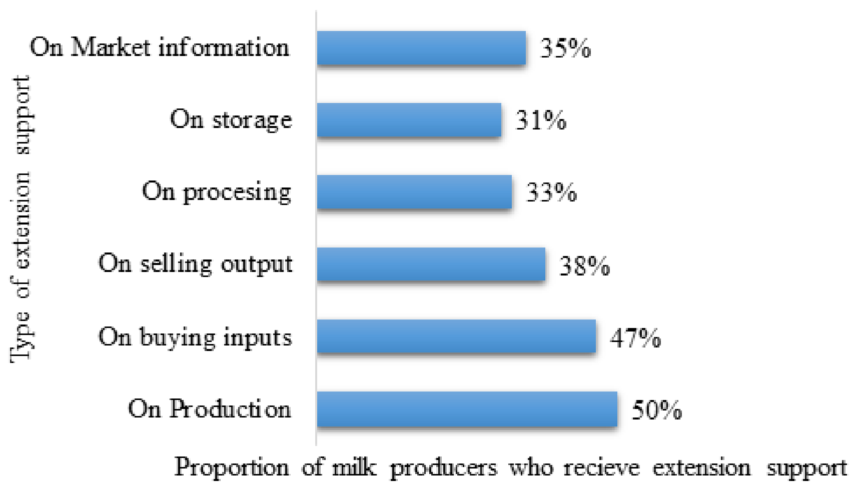
We asked farmers about the services they receive from the extension service. We categorized the extension services into three: (1) supply of information and advice, (2) training and skills development, and (3) facilitation of linkages with markets and services. This section presents descriptive results of the status of dairy extension service.

5. During the survey period USD 1 = ETB 19.

About 50% of our respondents received information/advice on improved dairy production practices and technologies during the year, while about 47% and 38% received information/advice on buying inputs and selling outputs, respectively (Figure 6). About 35% of producers also reported having received information and advice on prices for various dairy inputs and products. The main sources of market information are development agents, reported by 74% of the households and PA administration (11%). A limited proportion of dairy producers also access market information from district agricultural offices (8%), and other farmers (3%).

Even for those who reported as having received information/advice on improved production from the extension agents, the intensity of the service as measured by the number of visits/contacts is low. The median contact frequency is two per year, while the average contact frequency is four per year. About 75% of dairy producers had only three or less visits/contacts during the production season.

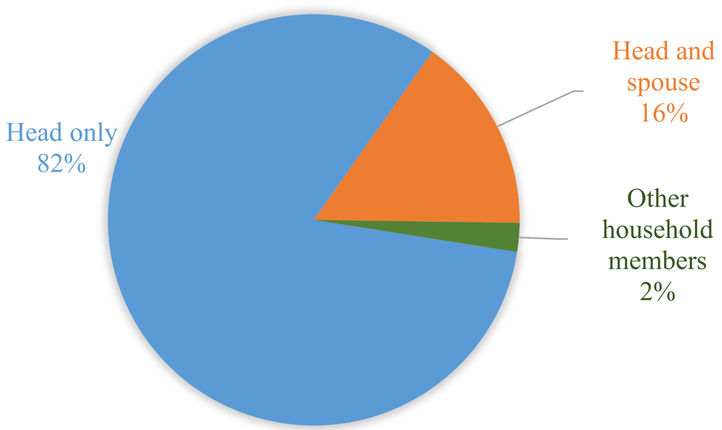
Figure 6: Extension support on information and advice on improved dairy.



Source: LIVES baseline data 2014.

Of those households who had contact with extension agents, about 82% reported that information/advice on technologies and practices for improved dairy production is received by the household heads (the husband in male-headed households) who might have relatively minor role in dairy production (Figure 7). This result implies that women, who usually play major role in rural dairy production, are left out.

Figure 7: Household member who received information/advice from extension on improved dairy production.



Source: LIVES baseline data 2014.

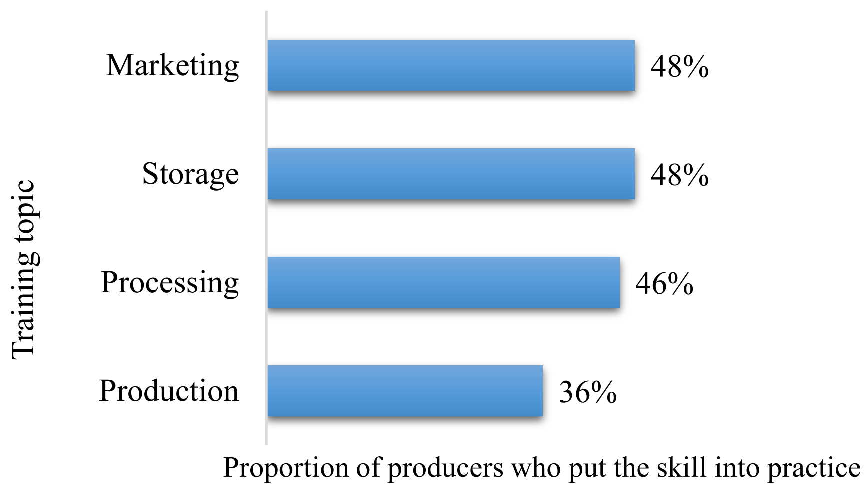
Timeliness and relevance of the information/advice received from the extension services on improved diary production measures its quality and usefulness. In this regard, the results show that about 75% of those who had contact with extension agents on improved dairy production reported that they received the information/advice in time to fulfill their decision-making needs and about 74% found that the information/advice they received was relevant to their needs. Our results also show that about 25% of the producers reported that the information/advice received was poor or very poor in terms of both timeliness and relevance, suggesting that a significant proportion of the household are dissatisfied with the extension services. Only about 24% of respondents reported to having received training on improved dairy production, and much lesser proportions (less than 13%) reported having received training on processing, storage and marketing of dairy products.

As with the information/advice services, mis-targeting seems to also be pervasive in the training and skill development efforts of the extension service. Although female members of the household predominantly do production, processing and marketing of dairy products, the training on these topics are primarily given to the household head, who is usually a man (in 85% of the time in our sample). The situation is further exacerbated by the fact that in rural areas husbands are poor (reluctant) at sharing information with their wives (Fletschner and Mesbah 2011).

Training on improved dairy production is primary provided by development agents (in about 61% of the responses) and district agricultural office experts (in about 36% of the responses). However, it should be noted that development agents in Ethiopia are usually trained on general animal science and may lack practical skills and tools to effectively deliver relevant training to dairy producers, as has been observed in some parts of Ethiopia (Belay and Abebaw 2004; Adane et al. 2015a) and other developing countries (Baloch and Thapa 2016). This highlights the importance of building the specific capacity and knowledge of extension agents on dairy production, processing and storage.

Trainings transform into useful learning and internalization only when they are applied. Our data reveal that less than half of those who took training on different aspect of dairy production and marketing do actually apply the skills (Figure 8).

Figure 8: Proportion of milk producers who put the skills obtained from extension training into practice.



Source: LIVES baseline data 2014.

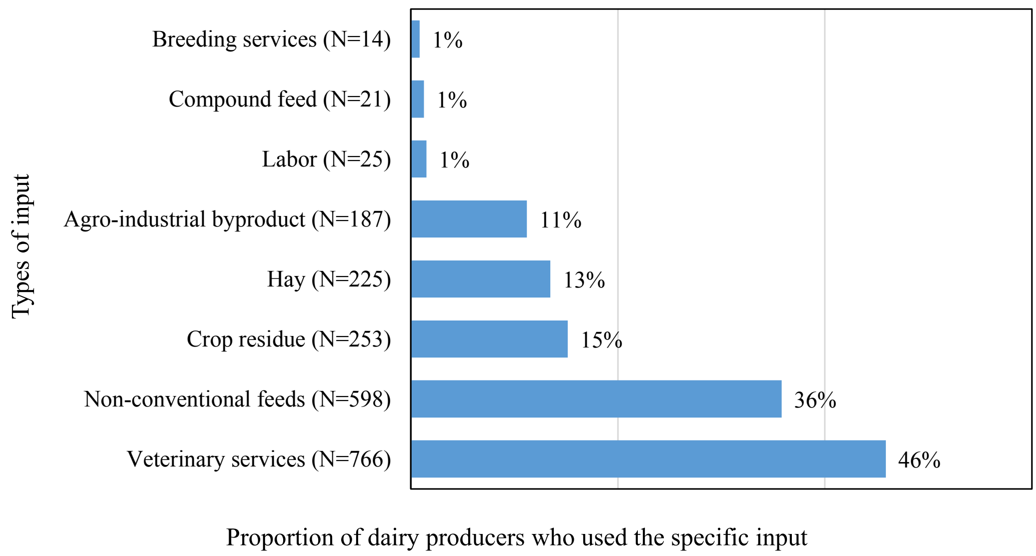
It looks like farmers' access to resources has a direct bearing on the effectiveness of the extension service. Our results indicate that as much as 80% of households who received training could not apply them due to limited access to productive resource such as livestock, finance, labour and time. This implies that female headed households would find it even more difficult to apply extension trainings due to their limited resource capacity. About 20% of respondents also mentioned the relevance and adequacy of the training as a reason for not applying the training.

Provision of facilitating linkages with input and output markets and services is the least provided service by the extension service to dairy producers. Only about 3% of milk producing households reported receiving any kind of linkage support in the production and marketing of dairy products. The finding underscores the fact that though creating marketing linkage encourages farmers to invest in their dairy business, and adopt technologies that can lead to an increase in productivity, it has not been given due attention by the extension system. This justifies the need for market-oriented extension in dairy production.

5. Input use and feeding practices

Use of purchased inputs for dairy production is limited. Our data show that more than half of the dairy producers (53.6%) did not use any type of purchased feed during the production season, showing that self-produced or communal feeds are used, which are crop residues and naturally available forages. The use of crop residues and natural forages only indicates the consequential nutrition problems that dairy animals face. The proportion of milk producers who purchased the different types of feed is given in Figure 9. The most purchased external inputs and services seem to be veterinary services and non-conventional feeds. About 46% of milk producers purchased veterinary services, while about 36% purchased non-conventional feed including local brewery byproducts and salt. Between 11% and 15% of milk producers purchased crop residues, hay and agro-industrial by-products. Only 1% of milk producers used compound feed, suggesting that promotion of compound feed will require concerted effort by the extension service.

Figure 9: Proportion of milk producers who used purchased inputs and services.



Source: LIVES baseline data 2014.

The intensity of purchased input use among users is also low. The expenditures on purchased inputs is given in Table 3. The maximum expenditure was on hired labour which amounted to ETB 1066, followed by agro-industrial byproducts (ETB 991). Although 46% of the milk producers purchased veterinary services, the average expenditure is only about ETB 72. The low expenditure on veterinary services is perhaps due to the fact that veterinary services are provided by the government and are heavily subsidized. About 75% of those who used purchased input spent about ETB 695, 750 and 900 or less on purchased crop residue, hay and compound feed, respectively. Farmers do not spend money on breeding services.

Expenditure on hired labour and agro-industrial byproduct is the highest followed by crop residue and hay. Annual expenditure on labour and agro-industrial byproduct reach about ETB 1000 each, however there is a wide variation among households as revealed by the high standard deviation.

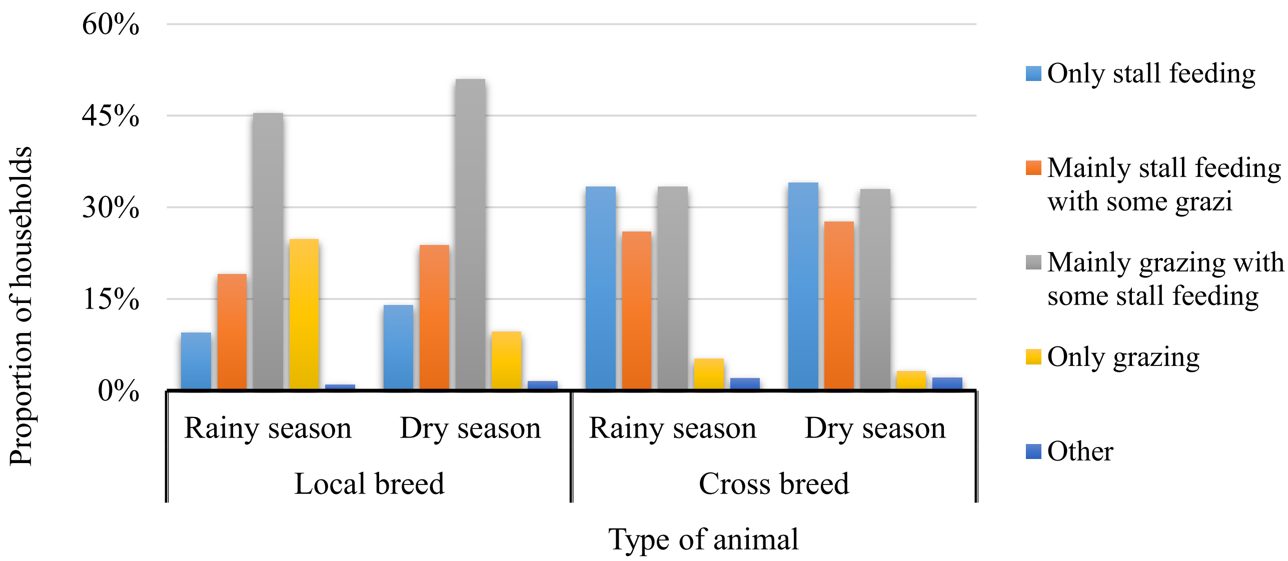
Table 3:Value of purchased input for dairy production among milk producers (ETB)

Types of input	N	Mean	Std. dev.	Quartiles		
				P25	**Median**	**P75**
Crop residue	253	679.67	1322.6	190	376	695
Hay	225	644.13	777.5	220	400	750
Compound feed	21	702.33	517.2	301	600	900
Agro-industrial byproduct	187	990.96	2932.7	165	360	800
Other supplements	598	108.02	384.5	18	39	80
Veterinary services	766	71.94	120.7	14	31	75
Breeding services	14	22.93	62.7	3	5	10
Labour	25	1066.2	1056.4	200	820	1500

Source: LIVES baseline data 2014.

Dairy produces seem to adjust their feeding practice with the type of animal they own. For example, about one in ten of dairy producers use only stall feeding for local breed while the same figure is one in three for crossbred animals (Figure 10). Irrespective of type of breed, the same feeding pattern is observed both in the dry and rainy seasons. For instance, for local cows about 45% practice mainly grazing with some stall-feeding and the proportion changes only slightly in the dry season. Overall, it seems that feeding practice of dairy producers mainly depends more on the type of dairy animal than on the season.

Figure 10: Feeding practice of dairy producers.



Source: LIVES baseline data 2014.

As expected and irrespective of animal type, watering frequency of dairy cows is higher during the dry season probably due to the high rate of transpiration. The result also shows that despite differences in productivity and size there seem to be little difference between watering frequency of local and crossbred dairy cows (Table 4). In addition to the environment, water intake depends on animal size, age, activity and productivity. The implication is that dairy farmers need to be informed about the fact that different breed animals could have different watering requirement.

Table 4: Watering frequency of dairy animal (per day)

Seasons	**Breed type**	**N**	**Mean**	**Std. dev.**	Quartiles		
					P25	**Median**	**P75**
Rainy	Local	901	1.1	0.32	1	1	1
	Cross	94	1.1	0.28	1	1	1
Dry	Local	974	1.68	0.63	1	2	2
	Cross	94	1.74	0.65	1	2	2

Source: LIVES baseline data 2014.

Results indicate that dairy animals do not have to walk long distance to reach water sources. On average, during the rainy season, the average walking distance to watering sources is about 12 minutes, while the corresponding walking distance during the dry season is about 20 minutes.

6. Econometric analysis

6.1 Data and description of variables

Results are based on analysis of data from a survey of 5000 smallholder households and 497 rural *kebeles*[6] (PAs) in the 4 highland regions of Ethiopia (Tigray, Amhara, Oromia, and Southern Nations, Nationalities and Peoples (SNNP) regions). For sampling purposes, the study districts were stratified into 10 agro-ecologies, and farm households were selected randomly based on proportional to size sampling technique. Survey was conducted in 2014 and referred to the 2012/13 production season.

Tables 5 and 6 presents descriptive statistics of continuous and categorical variables used in the regression models. About 32% of sample households participated in milk/butter production, of which 53% participated in butter market and 48% purchased some type of dairy inputs. Eighty one percent of the households are male-headed. The mean age of the household heads is about 46 years and on average, a household has about three working age family members. The average household's total land size is small at 1.41 ha and the variation is relatively small across households as is evident in the small standard deviation of 1.37. On average, a household has to travel for 108.76 minutes to reach nearest town market, 165.04 minutes to reach district town, 70.763 minutes to reach nearest livestock input market and 90.67 minutes to reach the nearest veterinary clinic. Moreover, only about 20% obtained credit during the previous production season. About 20% of respondents reported that there was cereal bran supplier in their PA and lesser proportion (13%) reported the presence of compound feed supplier. Hay sellers seems to be abundant with 80% of respondents reporting that there was a hay seller in their area.

Table 5: Definitions and summary statistics of the continuous variables used in the analysis

	Quartiles				
Explanatory variables	**25**	**50**	**75**	**Mean**	**Std. dev.**
Household characteristics					
Age of household head (year)	36	45	53	45.51	12.55
Number of adult household members (no.)	2	3	4	3.14	1.5
Number of children less or equal to 5 years (no.)	0	1	1	0.8	0.88
Household wealth (ETB1000)	0.94	2.87	8.28	17.43	55.49
Household non-farm income (ETB1000)	0	1.44	4.23	3.55	7.41
Farm characteristics					
Land owned (ha.)	0.5	1	1.75	1.41	1.37
Lagged number of small ruminants	0	1	6	4.14	6.66
Lagged number of crossbred cows	0	0	0	0.08	0.45
Annual crop residue produced (in kg)	0	0	0	264.03	1638.52
Total milk produced during the year (in litre)	122.5	210.3	375	332.61	440.03
Total number of lactating cows (no.)	1	1	2	1.42	0.77

6. A Kebele is the lowest administrative unit in Ethiopia and comprises of 4–5 villages.

Explanatory variables	Quartiles 25	50	75	Mean	Std.Dev
Proportion of crossbred lactating cows	0	0	0	0.06	0.23
Access to infrastructure, service and markets					
Distance to town market (walking minutes)	50	90	150	108.76	88.44
Distance to district town (walking minutes)	80	150	240	165.04	114.38
Distance to DA post (walking minutes)	10	20	40	30.55	29.9
Distance to the nearest livestock input provider (walking minutes)	20	60	90	70.75	77.14
Distance to the nearest veterinary clinic (walking minutes)	30	60	120	94.91	90.67
Community characteristics					
Population density (persons/ha.)	1.6	2.25	3.54	3.13	3.02
Grazing land (ha/tlu)	0.02	0.04	0.08	0.07	0.12
Wage rate for female for off-farm employment (ETB/hour)	0	0	47	23.36	27.54
Wage rate for male for off-farm employment (ETB/hour)	45	57	75	59.43	22.57
Prices					
Lagged district butter prices (ETB/kg)	77.21	100	122.5	105.54	32.71
Lagged district sheep prices (ETB/head)	600	700	760	714.33	168.12
Relative market price of Maize to butter	0.04	0.05	0.06	0.06	0.02
Relative market price of Teff to butter	0.1	0.12	0.14	0.12	0.02

Table 6: Definitions and summary statistics of the binary variables used in the analysis

Variables	Mean	Std. dev.
Household characteristics		
Male headed household (yes=1)	0.81	0.4
No education (yes=1)	0.58	0.49
1 to 4 years (yes=1)	0.18	0.38
5 to 8 years (yes=1)	0.19	0.39
More than 8 years (yes=1)	0.05	0.22
Agro ecological zones		
Agro ecological zone 1(=1 if altitude is > 2300 m)	0.26	0.44
Agro ecological zone 2 (=1 if altitude is 1500–2300 m)	0.66	0.47
Agro ecological zone 3 (=1 if altitude is <1500 m)	0.08	0.27
Access to credit and market		
Credit use (=1 if the farmer took credit)	0.18	0.39
Bran sellers are available in the PA	0.2	0.4
Compound feed seller are available in the PA	0.13	0.34
Hay seller are available in the PA	0.8	0.4
Shock		
Negative rainfall shock (yes=1)	0.32	0.47
Zones		
Eastern Tigray zone (yes=1)	0.1	0.3
Central Tigray zone (yes=1)	0.1	0.3
West Gojam zone (yes=1)	0.1	0.3
North Gondar zone (yes=1)	0.1	0.3
South Wello zone (yes=1)	0.1	0.3
East Shoa zone (yes=1)	0.1	0.3
West Shoa zone (yes=1)	0.1	0.3

Variables	Mean	Std. Dev
Jimma zone (yes=1)	0.1	0.3
Gamo Gofa zone (yes=1)	0.1	0.3
Sidama zone (yes=1)	0.1	0.3
Dependent variables		
Household participation in milk production	0.32	0.47
Household participates in butter market	0.53	0.5
Household intensity of butter marketing	6.11	7.16
Household use of purchased dairy inputs	0.48	0.5
Household intensity of purchased input use	821.80	2437.93

6.2 Econometric results

Engagement in milk production

Naturally butter market participation decision would involve four stages—milk production decision, butter production decision for milk producers, butter market participation decision for butter producers and finally intensity of participation for market participant butter producers. However, in our data almost all milk producers (94%) also produce butter. As such, the first and the second stages are combined. Thus, the first-stage probit model estimates milk/butter production decision, the second stage estimates butter market participation decision and the third stage estimates the level of participation (i.e., volume of butter sales).

Our model assumes a non-zero correlation among the three error terms. To test the assumption a restricted model is estimated by setting the correlation among the error term zero and likelihood ratio (LR) test is used to compare our model with the restricted one. The likelihood ratio test suggests that the unrestricted is preferred to the restricted model χ^2 (3) = 129.33, p = 0.000. In addition, the LR test of the hypothesis that all regression coefficients are jointly equal to zero is highly rejected. These suggest that failing to account for the two-sample selection biases would result in wrong inferences.

To identify the second stage equation of butter market participation, we used wage rate for off-farm employment for male as an exclusion restriction variable, which was shown to be statistically significant in stage 1 (milk/butter production decision) (p =0.062), but was both conceptually and empirically irrelevant in stage two (butter market participation) (p = 0.358). Likewise, we used distance to market town as an exclusion restriction variable to identify the third stage equation of intensity of butter market participation. Distance to market town was statistically significant in stage 2 (p = 0.052), but was insignificant in stage 3 (p = 0.897).

Table 7 presents the maximum likelihood estimates of the three-stage dairy production and butter market participation decision models. Column (i) presents coefficient estimates for factors associated with the probability of engaging in milk/butter production (stage 1). Column (ii) presents coefficient estimates for participation in butter market conditional on being a butter producer (stage 2). Column (iii) presents results of the butter supply function for butter market participating producers (stage 3).

The probit model for engagement in milk production gives intuitive results. Male-headed households have a greater likelihood of engaging in dairy production than female-headed households, with an average male-headed household being 30.8% more likely to engage in milk/butter production than a female-headed household (Table 7).

Table 7: Triple hurdle model estimates of milk/butter production and butter market participation decisions in rural Ethiopia

Variables	Stage 1: Production	Stage 2: Butter market participation	Stage 3: Sales volume
	Probit	Probit	Log normal
Household characteristics			
Age of household head (year)	-0.001 (0.914)	0.005 (0.763)	0.014 (0.497)
Age of household head squared	0.000 (0.915)	-0.000 (0.889)	-0.000 (0.376)
Male headed household (yes=1)	0.281*** (0.000)	-0.329*** (0.000)	0.300** (0.015)
Number of adult household members (no.)	0.051*** (0.001)	-0.059*** (0.005)	0.062** (0.026)
Number of children less or equal to 5 years (no.)	0.055** (0.028)	-0.054 (0.117)	0.061 (0.176)
1 to 4 years (yes=1)	-0.012 (0.826)	0.130 (0.104)	-0.233** (0.022)
5 to 8 years (yes=1)	0.150*** (0.008)	-0.084 (0.281)	0.011 (0.910)
More than 8 years (yes=1)	-0.023 (0.818)	-0.198 (0.153)	0.099 (0.581)
Household wealth (ETB1000)	0.000 (0.554)	-0.000 (0.308)	0.000 (0.811)
Household non-farm income (ETB1000)	-0.002 (0.463)	-0.010** (0.017)	0.006 (0.291)
Farm characteristics			
Land owned (ha.)	0.112*** (0.000)	-0.073*** (0.003)	0.098*** (0.002)
Lagged number of small ruminants	0.024*** (0.000)	-0.008* (0.072)	0.005 (0.367)
Lagged number of crossbred cows	0.392*** (0.000)	-0.149*** (0.009)	0.080 (0.286)
Annual crop residue produced (in kg)	0.000** (0.033)		
Total milk produced during the year (in litre)		0.001*** (0.000)	0.001*** (0.000)
Access to infrastructure, services and market			
Distance to town market (walking minutes)	-0.000 (0.451)	-0.000* (0.051)	
Distance to district town (walking minutes)	-0.000 (0.627)	-0.000 (0.479)	0.001 (0.136)
Distance to DA post (walking minutes)	0.001 (0.201)	-0.001 (0.303)	0.002* (0.099)
Credit use (=1 if the farmer took credit)	0.104** (0.045)	0.017 (0.812)	0.057 (0.537)
Distance to the nearest veterinary clinic (walking minutes)	0.000 (0.919)		

Variables	Stage 1: Production Probit	Stage 2: Butter market participation Probit	Stage 3: Sales volume Log normal
Community characteristics			
Population density (persons/ha.)	-0.019**	0.010	-0.004
	(0.041)	(0.386)	(0.819)
Grazing land (ha/tlu)	0.379**		
	(0.020)		
Wage rate for female for off-farm employment (ETB/hour)	0.001	-0.002	0.002
	(0.274)	(0.242)	(0.208)
Wage rate for male for off-farm employment (ETB/hour)	-0.002*		
	(0.062)		
Agro ecological zones			
Agro ecological zone 1(=1 if altitude is > 2300 m)	0.018	0.238	-0.294
	(0.886)	(0.171)	(0.190)
Agro ecological zone 2 (=1 if altitude is 1500–2300 m)	0.019	0.326*	-0.180
	(0.883)	(0.066)	(0.444)
Prices			
Lagged district butter prices (ETB/kg)	0.004**	0.001	-0.002
	(0.046)	(0.817)	(0.496)
Lagged district sheep prices (ETB/head)	-0.001	-0.000	-0.001
	(0.169)	(0.530)	(0.213)
Shock			
Negative rainfall shock (yes=1)	0.046		
	(0.310)		
Zones†			
Central Tigray zone (yes=1)	0.100	0.028	-0.451*
	(0.397)	(0.871)	(0.054)
West Gojam zone (yes=1)	0.583***	0.252	-0.515
	(0.004)	(0.353)	(0.135)
North Gondar zone (yes=1)	0.509***	0.280	-0.435
	(0.003)	(0.235)	(0.143)
South Wello zone (yes=1)	0.468***	0.558**	-0.343
	(0.002)	(0.015)	(0.215)
East Shoa zone (yes=1)	-0.108	0.816**	-0.640
	(0.622)	(0.012)	(0.122)
West Shoa zone (yes=1)	0.023	0.784***	-0.625**
	(0.877)	(0.000)	(0.017)
Jimma zone (yes=1)	0.108	0.417	-0.850**
	(0.582)	(0.120)	(0.015)
Gamo Gofa zone (yes=1)	0.369	0.720**	-0.906**
	(0.110)	(0.025)	(0.026)
Sidama zone (yes=1)	0.870***	0.249	-0.503*
	(0.000)	(0.288)	(0.079)
Constant	-1.493***	0.717	1.527
	(0.002)	(0.315)	(0.104)
Observations	4,610	1527	810

Variables	Stage 1: Production	Stage 2: Butter market participation	Stage 3: Sales volume
	Probit	Probit	Log normal
Ancillary parameters			
σ		1.261*** (0.000)	
ρ_{12}		-0.964*** (0.000)	
ρ_{13}		0.440*** (0.000)	
ρ_{23}		-0.640*** (0.000)	
Log likelihood		-4504.927	
LR chi2(106)		1187.40*** (0.000)	

P-values in parentheses. *** p<0.01, ** p<0.05, * p<0.1. †Eastern Tigray is the reference zone

Labour and land turned out to have positive and significant effects on the probability of engaging in dairy production. An additional adult member of the household raises the probability of engaging in dairy production by 1.8 percentage point. Similarly, an increase of land size by one standard deviation increases the probability of engaging in dairy production by 6.2 percentage points. This is hardly surprising since labour is a critical factor of production for dairy, while cultivated land is an important source of animal feed.

The coefficient for children less than or equal to five years of age have positive sign and was significantly different from zero in the first stage equation. An additional child less than or equal to five years of age increases the likelihood of engaging in dairy production by 1.9 percentage points. This is probably because existence of children in a household increases household's demand for milk because children need milk for growth and development. Household heads who had completed upper primary level (grade 5–8) are likelier to engage in diary production than those with no formal education—43% as compared to 38%. However, completing lower primary school (grade 1–4) or having more than primary school education (above 8th grade) did not have statistically significant effect.

Possession of small ruminants and crossbred dairy cows have positive and statistically significant relationship with the probability of being a milk producer. Likewise, the amount of crop residue produced and access to communal grazing land have statistically significant and positive effects on the probability of engaging in dairy production. This shows the close integration of dairy production into the crop production system which is consistent with the practices in other African countries (Ngongoni et al. 2006; Moll et al. 2007).

The result also shows that participation in dairy/butter production is negatively affected by population density. This is probably because high population density is associated with resource scarcity and degradation which ultimately affects availability of animal feed (Hassen et al. 2010). On the other hand, male's wage rate for off-farm employment is inversely related to the probability of being dairy producers. This is probably because wage rate for off-farm employment measures the opportunity cost of engaging in diary production, and as such the result suggests that farm households seem to compare the potential returns from dairy production to alternative enterprises before making production decision.

Access to credit has a positive and significant effect on production participation decision, with household that accessed credit having 9.4% greater likelihood of being a dairy producer. Freeman et al. (1998) found similar result for Ethiopia and Kenya where access to credit leads to higher investment on crossbred animals with higher milk production potential. This suggests the importance of access to credit for dairy development in rural areas.

Engagement in milk production is positively associated with lagged butter price. The finding is consistent with (Ahmed et al. 2004) where low milk producer prices was found to discourage production. This is probably because past output prices shapes smallholders' price expectations, which ultimately affect farmer's production decisions. As expected households who are located in west Gojam, north Gonder, south Wollo and Sidama are more likely to be engaged in milk production relative to eastern Tigray, indicating the relatively higher potential for dairy development in these zones.

Butter market participation and volume of sale

Although less likely to be engaged in dairy production, female-headed households are more likely to participate in butter market than their male counterpart, conditional on being a milk producer. An average female-headed household is 15% more likely to participate in butter market than an otherwise comparable male-headed household. This is consistent with Burke et al. (2015) study where they found that female-headed dairy producing households are more likely to be net sellers in rural Kenya. Given that a household is a seller, however, we find a positive and statistically significant relationship between male-headedness and quantity sold. All else equal, male-headedness increases the (conditional) quantity sold by 12% but decrease the unconditional[7] amount by 0.8%.

Market participation declines with the number of adult members and children under 5 years of age indicating the effect of household consumption on milk sales. Burke et al. (2015) found similar result for children in milk producing households in rural Kenya.

Not surprisingly, the volume of milk produced significantly affect the probability of market participation as well as the volume of sales. This is in line with Negassa (2009) findings where low level of production was identified as one of the main reasons for not selling milk in the market. The results suggest that, keeping other things constant, an increase in annual milk production by 1000[8] litres on average increases the conditional probability of market participation by 25% and the unconditional probability by 9.7%. Similar increase in annual milk production also increases the conditional and unconditional expected volume of butter sales by 172.3 % and 142.5%, respectively. The implication is that promoting productivity and production at household level is a potent policy option in promoting market orientation in dairy production in rural Ethiopia, particularly through the use of high producing crossbred animals. This is consistent with pervious study by Holloway et al. (2000a) who focused on the fluid milk market in Ethiopia.

Probability of market participation is decreasing in household non-farm income, land size and possession of small ruminants, ceteris paribus. This is probably because all three variables represent alternative sources of income for the households, and as such, dairy/butter producers who have access to these other income sources would not have as much motivation to participate in butter market as those who have not. However, only land size has a statistically significant and positive effect on the volume of sale, perhaps because of its effect on feed production.

Lagged possession of crossbred dairy cows decrease the probability of participating in butter market for milk/butter producers. This finding is consistent with the notion that dairy producer who owns crossbred cows are more likely to sell fluid milk than butter (Tegegne et al. 2013).

As expected distance to market town, which is included to proxy for fixed marketing costs has statistically significant and negative effect on the probability of market participation but not on the volume of sale for a given seller. Similar result has been found by Holloway et al. (2000b) and Holloway et al. (2004) for milk marketing in Ethiopian highlands as well as by Staal et al. (1997) in Ethiopia and Kenya. The results show that the probability of market participation is 3.8% lower for milk/butter producers located at two hours walking distance from market town (the 75th percentile)

7. The term unconditional is used here to indicate that the partial effect of a given explanatory variable is not conditional on any of the dependent variables (production and market participation) taking a specific value.
Debrah and Anteneh 1995 estimated that annual milk yield from a crossbred cow in rural Ethiopia is about 1120–2500 litres

8. Debrah and Anteneh 1995 estimated that annual milk yield from a crossbred cow in rural Ethiopia is about 1120–2500 litres

than those located at 40 minute walking distance (25th percentile). These findings suggest that investments in market infrastructure are important to promote participation in dairy markets.

Surprisingly, butter sellers do not respond to price signals. This is contrary to results found by Burke et al. (2015) for milk in rural Kenya. This could be because butter producers sale butter to meet household cash needs, not necessarily to maximize profit, which is not unusual consideration for livestock producers in rural Africa (Bellemare and Barrett 2006). Rather unexpectedly, volume of sales increases with distance to DA office which proxies for access to extension services. This apparent paradox may be explained by the fact that dairy producers who are located far from DA offices are also more likely to be butter sellers rather than fluid milk sellers. However, this is a tentative explanation for unexpected result and needs further verification.

Purchased input use and demand in dairy production

The input demand model assumes a nonzero correlation among the three error terms corresponding to the three equations representing milk/butter production, participation in dairy input market and intensity of participation. To test the assumption, a restricted model is estimated by setting the correlation among the error term zero and likelihood ratio (LR) test is used to compare our unrestricted model with the restricted one. The likelihood ratio test suggests that the unrestricted model is preferred to the restricted model χ^2 (3) = 54.92, p = 0.000. This suggests that failing to account for the two-sample selection bias would result in wrong inferences. In addition, the LR test for the overall model suggests that the independent variables taken together influence the production and market participation decisions χ^2 (120) = 1005.66, p = 0.000.

To identify the second stage equation of participation in purchased input use, we used wage rate for off-farm employment for male as an exclusion restriction variable, which is statistically significant in stage one (p =0.062), but both conceptually and empirically irrelevant in stage two (p=0.3584). Likewise, we used distance to nearest livestock input supply centre, and availability of shops for compound feed, hay and bran as exclusion restriction variables to identify the third stage equation of purchased input demand. These variables are jointly statistically significant in stage 2 χ^2 (4) = 11.15, p = 0.0249, but are either insignificant (as in the case of distance to nearest livestock input supply centre) (p= 0.4236) or conceptually irrelevant after the market participation decision has been made (as in the case of availability of feed shops)[9].

The input demand model shares the same first stage equation with the butter market participation model. Thus, only the results for input market participation and level of participation conditional on being milk/butter producer are presented and discussed in this section. Estimation results for the triple hurdle model of smallholders' input market participation decision are presented in Table 8.

Table 8: Triple hurdle model estimates of dairy input market participation decision in Ethiopia

	Stage 2:	Stage 3:
	Dairy input market participation	Purchases volume
Variables	Probit	Log normal
Household characteristics		
Age of household head (year)	0.013	-0.006
	(0.558)	(0.848)
Age of household head squared	-0.000	0.000
	(0.401)	(0.872)
Male headed household (yes=1)	0.074	-0.580***
	(0.609)	(0.000)

9. We have not been able to test the significance of the availability of feed shops variable as the third stage equation would not converge when these variables were included.

	Stage 2:	Stage 3:
	Dairy input market participation	Purchases volume
Variables	Probit	Log normal
Number of adult household members (no.)	0.061*	0.001
	(0.052)	(0.969)
Number of children less or equal to 5 years (no.)	0.089*	0.027
	(0.060)	(0.654)
1 to 4 years (yes=1)	0.063	0.003
	(0.559)	(0.980)
5 to 8 years (yes=1)	0.000	-0.199
	(0.997)	(0.134)
More than 8 years (yes=1)	0.275	0.345
	(0.124)	(0.110)
Household wealth (ETB 1000)	0.000	0.000
	(0.687)	(0.499)
Household non-farm income (ETB 1000)	0.016**	0.010
	(0.027)	(0.126)
Farm characteristics		
Land owned (ha.)	0.032	-0.117**
	(0.408)	(0.014)
Lagged number of small ruminants	0.026***	-0.014*
	(0.000)	(0.054)
Total number of lactating cows (no.)	0.126**	0.094
	(0.027)	(0.155)
Proportion of crossbred lactating cows	0.221	0.294
	(0.322)	(0.138)
Annual crop residue produced (in kg)	0.000	0.000
	(0.815)	(0.117)
Access to infrastructure, services and market		
Distance to town market (walking minutes)	-0.000	-0.000
	(0.946)	(0.664)
Distance to district town (walking minutes)	0.001***	-0.000
	(0.006)	(0.712)
Distance to DA post (walking minutes)	-0.001	-0.003*
	(0.667)	(0.050)
Distance to the nearest veterinary clinic (walking minutes)	-0.001	-0.001
	(0.127)	(0.383)
Distance to the nearest livestock input provider (walking minutes)	-0.001**	
	(0.036)	
Credit use (=1 if the farmer took credit)	0.056	-0.143
	(0.554)	(0.217)
Bran sellers are available in the PA	-0.200	
	(0.156)	
Compound feed seller are available in the PA	0.442**	
	(0.022)	
Hay seller are available in the PA	0.232*	
	(0.092)	

Variables	Stage 2: Dairy input market participation Probit	Stage 3: Purchases volume Log normal
Community characteristics		
Population density (persons/ha.)	0.019	0.066***
	(0.299)	(0.003)
Grazing land (ha/tlu)	0.001	-0.957**
	(0.998)	(0.015)
Wage rate for female for off-farm employment (ETB/hour)	0.000	0.002
	(0.908)	(0.422)
Agro-ecological zones		
Agro ecological zone 1(=1 if altitude is > 2300 m)	-0.042	0.115
	(0.857)	(0.703)
Agro ecological zone 2 (=1 if altitude is 1500–2300 m)	0.472*	-0.090
	(0.054)	(0.778)
Prices		
Lagged district butter prices (ETB/kg)	0.001	-0.003
	(0.863)	(0.596)
Lagged district sheep prices (ETB/head)	-0.003***	-0.000
	(0.002)	(0.990)
Relative market price of Maize to butter	4.643	-13.508***
	(0.250)	(0.003)
Relative market price of Teff to butter	1.919	-0.392
	(0.515)	(0.908)
Shock		
Negative rainfall shock (yes=1)	0.004	0.017
	(0.967)	(0.881)
Zones†		
Central Tigray zone (yes=1)	-0.569**	0.518*
	(0.012)	(0.084)
West Gojam zone (yes=1)	-0.081	-0.473
	(0.845)	(0.352)
North Gondar zone (yes=1)	0.575	-0.514
	(0.106)	(0.215)
South Wello zone (yes=1)	0.451	0.632
	(0.250)	(0.194)
East Shoa zone (yes=1)	-0.118	0.182
	(0.807)	(0.770)
West Shoa zone (yes=1)	-0.107	-0.567
	(0.724)	(0.155)
Jimma zone (yes=1)	-2.057***	-1.001
	(0.000)	(0.126)
Gamo Gofa zone (yes=1)	-0.062	-1.255**
	(0.892)	(0.019)
Sidama zone (yes=1)	-0.587	-1.615***
	(0.134)	(0.000)
Constant	-0.319	9.840***
	(0.795)	(0.000)

Variables	Stage 2: Dairy input market participation Probit	Stage 3: Purchases volume Log normal
Observations	1,489	734
Ancillary parameters		
σ	1.758*** (0.000)	
ρ_{12}	-0.191 (0.483)	
ρ_{13}	-0.927*** (0.000)	
ρ_{23}	0.133 (0.690)	
Log likelihood	-4544.939	
LR $chi^2(120)$	1005.66*** (0.000)	

P-values in parentheses. *** p<0.01, ** p<0.05, * p<0.1. †Eastern Tigray is the reference zone

Though sex of household head does not have a statistically significant effect on the probability of dairy input market participation, female-headed milk/butter producers use purchased dairy input more intensively than male-headed households. Holding other variables fixed, female-headedness is expected to increase the amount spent on dairy inputs by 9.2%. This could be partly because, female-headed households, once involved in milk production, are more focused on dairy as source of income and manage their dairy farms more intensively than their male counterparts. Similar findings are reported by Alene et al. (2008) and Winter-Nelson and Temu (2005) where female-headed households used fertilizer more intensively than male headed households in Kenya and Tanzania, respectively.

Conditional on being a dairy farmer, the probability of participating in input market increases with adult household members as well as children under five years of age partly due to the fact that demand for milk increase with household member especially with children. Non-farm income as well as ownership of small ruminant are positively associated with the probability of participating in input market. This is probability because both are sources of cash income for the households and households with access to cash income have a relatively high purchasing power that would enable them to buy inputs. However, after the market participation decision is made, ownership of small ruminant and land size negatively affect the intensity of input market participation partly due to resource diversion.

Higher lagged price of small ruminants is associated with a lower probability of milk producers participating in input markets for dairy. Farmers keep small ruminant as a source of income and as such if households expect higher returns from this alternative sub-sector they are more likely to divert resources from other activities. Similarly, higher relative prices of maize, which is one of the major cereals grown by smallholder farmer in Ethiopia, decreases the amount of purchased inputs. As expected input market participation increase with total number of lactating cows, although number of lactating cows did not affect the intensity of use of purchased dairy inputs. On average, each additional lactating cow increases the probability of input market participation by 4.1%.

An increase in time taken to reach the nearest livestock input market decreases the probability of input market participation albeit only slightly. The results show that a household located within 30 walking minutes radius from livestock input market (the 25th percentile) has a 53% probability of participating in the input market, while an otherwise-comparable households located some 2 hours (the 75th percentile) has an 49% percent chance. The negative relationship between distance to market and input market participation is consistent with pervious agricultural market participation studies (Alene et al. 2008; Ouma et al. 2010).

Compound feeds and hay shops in the PA are positively and significantly associated with the probability of participating in input market. Compared to households in a PA where no such feed suppliers exit, any given household's likelihood of participating in input market is 28.7% higher in areas where compound feed supplier exist and 17.2% where hay supplier exits. The implication is that there is potential to increase input use by dairy farmers through improved input distribution system. Likewise, population density and access to communal grazing land which affect the quality and quantity of forage have statistically significant positive and negative effect on the amount spent on purchased dairy input, respectively.

Unexpectedly, results show that milk/butter producers who are located far from the district towns are more likely to participate in input markets than are their counterparts. On the other hand, distance to DA office, which was included in the model to capture access to extension services, negatively affects the intensity of input market participation. The implication is that improving access to extension services engender participation in input market. This is consistent with other studies where extension services has been identified as an essential ingredients to promote commercialized agriculture in developing countries (Holloway et al. 2000a; Lerman 2004).

7. Conclusion and implications

This paper estimates two triple-hurdle models using a data set collected from 5000 households in the highlands of Ethiopia to analyse the factors influencing household decisions to engage in dairy production and butter marketing, and to participate in dairy input markets. Analysis of descriptive information was used to describe households' practices in milk/butter production and animal management.

The number of milking cows per households is very small, with an average household engaged in milk production owning 1.40 cows. Use of crossbred cows is very rare. Most of the milk produced (about 68%) is processed into butter, by about 94% of the milk producers. Only 2% of the milk is sold as fluid milk. Milk producing households consume slightly less than a third of the milk they produce. More than half of milk producers sell butter, with an average sales of about 6 kg/household per year.

Use of purchased inputs is limited due to limited physical and economic access. The majority of dairy producers depend on own crop residue and naturally available forage to feed their dairy animals which have low nutritive values and whose supply is characterized by sever seasonal fluctuations. The intensity of purchased input use among input buyers is also low. The extension service mainly targets household heads who are more often than not men and who have relatively low involvement in the production and marketing of dairy products. In this respect, the extension services need to consciously target women in male-headed households and female household heads so that the trainings and advices bring about the intended outcomes. Alternatively, the extension service can follow the approach of 'couples training' by including both the husband and the spouse in training and other extension services.

Econometric results show that availability of feed stands out as an important factor influencing household decision to engage in milk production. Households with greater amounts of cultivated land who produce more crop residues, and live in communities with larger amounts of communal grazing land per TLU are more likely to be involved in milk production. These results imply the urgent need to develop feed resources to support dairy production in rural Ethiopia. Moreover, household labour supply seems to be an important consideration in milk production, reflecting the labour requirements for feeding, herding, milking and other farm management practices.

Milk production in rural Ethiopia seems to have an interesting and complex gender dimension. While female-headed households are less likely to be engaged in dairy production than their male-headed counterparts, they are more likely to participate in butter markets as sellers, conditional on being milk producers. Interestingly, conditional on being a butter seller, female-headed households sell lower amounts of butter. Female-headed milk producers also use larger amounts of purchased inputs, suggesting that such households manage their dairy farms more intensively. These results suggest that targeted support to female-headed households to engage in dairy production may be a useful policy direction to promote dairy production in rural Ethiopia.

Household milk consumption needs also stands out as an important factor in the decision to engage in milk production, butter marketing and the use of purchased dairy inputs. Households with higher numbers of children under five years of age, and larger family sizes, are more likely to be milk producers, and less likely to sell butter, and households with higher numbers of children under five years of age sell less butter. Similarly, the volume of milk produced increases probability of selling butter as well as increases the volume of sales. Conditional on being a milk producer, the probability of using purchased dairy inputs increases with the number of children under five years of age and the number of working age family members. These results imply the dire need to promote interventions that increase animal productivity and milk production.

Opportunity cost of factors of production also seems to matter in milk production. In areas where wage rates for off-farm employment for males is higher, involvement in dairy production is lower, indicating a trade-off in the use of labour for dairy production and off-farm activities. Butter sellers with larger small ruminant flock sizes purchase less dairy inputs. The relative price of maize to butter is also negatively associated with the value of purchased dairy input use. This result suggests that improving the profitability of dairy production or the adoption of labour-saving technologies and practices may help promote dairy production.

Marketing costs also matter in dairy production in rural Ethiopia. Distance to market discourages butter markets participation. Moreover, distance to livestock input markets decreases the probability of input market participation. These results imply the need to develop livestock output and input markets to promote market-oriented dairy production.

Clearly, dairy producers in rural Ethiopia are facing liquidity constraints. Access to credit is associated with a higher probability of dairy production, and income from off-farm employment and the sale of small ruminants encourages the use of purchased inputs. These results suggest that credit facilities targeted at dairy production are needed in rural Ethiopia.

Our results also indicate that market orientation in dairy production in rural Ethiopia is low. Milk production and butter sales is considered as an alternative source of income to the household, but not necessarily meant as a business enterprise aimed at maximizing profit. While engagement in milk production is positively influenced by butter prices, participation in butter markets as sellers or the amount of butter sales do not respond to price signals. Moreover, households with higher off-farm income are less likely to sell butter.

References

Adane, Z., Duguma, G., Ebro, A. and Chali, A. 2015a. S*timulating the use of farmer training centres in Oromia*. Blog story. URL https://lives-ethiopia.org/2015/03/23/farmer-training-centers-ftcs-in-oromia/ (accessed 10.5.16).

Adane, Z., Shiferaw, K. and Gebremedhin, B. 2015b. *Sources of technical inefficiency of smallholder farmers in milk production in Ethiopia*. LIVES Working Paper 3. Nairobi, Kenya: ILRI.

Ahmed, M., Ehui, S. and Yemesrach, A. 2004. *Dairy development in Ethiopia*. Washington DC, USA.

Alene, A.D., Manyong, V.M., Omanya, G., Mignouna, H.D., Bokanga, M. and Odhiambo, G. 2008. Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya. *Food Policy* 33:318–328. doi:10.1016/j.foodpol.2007.12.001.

Baloch, M.A. and Thapa, G.B. 2016. The effect of agricultural extension services: Date farmers' case in Balochistan, Pakistan. *J. Saudi Soc. Agric. Sci.* doi:10.1016/j.jssas.2016.05.007.

Belay, K. and Abebaw, D. 2004. Challenges Facing Agricultural Extension Agents: A Case Study from South-western Ethiopia. *African Dev. Rev.* 16:139–168. doi:10.1111/j.1467-8268.2004.00087.x.

Bellemare, M.F. and Barrett, C.B. 2006. An Ordered Tobit Model of Market Participation: Evidence from Kenya and Ethiopia. *Am. J. Agric. Econ.* 88:324–337. doi:10.1111/j.1467-8276.2006.00861.x.

Beyene, B. 2015. Review on Value Chain Analysis of Dairy Products in Ethiopia College of Agriculture and Veterinary Medicine. *J. Econ. Sustain*. Dev. 6:26–37.

Burke, W.J., Myers, R.J. and Jayne, T.S. 2015. A Triple-Hurdle Model of Production and Market Participation in Kenya's Dairy Market. *Am. J. Agric. Econ*. 97:1227–1246. doi:10.1093/ajae/aav009.

Cragg, J.G. 1971. Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods. *Econometrica* 39:829–844. doi:10.2307/1909582.

CSA. 2016. Agricultural Sample Survey 2015/16 [2008 E.C.] Volume II Report on Livestock and Livestock Characteristics (Private Peasant Holdings). Addis Ababa, Ethiopia.

CSA. 2014. Agricultural Sample Survey 2013/14 [2006 E.C.] Volume VII Report on Crop and Livestock Product Utilization (Private Peasant Holdings, Meher Season), Report. Addis Ababa, Ethiopia.

Debrah, S. and Anteneh, B. 1995. Dairy marketing in Ethiopia, Markets of first sale and producers' marketing patterns. (No. 19), ILCA Research Report. Addis Ababa.

Duguma, B., Kechero, Y. and Janssens, G.P.J. 2012. Survey of major diseases affecting dairy cattle in Jimma town, Oromia, Ethiopia. *Glob. Vet*. 8:62–66.

Duncan, A.J., Teufel, N., Mekonnen, K., Singh, V.K., Bitew, A. and Gebremedhin, B. 2013. Dairy intensification in developing countries: effects of market quality on farm-level feeding and breeding practices. *Animal* 7:2054–62. doi:10.1017/S1751731113001602.

Food and Agriculture Organization of the United Nations (FAO). 2013. Milk and dairy products in human nutrition, Milk and Dairy Products in Human nutrition. Rome, Italy: FAO.

Fletschner, D. and Mesbah, D. 2011. Gender disparity in access to information: Do spouses share what they know? *World Dev*. 39:1422–1433. doi:10.1016/j.worlddev.2010.12.014.

Francesconi, G.N., Heerink, N. and D'Haese, M. 2010. Evolution and challenges of dairy supply chains: Evidence from supermarkets, industries and consumers in Ethiopia. Food Policy 35:60–68. doi:10.1016/j.foodpol.2009.06.003

Freeman, H.A., Ehui, S.K. and Jabbar, M. 1998. Credit constraints and smallholder dairy production in the East African highlands: Application of a switching regression model. *Agric. Econ.* 19:33–44. doi:10.1016/S0169-5150(98)00044-9.

Fulgoni, V.L., Keast, D.R., Auestad, N. and Quann, E.E. 2011. Nutrients from dairy foods are difficult to replace in diets of Americans: Food pattern modeling and an analyses of the National Health and Nutrition Examination Survey 2003-2006. *Nutr. Res.* 31:759–765. doi:10.1016/j.nutres.2011.09.017.

Gebremedhin, B., Tegegne, A., Hoekstra, D., Jemaneh, S., Shiferaw, K., Bogale, A. and Getahun, Y. 2014. Developing the butter value chain in Ethiopia. LIVES Working Paper 1. Nairobi, Kenya: ILRI.

Goetz, S.J. 1992. A Selectivity Model of Household Food Marketing Behavior in Sub-Saharan Africa. *Am. J. Agric. Econ.* 74:444–452. doi:10.2307/1242498.

Hassen, A., Ebro, A., Kurtu, M. and Treydte, A.C. 2010. Livestock feed resources utilization and management as influenced by altitude in the central highlands of ethiopia. Livest. *Res. Rural Dev.* 22.

Heckman, J.J. 1979. Sample Selection Bias as a Specification Error. *Econometrica* 47:153–161.

Holloway, G., Ehui, S. and Teklu, A. 2008. Bayes estimates of distance-to-market: Transactions costs, cooperatives and milk-market development in the Ethiopian Highlands. J. Appl. *Econom.* 23:683–696. doi:10.1002/jae.1019.

Holloway, G., Nicholson, C., Delgado, C., Staal, S. and Ehui, S. 2004. A revised Tobit procedure for mitigating bias in the presence of non-zero censoring with an application to milk-market participation in the Ethiopian highlands. *Agric. Econ.* 31:97–106. doi:10.1016/j.agecon.2003.12.001

Holloway, G., Nicholson, C., Delgado, C., Staal, S. and Ehui, S. 2000a. *How to make a milk market: A case study from the Ethiopian highlands.* (No. 28). Socio-economics and Policy Research Working Paper. Nairobi, Kenya.

Holloway, G., Nicholson, C., Delgado, C., Staal, S. and Ehui, S. 2000b. Agro industrialization through institutional innovation transaction costs, cooperatives and milk-market development in the east-African highlands. *Agric. Econ.* 23:279–288. doi:10.1016/S0169-5150(00)00089-X.

Hoorweg, J., Leegwater, P. and Veerman, W. 2000. Nutrition in agricultural development: Intensive dairy farming by rural smallholder. *Ecol. Food Nutr.* 39:395–416. doi:10.1080/03670244.2000.9991627.

Johnson, N., Njuki, J., Waithanji, E., Nhambeto, M., Rogers, M. and Kruger, E.H. 2015. The gendered impacts of agricultural asset transfer projects: Lessons from the Manica Smallholder Dairy Development Program. *Gend. Technol. Dev.* 19:39. doi:10.1177/0971852415578041.

Kaitibie, S., Omore, A., Rich, K. and Kristjanson, P. 2010. Kenyan Dairy Policy Change: Influence Pathways and Economic Impacts. *World Dev.* 38:1494–1505. doi:10.1016/j.worlddev.2010.06.008.

Kidoido, M. and Korir, L. 2015. Do low-income households in Tanzania derive income and nutrition benefits from dairy innovation and dairy production? *Food Secur.* 7:681–692. doi:10.1007/s12571-015-0419-z.

Kumar, C.S., Turvey, C.G. and Kropp, J.D. 2013. The Impact of Credit Constraints on Farm Households: Survey Results from India and China. *Appl. Econ. Perspect. Policy* 35:508–527. doi:10.1093/aepp/ppt002.

Lerman, Z. 2004. Policies and institutions for commercialization of subsistence farms in transition countries. *J. Asian Econ.* 15:461–479. doi:10.1016/j.asieco.2004.05.004.

Makoni, N., Mwai, R., Redda, T., van der Zijpp, A. and van der Lee, J. 2013. White Gold: Opportunities for Dairy Sector Development Collaboration in East Africa. *Cent. Dev. Innov.* 203. doi:CDI-14-006.

Mekonnen, H., Dehninet, G. and Kelay, B. 2010. Dairy technology adoption in smallholder farms in "Dejen" district, Ethiopia. *Trop. Anim. Health Prod.* 42:209–216. doi:10.1007/s11250-009-9408-6.

Moll, H.A.J., Staal, S.J. and Ibrahim, M.N.M. 2007. Smallholder dairy production and markets: A comparison of production systems in Zambia, Kenya and Sri Lanka. *Agric. Syst.* 94:593–603. doi:10.1016/j.agsy.2007.02.005.

Negassa, A. 2009. Improving smallholder farmers' marketed supply and market access for dairy products in Arsi zone, Ethiopia. ILRI Research Report 21. 107 pp. Nairobi, Kenya: ILRI.

Ngongoni, N.T., Mapiye, C., Mwale, M. and Mupeta, B. 2006. Factors affecting milk production in the smallholder dairy sector of Zimbabwe. *Livest. Res. Rural Dev.* 18:89.

Ouma, E., Jagwe, J., Obare, G.A. and Abele, S. 2010. Determinants of smallholder farmers' participation in banana markets in Central Africa: The role of transaction costs. Agric. Econ. 41:111–122. doi:10.1111/j.1574-0862.2009.00429.x

Quisumbing, A.R., Roy, S., Njuki, J., Tanvin, K. and Waithanji, E. 2013. *Can dairy value-chain projects change gender norms in rural Bangladesh? Impacts on assets, gender norms, and time use*. IFPRI Discussion Paper 01311. Washington DC, USA: IFPRI.

Staal, S., Delgado, C. and Nicholson, C. 1997. Smallholder dairying under transactions costs in East Africa. *World Dev.* 25:779–794. doi:10.1016/S0305-750X(96)00138-6.

StataCorp.2015. Stata: Release 14. Statistical Software. Cllege Station, TX: StataCorp LP.

Tegegne, A., Gebremedhin, B., Hoekstra, D., Belay, B. and Mekasha, Y. 2013. *Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences and opportunities for market-oriented development*. IPMS Working Paper 31. Nairobi, Kenya: ILRI.

Winter-Nelson, A. and Temu, A. 2005. Impacts of prices and transactions costs on input usage in a liberalizing economy: Evidence from Tanzanian coffee growers. *Agric. Econ.* 33:243–253. doi:10.1111/j.1574-0864.2005.00064.x.

Yigrem, S., Beyene, F., Tegegne, A. and Gebremedhin, B. 2008. *Dairy production, processing and marketing systems of Shashemene-Dilla area, south Ethiopia*. IPMS Working Paper 9. Nairobi, Kenya: ILRI.

Yilma, Z., Emannuelle, G.B. and Ameha, S. 2011. *A Review of the Ethiopian Dairy Sector*. Addis Ababa, Ethiopia: Food and Agriculture Organization of the United Nations, Sub-Regional Office for Eastern Africa, pp 81.

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Livestock and irrigation value chains for Ethiopian smallholders project aims to improve the competitiveness, sustainability and equity of value chains for selected high-value livestock and irrigated crop commodities in target areas of four regions of Ethiopia. It identifies, targets and promotes improved technologies and innovations to develop high value livestock and irrigated crop value chains; it improves the capacities of value chain actors; it improves the use of knowledge at different levels; it generates knowledge through action-oriented research; and it promotes and disseminates good practices. Project carried out with the financial support of the Government of Canada provided through Foreign Affairs, Trade and Development Canada (DFATD). lives-ethiopia.org

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