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Abstract

Market access plays an essential role in assuring better income and welfare levels for smallholder livestock producers, and thus contributes to poverty alleviation. This is even more so in the Ethiopian context where livestock play an essential role in the economy. Making use of the Heckman estimation procedure, this paper identifies policy and technology options to increase participation and sales of smallholder producers in livestock markets in Ethiopia, based on data from 934 household surveys conducted between 1999 and 2001 in the highlands of Tigray and Amhara regions in northern Ethiopia. The analysis demonstrates that physical capital (ownership of different species of livestock and landholding) and financial capital (crop income and non-farm income) are the main factors influencing market participation and sales. Education was also found to positively affect value of sales of dairy products. Distance to markets and towns were not found to be significant. We conclude that in the case of Ethiopia, constraints to production of livestock and livestock products (e.g. capital to purchase animals, feed, and processing equipment) are the main factors limiting participation and sales in livestock markets.

Key words: market participation and sales, livestock markets, Ethiopian smallholder farmers

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1. Introduction

In a recent study, Delgado et al. (1999) projected that per capita consumption of livestock products will increase by about 50percent from 1993 to 2020, with most of the increases attributed to developing countries, as a result of population growth, urbanization, and rising incomes. In sub-Saharan Africa (SSA) total consumption of meat and milk is expected to double between 1997 and 2020 to reach 11.3 and 35.4 million tonnes (Ehui et al. 2002). This expected increase in demand for animal products has profound implications for food security and poverty alleviation among rural people in SSA. In particular, the expected demand for livestock products presents expanding market opportunities for poor smallholder livestock producers. Therefore, improving access to markets of poor smallholder livestock producers can help them benefit from the rapidly growing demand for livestock products. The International Livestock Research Institute (ILRI) and its partners have identified that encouraging market participation of smallholder livestock producers is a major pathway for getting rural people out of poverty and improving their food security, as livestock contribute to the livelihoods of more than two-thirds of the world's rural poor (ILRI 2002).

Market access plays an essential role in assuring better income and welfare for smallholder livestock producers through various channels. By raising incomes, markets increase purchasing power, which creates demand for consumer goods and, thus, enhances welfare. In addition, by creating demand for production inputs and investment goods, markets promote economic growth. Markets also facilitate the accumulation of assets, provide the opportunity for improved nutrition and balanced diets and, therefore, help alleviate poverty. In parts of the world, rural people often say that one reason they cannot improve their living standards is that they face difficulties in accessing markets (IFAD, 2003). Also with limited opportunities for access to markets, livestock are often kept beyond their optimum productive levels (e.g., in terms of producing milk, meat, and draft power) where there is no value-added from feeding and grazing, resulting in overstocking and overgrazing. Furthermore, improving market access can also increase productivity and supply of livestock, without which the anticipated increase in demand for livestock products may not be met.

Although improving access to markets has numerous benefits, there may be potential offsetting effects associated with removing the constraints limiting market participation and supply. For example, market access is restricted primarily by higher transaction costs created by poor or lack of roads. Thus, while building roads or improving road conditions may increase access to markets, which may in turn increase participation and supply in the short run, it may also increase non-farm employment opportunities and raise the opportunity cost of livestock production and reduce participation and supply in the long run. This complicates policy implications of road development on market participation and supply decisions. Similar complications arise for other factors that limit market access, including lack of financial and physical capital.

This paper provides an empirical basis for identifying options to increase participation and sales of smallholder producers in livestock markets in Ethiopia, based on data from 934 household surveys conducted between 1999 and 2001 in the highlands of Tigray and Amhara regions in northern Ethiopia.

Identifying policy options for improving market participation and sales of livestock and livestock products is particularly important in the Ethiopian context as livestock play a very prominent role in the Ethiopian economy. With a per capita gross national income (GNP) of US$ one hundred and 31percent of the population living on less than US$ one a day (World Bank 2003[1]), Ethiopia is one of the poorest countries in the world. Ethiopia has the largest livestock population in Africa where livestock contribute about 30 –to 35percent to agricultural gross domestic product (GDP) and about 13 –to 16percent to overall GDP (Degefe and Nega 2000). Moreover it is estimated that over 85percent of farm cash income is generated from livestock (ibid.). Over the last decade (between the Ethiopian fiscal years1991/92 and 2000/01), the share of livestock in agricultural exports and total exports averaged 15percent and 13percent respectively[2]. Thus, identifying policy options for increasing market participation and sales of livestock and livestock products is believed to

[1] The figures for per capita GNP and the percentage of the population living below US$ 1 a day are reported for the years 2001 and 1995 respectively.
[2] Authors' calculations using data obtained from the National Bank of Ethiopia (the data originated from the Ethiopian Customs Authority).

significantly improve the income and welfare of smallholder livestock producers and help alleviate poverty in Ethiopia.

The next section presents the conceptual framework and hypotheses regarding market participation and supply decisions. Section 3 presents the data. Empirical approach, results and discussion are presented in Section 4, and conclusions and policy implications in Section 5.

2. Conceptual framework and hypotheses

The econometric approach used is the Heckman (1979) two-step procedure. First, the factors that influence the decision to sell live animals and/or animal products are estimated. Second, the factors that affect the amount of sales are identified, using results from the first stage.

The decision to participate in the market (the selection equation) is specified in equation (1), where the selection variable z^* (probably based on marginal profitability of participating) is not observed but rather a sign of whether they participate or not.

$$z_i^* = \gamma' w_i + u_i, \tag{1}$$

where $u_i \sim N(0,1)$ and,

$z_i = 1$ if $z_i^* > 0$,

$z_i = 0$ if $z_i^* \leq 0$

Equation (1) is estimated by maximum likelihood as an independent probit model from the entire sample of market participants and non-participants; w is a vector of factors influencing the decision. The sample selection bias, what Heckman (1979) refers to as the inverse Mill's ratio (λ), is computed from the parameter estimates of the selection equation for each observation in the selected sample (Greene 1993), and is represented by:

$$\lambda_i = \frac{\phi(\gamma' w_i)}{\Phi(\gamma' w_i)} \tag{2}$$

where ϕ and Φ are, respectively, the density and distribution functions.

The level of sales, y, specified in equation (3), is observed only if $\gamma' w_i + u_i > 0$, and is estimated by ordinary least squares, where the vector of inverse Mill's ratios is included as an additional regressor.

$$y_i = \beta' x_i + \theta \lambda_i + \varepsilon_i \tag{3}$$

where $\varepsilon_i \sim N(0, \sigma)$

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 ε_i is represented by ρ, where u_i and ε_i are bivariate and normally distributed (Greene 1993).

$$corr(u_i, \varepsilon_i) = \rho \tag{4}$$

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.

Note that w and x are the vectors of factors affecting participation and sales, respectively, and $w \subset x$. The factors, drawing from the literature on the determinants of market participation and sales (Holloway et al. 2000; Lapar, Holloway, and Ehui 2002), include transaction costs (distance to roads, markets and towns, transport availability, labour, and population density), human capital (age, education, gender, extension training), physical capital (number of livestock producing stock, farmland), and financial capital (crop income, non-farm income, credit). In general, farmers first decide to participate in the market when it is profitable to do so, and then decide on how much to sell. Thus, the factors mentioned above are those that affect profitability by affecting marketing costs.

Transaction costs. In general, we expect that farmers with lower transaction costs will be more likely to participate in markets and sell more, as they are more likely to recover their

production and marketing costs. Thus, we expect farmers living closer to roads, markets or towns, having means of transportation, or more labour, to participate and sell more livestock and livestock products. Similarly, farmers in more densely populated areas will face greater demand for livestock and livestock products and have lower search costs, and so population density is expected to positively affect participation and sales. However, the impacts may also be negative. For example, better access to roads, markets or towns may increase the opportunity cost of labour and capital in livestock production and marketing (especially where alternative employment opportunities exist and the returns to labour and capital are higher) and may in turn reduce participation and sales. Larger households also tend to have more dependents and their production activities may be more subsistence oriented, diminishing market participation and sales. More dense areas also tend to be associated with greater demand for other services, creating opportunities for other employment, increasing the opportunity cost of labour and capital investment in agriculture.

Human capital. We expect age to be negatively associated with market participation, as older households tend to have more dependents and more subsistence production activities. Gender is also expected to influence market participation, and expect female-headed households and households with more female members to have a positive effect, especially with respect to dairy products, since females are primarily involved in these production activities. Education and extension may have mixed impacts. On one hand, education and extension enhances the skill and ability to better utilize market information, which may reduce marketing costs and make it more profitable to participate in the market. This is very important given the general belief by farmers that markets are not favourable. Education, however, raises the opportunity cost of labour and may reduce the profitability of livestock production and market participation by farmers where alternative employment opportunities exist and are more profitable to engage in. With a crop focus, extension training is expected to increase the profitability of crop production relative to livestock, reducing participation in livestock markets.

Physical capital. Ownership of more livestock producing stock is expected to have a positive effect on participation and sales, although different species may have different

effects, depending on the roles and functions they play in the farming system. For example, since cows are primarily kept for milk production, ownership of cows is more likely to have a positive effect on dairy (milk, butter, and cheeses) market participation and sales, while ownership of young cattle, small ruminants, and poultry are more likely to have a positive impact on sales of lives animals. Ownership of bulls and oxen, on the other hand, may have non-positive effects, as they are kept for reproductive purposes and draught power, respectively. Physical assets such as land may have indirect positive impacts by enabling farmers to overcome credit constraints, where land can be used as collateral for credit, and allow them to adopt improved technologies that increase productivity.

Financial capital. This is expected to have mixed impacts. For example, households with higher crop income may indicate low profitability of livestock production, diminishing participation and sales. On the other hand, households with higher crop income may be more likely to diversify their production activities into livestock and adopt improved technologies that could potentially increase productivity. Similarly, higher non-farm income of households may indicate low profitability of livestock production, diminishing participation and sales, although exogenous income, such as remittances, may increase adoption of improved technologies and increase livestock productivity and, hence, participation and sales. Credit for livestock activities (such as fattening or purchase of cow) is expected to have positive effects, while those given for cropping and other activities may raise the opportunity cost of livestock production, hence reducing participation in livestock markets and sales of livestock and livestock products.

Factors affecting market participation but not sales. It is clear to see why factors that affect the decision by farmers on how much to sell will also affect the decision on whether or not to participate in the market. These factors primarily affect productivity of livestock and, hence, determine how much is produced, so that greater production leads to greater marketable surplus. However, there are factors that may influence the decision on whether or not to sell, but not how much to sell. Such factors, including many of the household characteristics, do not have influence on the productivity of livestock. This issue is taken up

when discussing the econometric model in Section 4, with respect to identification and estimation of the sales equation.

3. Survey and data

The variables used in this analysis were constructed from data collected in a sample survey conducted among 198 villages (communities) and 934 households in Tigray and Amhara regions of northern Ethiopia between 1998 and 2001. A stratified random sample of 99 Peasant Associations (PAs) (usually consisting of four or five villages)[3] was selected from highland areas (above 1,500 m.a.s.l.) of the two regions. Strata were defined according to variables associated with moisture availability (one major factor affecting agricultural productivity), market access, and population density.

In Amhara region, secondary data was used to classify the *weredas* (districts) according to access to an all-weather road, the 1994 rural population density (greater or less than one hundred persons/km^2), and whether the area is drought-prone or not (following the definition of the Ethiopian Disaster Prevention and Preparedness Committee). Two additional strata were defined for PAs where irrigation projects are found to give a total of ten strata. In each of the strata, four to five PAs were randomly selected. From each sample PA, two villages were randomly selected, for a total of 98 villages. In each village, four to five households were randomly selected, for a total of 434 households.

In Tigray region, PAs were stratified by whether an irrigation project was present or not, and for those without irrigation, by distance to the *wereda* town (greater or less than ten km.). A total of three strata were defined in Tigray, with 54 PAs randomly selected per strata. PAs closer to towns and in irrigated areas were selected with a higher sampling fraction to assure adequate representation. Four PAs in the northern part of Tigray could not be studied due to the war with Eritrea. From each of the remaining PAs, two villages were randomly

[3] The Peasant Association (PA) is the lowest administrative unit in Ethiopia.

selected, and from each village, five households were randomly selected. A total of 50 PAs, one hundred villages, and five hundred households were then surveyed.

Information collected includes sales of livestock and livestock products, ownership of various species of livestock, and access to markets, infrastructure and services, household composition, and assets. The data were supplemented by secondary geographic, demographic and climatic information.

The farming system in the northern Ethiopian highlands is characterized by mixed crop-livestock production, where households hold an average of 1.2 hectares of farmland, with about 82percent of the households in the study area owning up to 17 (average of 3.3) tropical livestock units of cattle and small ruminants. On average, the number of livestock owned per household was 1.4 oxen, 0.8 cows, 0.5 TLUs of other cattle (bulls, young bulls, heifers and calves), and 2.5 sheep and goats. Ownership of poultry and pack animals was also common, averaging 2.4 and 0.3 per household, respectively. Sales were restricted to live animals and dairy products (milk, butter and cheese). Among the households that owned cattle and small ruminants, about 50percent of them sold live animals, averaging one TLU or Ethiopian Birr (EB) 582.[4] With respect to dairy products, only 264 households produced milk, butter or cheese, and about 50percent of them did sell some, averaging EB 141 per household. The total value of live animals and dairy products sold was EB 558 per household.

4. Econometric approach and results

Econometric approach and estimation

We estimated three sets of regressions where the dependent variables are: 1a) whether or not households sold live animals (cattle and small ruminants)[5], and 1b) value of live animals sold; 2a) whether or not households sold dairy products (milk, butter, and cheese), and 2b)

[4] During the survey period, US$ 1≈EB 8.5.

[5] We only estimate participation and sales with respect to cattle and small ruminants, as they constitute the bulk of live animal sales by households.

value of dairy products sold; and 3a) whether or not households sold live animals or dairy products, and 3b) total value of live animals and dairy products sold.

As discussed in Section 2 we estimated the participation equation by probit, and used Heckman's approach (Heckman 1979; Maddala 1983) to estimate the sales equation, since sales are observed only for those households that participated in the market or sold livestock or livestock products. Therefore, sales of livestock and livestock products are censored at values greater than zero. In principle, estimating the sales equation independently will result in inconsistent estimates due to sample selection bias. Thus, we use the inverse mills ratio (IMR) obtained form the probit estimation of participation in the least squares estimation of the sales. Since the sales equation uses IMR estimated from another estimation, the standard errors are biased and need to be corrected for. We use the Heckman procedure in STATA software (StataCorp 2002), which corrects for the bias in the standard errors. We also tested for independence of the participation and sales equations, which we failed to reject in all three sets of estimations.

The explanatory variables used in the estimations are those that influence transaction costs and associated with human capital, physical capital, and financial capital. Description of all the variables (dependent and explanatory) and summary statistics are shown in Tables 1 and 2, respectively.

There are two econometric issues to deal with here. First, is the identification of the sales equation, which we deal with by excluding some of human capital variables (including age and sex of household, household size, proportion of female household members, and dependency ratio) used in the probit estimation of participation from the sales regression. These variables are expected to have effects on participation but not on sales.

The second econometric issue is censoring of the market participation variable. This problem arises because of the nature of the data and how the effective sample size for participation is defined. For example, households that did not own cattle or small ruminants (or produced these animals) could not have participated in the market for selling them even if they would have otherwise. Similarly, households that did not produce milk, butter or cheese could not have participated in the market for selling these products. Therefore, the effective

sample size for participation in the market for cattle, small ruminants, or dairy products are restricted to only those households that owned cattle or small ruminants or produced milk, butter or cheese, meaning that the market participation variable is also censored. Thus, we first predict the probability of owning cattle or small ruminants or producing milk, butter or cheese, obtain the IMRs associated with ownership or production, and use the IMRs in the respective probit estimation of the participation equations. Note that the identification issue and correcting the standard errors also applies. Therefore, in addition to the explanatory variables used in the participation equation (except ownership of cattle and small ruminants), we included distance to veterinary clinic, distance to nearest all-weather road, and altitude as instruments, and then estimated the ownership and participation equations using the *heckprob* command in STATA (StataCorp 2002).

Results and discussion

The econometric results for participation and sales are shown in Tables 3 and 4, and the probit results for predicting the probability of owning cattle or small ruminants and producing milk, butter, and cheese are shown in the Appendix.

Market participation. The results show that participation in livestock (cattle and small ruminants) and livestock products (milk, butter, and cheeses) markets is influenced to a great extent by physical and financial capital of the household, and not so much by human capital (except dependency ratio which is positively associated with participation) or the physical distance from markets and access to infrastructure. Landholding unambiguously reduces participation in both markets, suggesting crop production bias. However, ownership of small ruminants increases participation in the market for live animals, but reduces participation in the market for dairy products, while ownership of oxen also reduces participation in the market for dairy products. That ownership of small ruminants increases participation in markets is not surprising because small ruminants require minimal inputs and are easy to dispose of. Crop income and non-farm income increases participation in both live animals and dairy products markets, although crop income is associated with a reduction in participation in dairy products markets. Households located in Tigray, compared to their

Amhara counterparts, were associated with lower likelihood to participate in dairy products markets, although there was no significant difference between the two regions in participation in live animals markets.

Sales. Here too physical distance to markets and towns has no significant impact. However, population density, education, and physical and financial capital of households significantly affect sales (value) of livestock and livestock products. Areas with greater population pressure are associated with lower sales of live animals, but greater sales of dairy products, suggesting the profitability of dairy production in densely populated areas. Households with better education, more cows, and greater non-farm income are associated with greater sales of dairy products, while those with more young cattle, pack animals, and crop income are associated with greater sales of live animals. These findings reinforce the findings of Holloway et al. (2000) where they find that access to animal stock and intellectual capital such as extension increases access to dairy markets by smallholder producers. In a similar ILRI study conducted in the Philippines, Lapar, Holloway, and Ehui (2002) also show that smallholder participation in livestock markets and sales increase with higher levels of animal stock, financial capital resources, and lower levels of transaction costs. Ownership of poultry reduces sales, while location in Tigray (or Amhara) has mixed impacts. In particular, households located in Tigray are associated with greater sales of dairy products, while those located in Amhara are associated with greater sales of live animals.

5. Conclusions and implications

This paper examined the factors affecting livestock market participation and sales, using the Heckman procedure and data from the mixed crop-livestock farming systems in the highlands Amhara and Tigray regions of northern Ethiopia. The results show that physical capital (ownership of different species of livestock and landholding) and financial capital (crop income and non-farm income) are the main factors influencing market participation and sales, and not the distance to markets and towns. These suggest that constraints to production of

livestock and livestock products (e.g., capital to purchase animals, feed, and processing equipment) may be the main factors limiting market participation and sales. Since livestock are trekked to markets, ownership of pack animals (mules, donkeys, horses, and camels) is critical in promoting market participation. Pack animals serve two purposes of transporting people to the market and commodities purchased from the market to the home.

Education was also found to positively affect value of sales of dairy products. This suggests that income from sale of milk, butter, and cheese can be increased through education and training (especially targeting females) to improve the quality of products, which can in turn attract better prices.

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Table 1: Description of variables

Variable	Description
Dependent variables	
Whether sold live animals	Dummy variable of whether or not household sold live animals (1=yes; 0=no)
Value of live animals sold	Value of live animals sold by household (Ethiopian Birr)
Whether sold dairy products	Dummy variable of whether or not household sold dairy products (1=yes; 0=no)
Value of dairy products sold	Value of dairy products sold by household (Ethiopian Birr)
Whether sold live animals or dairy products	Dummy variable of whether or not household sold live animals or dairy products (1=yes; 0=no)
Value of live animals and dairy products sold	Value of live animals and dairy products sold by household (Ethiopian Birr)
Explanatory variables	
Distance to nearest market	Walking time from peasant association to the nearest market (minutes)
Distance to district town	Distance from peasant association to the district town (kilometres)
Population density	Number of households in peasant association per hectare
Education	Average number of years of formal education of household members
Extension	Dummy variable of whether or not household received extension (1=yes; 0=no)
Oxen owned	Number of oxen owned by household
Cows owned	Number of local and crossbred cows owned by household
Other cattle owned	Number of other cattle (bulls, young bulls, heifers and calves) owned by household (TLU)
Small ruminants owned	Number of sheep and goats owned by household
Poultry owned	Number of chickens owned by household
Pack animals owned	Number of pack animals (donkeys, horses and camels) owned by household (TLU)
Landholding	Amount of farmland owned by the household (hectares)
Crop income	Amount of crop income of household (Ethiopian Birr)
Non-farm income	Amount of non-farm income of household (Ethiopian Birr)
Credit	Dummy variable of whether or not household received credit (1=yes; 0=no)
Region	Dummy variable of regional location of household (1=Amhara region; 0=Tigray region)
Instruments	
Sex of household head	Sex of household head (1=female; 0=male)
Age of household head	Age of household head (years)
Household size	Number of household members
Proportion of females	Proportion of household members that are female
Dependency ratio	Proportion of household members less than 15 years or greater than 59 years
Distance to nearest all-weather road	Walking time from peasant association to the nearest all-weather road (minutes)
Distance to veterinary clinic	Walking time from peasant association to the nearest veterinary clinic (minutes)
Altitude	Average elevation of the peasant association of the household (meters above sea level)

Table 2. Summary statistics

Variable	N	Mean	Standard Error	Min	Max
Dependent variables					
Whether sold live animals	727	0.448	0.031	0.00	1.00
Value of live animals sold	326	582.108	46.010	7.00	2800.00
Whether sold dairy products	264	0.472	0.056	0.00	1.00
Value of dairy products sold	132	140.803	19.241	3.90	1900.00
Whether sold live animals or dairy products	738	0.495	0.031	0.00	1.00
Value of live animals and dairy products sold	379	558.358	47.632	7.00	3150.00
Explanatory variables					
Distance to nearest market	911	91.391	4.064	0.00	480.00
Distance to district town	911	35.465	1.467	0.00	168.00
Population density	891	0.425	0.013	0.04	1.37
Education	911	1.809	0.108	0.00	19.50
Extension	911	0.504	0.027	0.00	1.00
Oxen owned	911	1.366	0.060	0.00	7.00
Cows owned	911	0.838	0.061	0.00	12.00
Other cattle owned	911	0.461	0.035	0.00	5.50
Small ruminants owned	911	2.523	0.203	0.00	49.00
Poultry owned	911	2.375	0.184	0.00	60.00
Pack animals owned	911	0.340	0.032	0.00	5.6.00
Landholding	870	1.141	0.048	0.00	7.90
Crop income	911	2094.155	121.362	0.00	14901.33
Non-farm income	908	409.897	29.087	0.00	12800.00
Credit	911	0.630	0.025	0.00	1.00
Region	911	0.179	0.005	0.00	1.00
Instruments					
Sex of household head	911	0.133	0.018	0.00	1.00
Age of household head	911	43.548	0.685	16.00	86.00
Household size	911	6.315	0.145	1.00	16.00
Proportion of females	911	0.486	0.009	0.00	1.00
Dependency ratio	911	0.537	0.010	0.00	1.00
Distance to nearest all-weather road	910	183.940	8.385	0.00	1440.00
Distance to veterinary clinic	909	127.036	4.435	0.00	840.00
Altitude	911	2428.560	19.862	1500.00	3635.00

Notes: During the period of the survey, US$1≈EB8.5. Means and standard errors are adjusted for weighting, stratification and clustering of sample.

Table 3. Econometric results of livestock and livestock products market participation by households (probit corrected for sample selection)

Explanatory variable	Whether sold live animals		Whether sold dairy products		Whether sold live animals or dairy products	
Distance to nearest market	0.0015		0.0015		0.0015	
Distance to district town	-0.0031		-0.0015		-0.0033	
Population density	0.3168		0.0021		0.2036	
Sex of household head	-0.1458		0.0568		-0.2226	
Age of household head	-0.0014		-0.0104		0.0000	
Household size	-0.0015		-0.0026		-0.0091	
Proportion of females	0.5977		0.7563		0.4933	
Dependency ratio	0.7998	*	0.8406		0.8750	*
Education	0.0278		0.0205		0.0247	
Extension	0.2589		-0.2313		0.2183	
Oxen owned	-0.1256		-0.1733	***	-0.1541	
Cows owned	0.1095		-0.0133		0.1830	**
Other cattle owned	-0.1079		0.1664	**	-0.0271	
Small ruminants owned	0.0490	***	-0.0144	***	0.0321	*
Poultry owned	-0.0266		0.0071		-0.0198	
Pack animals owned	-0.0682		-0.0985		0.0056	
Landholding	-0.3080	***	-0.2642	**	-0.2882	***
Crop income	0.0001	**	-0.0002	***	0.0001	*
Non-farm income	0.0002	*	-0.0000		0.0003	***
Credit	0.0356		-0.3268	*	0.0325	
Region	0.0031		-0.8785	***	0.0764	
Inverse mills ratio associated with owning livestock or producing milk	-2.2711		-3.558	**	-1.9957	**
Intercept	-0.7353		2.2540	***	-0.6607	
Chi-squared statistic	41.4900	***	145.4400	***	37.9000	***
Number of observations	683		253		693	

Notes: Detailed description of dependent and explanatory variables is given in Table 1. The dependent variables are dummy variables of whether or not household sold a particular item. Coefficients are corrected for weighting, stratification and clustering of sample. *, ** and *** indicate statistical significance at the 10, 5 and 1percent levels, respectively.

Table 4. Econometric results of sales of livestock and livestock products by households (Heckman second-stage regression)

Explanatory variable	Value of live animals sold		Value of dairy products sold		Value of live animals and dairy products sold	
Distance to nearest market	-0.4494		0.3545		-0.4393	
Distance to district town	-1.0475		0.2769		-0.9096	
Population density	-357.0670	***	264.1013	***	-254.5551	*
Education	1.1815		13.3306	**	4.8732	
Extension	29.9347		3.0234		63.1691	
Oxen owned	0.5757		13.9895		-2.4621	
Cows owned	-16.6416		30.4656	*	-26.8594	
Other cattle owned	125.4479	**	-36.2912		108.4980	*
Small ruminants owned	-3.2148		-2.4801		4.4802	
Poultry owned	-13.2304	*	-10.6378	***	-15.7609	**
Pack animals owned	92.3673	*	-3.1906		72.8187	*
Landholding	-66.7317		80.2008	***	-53.7187	
Crop income	0.0404	*	0.0061		0.0389	*
Non-farm income	0.0606		0.0425	***	0.0490	
Credit	71.7862		-29.2254		60.8650	
Region	-173.6522	**	98.5587	*	-172.9850	**
Inverse mills ratio associated with participation	374.6619	***	160.6887	***	404.6642	***
Intercept	730.3359	***	-148.1872	*	664.7062	***
Chi-squared statistic	56.6500	***	34.0100	***	45.7300	***
Number of observations	299		126		353	

Notes: Detailed description of dependent and explanatory variables is given in Table 1. The dependent variables are the values sold by the household of a particular item. Coefficients are corrected for weighting, stratification and clustering of sample. *, ** and *** indicate statistical significance at the 10, 5 and 1percent levels, respectively.

Appendix: Econometric results of sales of livestock ownership and production of dairy products by households (probit regression)

Explanatory variable	Whether owned cattle or small ruminants		Whether produced dairy products		Whether owned cattle or small ruminants or produced dairy products	
Distance to nearest market	-0.0025		-0.0014		-0.0022	
Distance to district town	0.0008		-0.0062	**	0.0008	
Population density	0.4482		-0.4504		0.3397	
Sex of household head	0.0020		-0.7133		0.0019	
Age of household head	-0.0085		0.0014		-0.0105	
Household size	0.0233		0.0112		0.0326	
Proportion of females	-0.7930	*	-0.3565		-0.8921	**
Dependency ratio	0.1696		-0.4717		0.2284	
Education	0.0526		0.0191		0.0778	**
Extension	-0.1030		-0.1555		-0.1620	
Poultry owned	0.0481	*	0.0329		0.0578	**
Pack animals owned	1.0336		0.1756		0.9432	***
Landholding	0.5770	***	0.3187	***	0.6153	***
Crop income	0.0002	*	0.0001		0.0002	***
Non-farm income	-0.0002		0.0001		-0.0002	*
Credit	-0.1530		-0.1529		-0.2330	
Region	0.2738		0.8008	***	0.2259	
Distance to nearest all-weather road	-0.0005		0.0006	**	-0.0003	
Distance to veterinary clinic	0.0009		-0.0010		0.0005	
Altitude	0.0003	*	0.0004	***	0.0003	*
Intercept	-0.2579		-1.5396	***	-0.1244	
Chi-squared statistic	41.4900		145.4400		37.9000	
Number of observations	845		845		845	

Notes: Detailed description of explanatory variables is given in Table 1. The dependent variables are the values sold by the household of a particular item. Coefficients are corrected for weighting, stratification and clustering of sample. *, ** and *** indicate statistical significance at the 10, 5 and 1percent levels, respectively.