Crop-Livestock Interactions in Smallholders' Market Participation: Evidence from Crop-Livestock Mixed Systems in Ethiopia

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Abstract

Most studies on smallholder market participation decisions analyze crop or livestock market participation separately. However, in mixed crop-livestock farming systems, smallholders' participation decisions in crop and livestock markets may not be separate as a household's position in one market may be influenced by its position in the other. Where there is limited income from off-farm and/or non-farm activities, household cash requirements for crop production or household consumption are usually met by selling livestock. Similarly, livestock purchase is usually financed by income from crop sales. However, to what extent the position in one market influences the other is still not well explored in the literature. The aim of this paper is to investigate the interactions of crop and livestock output market participation of smallholders, by analyzing the determinants of household market participation positions in both commodities simultaneously. Household level data collected in 2009 from 1075 sample households in ten districts of the four major regions of Ethiopia is used for the analyses. Using simultaneous equation models, we test whether the position of being a net seller in crop market is affected by the position of being a net buyer in the livestock market, and vice versa. Results show that the decision to be a net buyer in crop market is associated positively with the decision to be a net seller in livestock market. Similarly, the decision to be a net seller in crop market is associated positively with the decision to be a net buyer in livestock market. This implies that crop purchase is financed by livestock sale and excess income from crop sale is saved in the form of livestock asset. Thus, policies/strategies enhancing smallholders' participation in crop and livestock markets in mixed crop-livestock system should pay attention to the production and marketing of both commodities simultaneously.

Key words: market participation, market position, crop-livestock system, smallholder, Ethiopia.

1. Introduction

Integration of smallholders into markets is essential for sustainable development of the agricultural sector in agriculture-based economies (World Bank, 2008). Smallholder market participation depends on various factors including farm productivity (Rios et al. 2009; Gebremedhin et al., 2009), transaction costs (Key et al., 2000; Alene et al., 2008), access to input supply and services (Gebremedhin et al., 2009), and access to output markets (de Janvry et al., 1991).

Most studies on household market participation focus either on crop or livestock markets separately (Lapar et al., 2003; Jaleta and Gardebroek, 2008; Negassa and Jabbar, 2008; among others). Moreover, in explaining household participation in crop markets, livestock usually enters the crop market participation equation as a wealth indicator or as alternative income source to crop sales, assuming that household decision in livestock markets is given. However, in mixed crop-livestock production systems, household market participation decisions in crop and livestock markets might be made jointly. The simultaneity of these decisions arises from the fact that income from one market can be used to finance purchase from the other or demand for cash in one market may necessitate the sell of commodities in the other. For example, cash from crops sales could deter the sale of livestock, and vice versa.

This paper examines how household decisions in crop sales affect decisions in livestock sales and vice versa. It helps to examine the extent of livestock supply to the markets under different crop production and sale circumstances. Results are based on data collected from 1075 sample households in ten districts in four regional states of Ethiopia. Determinants of household net positions in crop and livestock market were analyzed independently and jointly.

Results show that the decision to be a net buyer in crop market is associated positively with the decision to be a net seller in livestock market. Similarly, the decision to be a net seller in crop market is associated positively with the decision to be a net buyer in livestock market. Results imply that market participation analyses in either crop or livestock markets should consider household's position in the other market.

The paper is structured as follows. Section 2 describes the context of the study briefly. Section 3 presents conceptual framework, methods, and hypotheses. Section 4

discusses results from descriptive and empirical analyses, while section 5 concludes the paper and draws implications.

2. Context

In most parts of the Ethiopian highlands, smallholders operate mixed crop-livestock enterprises, with a strong interaction between the two sub-sectors, both at production and marketing levels. Draft power in crop production and manure for soil fertility are obtained from livestock, while crop residue is used to feed livestock. Availability of surplus crop production may encourage farmers to restock their livestock assets or, discourage the sale of livestock to meet cash requirements. Similarly, households may finance crop purchase (if there is a deficit in level of production for home consumption) through income from livestock sale, given that the household is in a better position in livestock assets.

Thus, in mixed crop-livestock farming systems in the Ethiopian highlands, where diverse types of crops are produced and diverse types of animals are kept, the market position in one sub-component is likely to be influenced by the other. However, there is no clear empirical evidence in literature showing these interactions in determining household level market positions in crop and livestock markets.

3. Conceptual Framework, Methods and Hypotheses

3.1 Conceptual framework

There are a number of studies on smallholders' crop and livestock market participations in Ethiopian and other developing countries in the world (Makhura 2001; Bellemare and Barrett, 2006; Gebremedhin and Hoekstra, 2007; Barrett, 2008; Jaleta and Gardebroek, 2008). However, studies on smallholder market participation usually fail to capture the net position of smallholders in these particular markets. Households could participate in a given market both as a seller and buyer of a specific commodity at different times in the same production year. This might be common under destitute sales to meet cash requirements and repurchase the same crop or animal type latter. Households may also buy animals with a purpose of resale after fattening or sale animals to replace with new stock. Under such cases, unless the net position of households in a

given market is considered, analyses on one-side market participation alone may lead to erroneous conclusions and derived policy implications.

More importantly, the pull and push factors from one sub-system (crop or livestock) on the household's net market position in the other can not be captured only by considering the available stocks in the other sub-system as explanatory variable. Therefore, for a more sound analysis of smallholders' market participation and its extent, considering household market participation and net position decisions for both crop and livestock jointly is paramount. This paper is, thus, trying to assess how a household's participation decisions in the two markets influence each other.

3.2 Methods

3.2.1. Empirical models

For smallholders operating in a mixed crop-livestock farming systems, household decisions in selling either crop or livestock or livestock outputs may not usually be independent since all sales contribute towards easing household's liquidity constraints. There could also be a linkage between crop and livestock market participations as the cash income obtained from crop or livestock sale could be used in purchase of the other. Given the proportion of crop and livestock production values in the total household income, household's net position in one market might be affected by its position in the other. Considering the three possible positions (net seller, autarkic[1], and net buyer) that a household could assume in a given market (be it in crop or livestock market), the possible linkage in these net positions can be specified as follows.

$$M_{Ci}^{*} = \alpha_0 + \alpha_1 M_{Li}^{*} + \beta_1 X_{Ci} + u_{Ci} \quad (1)$$

$$M_{Li}^{*} = \chi_0 + \chi_1 M_{Ci}^{*} + \beta_2 X_{Li} + u_{Li} \quad (2)$$

[1] In this study, autarkic households are defined as households that neither sold nor purchased the particular product. Farmers who might have sold and re-purchased the same product at equal amount of money are considered separately.

Where M_{Ci}^{*} and M_{Li}^{*} are household's latent market position in crop and livestock markets, respectively, X_C and X_L are vector of explanatory variables with some common variables in both equations, u_{Ci} and u_{Li} are error terms assumed to be independently and identically distributed with mean zero and constant variance.

The reduced forms are given as:

$$M_{Ci}^{*} = \pi_0 + \pi_1 X_{Ci} + \pi_2 X_{Li} + v_{Ci} \quad (3)$$

$$M_{Li}^{*} = \theta_0 + \theta_1 X_{Ci} + \theta_2 X_{Li} + v_{Li} \quad (4)$$

The derived values of the structural parameters

$$\pi_0 = \frac{\alpha_0 + \alpha_1\chi_0}{1-\alpha_1\chi_1}, \quad \pi_1 = \frac{\alpha_1\beta_2}{1-\alpha_1\chi_1}, \quad \pi_2 = \frac{\beta_1}{1-\alpha_1\chi_1}, \quad v_C = \frac{\alpha_1 u_L + u_C}{1-\alpha_1\chi_1}$$

$$\theta_0 = \frac{\chi_0 + \chi_1\alpha_0}{1-\chi_1\alpha_1}, \quad \theta_1 = \frac{\chi_1\beta_1}{1-\chi_1\alpha_1}, \quad \theta_2 = \frac{\beta_2}{1-\chi_1\alpha_1}, \quad u_L = \frac{\chi_1 u_C + u_L}{1-\chi_1\alpha_1}$$

The identification problem of the simultaneous equation is solved by considering at least one explanatory variable in each of equation (1) and (2) that is not in the other (Maddala, 1983: 208,233; Wissen and Golob, 1988) and $\alpha_1\chi_1 \neq 1$ (Amemiya, 1974). The joint distribution of the error terms in the reduced form equations v_C and v_L are assumed to be bivariate normal. Hence, the error terms have a zero mean and a constant variance.

$$E[v_C] = E[v_L] = 0 \; ; \quad E[v_C{}^2] = \sigma_C^2 = 1 \quad ; \quad E[v_L{}^2] = \sigma_L^2 = 1 \; ; \quad E[v_C v_L] = \sigma_{CL}$$

The two pairs of simultaneous equations hypothesized to examine whether the household positions in crop and livestock markets are made jointly are given as:

$$\begin{cases} M_{Ci}^{NB} = f(M_{Li}^{NS},\ HH,\ HR, CROP_V, DAIRY_{INC}, OINC, DUMLin, u_{M_{Ci}^{NB}}) \\ M_{Li}^{NS} = f(M_{Ci}^{NB}, HH,\ HR,\ CROP_V, DEATH_L, DAIRY_{INC}, OINC, u_{M_{Li}^{NS}}) \end{cases} \quad (5)$$

and

$$\begin{cases} M_{Ci}^{NS} = f(M_{Li}^{NB},\ HH,\ HR, CROP_V, DAIRY_{INC}, OINC, DUMLin, u_{M_{Ci}^{NS}}) \\ M_{Li}^{NB} = f(M_{Ci}^{NS}, HH,\ HR,\ CROP_V, DEATH_L, DAIRY_{INC}, OINC, u_{M_{Li}^{NB}}) \end{cases} \quad (6)$$

Where M_{Ci}^{NB} and M_{Li}^{NS} are binary dependent variables referring to net buyer in crop market and net seller in livestock market, respectively. Similarly, M_{Ci}^{NS} and M_{Li}^{NB} are binary dependent variables referring to net seller in crop market and net buyer in livestock market, respectively. HH is household characteristics like household head's age, sex, and education, family size, and available family labor. HR is household resource endowments like land owned and livestock owned (in TLU) [2]. $CROP_V$ is value of crop produced during the specific production year; $DEATH_L$ is the value of livestock loss due to death (in TLU); $DAIRY_{INC}$ is income obtained from selling dairy products; $OINC$ is other income from honey, off-farm and non-farm sources including remittances, $DUMLin$ is dummy variable whether a household rented or shared in farmland, $u_{M_{Ci}}$ and $u_{M_{Li}}$ are error terms.

3.2.2 Data

In this study, we used household survey data collected from 1075 sample households in 2009 from ten districts in four regional states of Ethiopia. In the survey, various types of information at household level were collected including household level livestock inventory, crop production and marketing, expenditures on agricultural and non-agricultural products, off and non-farm income, etc.

[2] TLU is Tropical livestock Unit as defined in Storck et al. (1991:188).

3.2.3. Econometrics approach

The simultaneity in households' net position in crop and livestock market is estimated using 2SLS estimation method. Before proceeding with the 2SLS estimation, the existence of joint decisions in the possible combinations of crop and livestock net market positions should be determined. In doing so, first, the dichotomous dependent variables for each of the net market positions are estimated over the predetermined exogenous variables using a Probit model. In this specification, dummy variable on land rented or shared in and livestock loss due to death are used as identifying variables. Using the predicted values from the Probit model and the actual dichotomous variable in the original, the endogeneity of the net market positions in each equation are tested using Hausman's test (Maddala, 2001:381). The existence of endogeneity is a sign of joint household decisions in assuming the specific market positions under the analysis. For equations in which the endogeneity could not be rejected, predicted probability values of the net market position is used instead of the actual dichotomy variable with one and zero values. Marginal effects of the explanatory variables on the probabilities of assuming the net position considered as dependent variable could also be obtained after each estimation.

3.2.4. Hypotheses

In setting our hypotheses, we focus on the testing whether the household level crop and livestock market positions are jointly determined.

Net market position

Being a net buyer in crop or livestock market requires cash income from other sources. In the case of net buyer in crop market, the source of cash could be either from livestock or dairy products sale, off-farm and/or non-farm income, or remittances. Lack of enough cash income from the non-livestock sources could result into selling livestock to secure home consumption in food crops. This could possibly put the household under a net seller position in livestock market. On the other hand, there are two possible reasoning that could influence households to be net sellers in crops and net buyers in livestock markets. First, households with surplus production in perishable cash crops or

grains that can not be stored for longer periods due to pests could prefer to sell these crops and save the income in the form of livestock asset. Second, livestock loss due to death or other causes might influence households to restock by selling crop outputs.

Total production

Both in cop and livestock, total production affects households' market position positively. It is very likely that households are in a net seller position when they produce larger volume of crop or hold more livestock herd.

Family size

Given the level of crop production per household, household position in crop markets could depend on family size or the per capita consumption requirement that could not been satisfied from own production.

Income from other sources

Income from non-crop and non-livestock sales might affect the position that one takes in crop or livestock markets. Usually, when a household earns sufficient income from other sources, it is less likely that the household sells either crop or livestock to meet cash requirements. Thus, under higher earnings from other sources, households might prefer to be autarkic in crop and livestock markets or take a net sellers position if engaged in surplus grain production or other cash crops.

Dummy land rented or shared in

Households renting-in or sharing-in land are more likely to sell crops as they have to use the land to produce more marketable crops with higher returns to pay back the rent or compensate their labor from the half of crop produce shared from the land.

Livestock loss due to death

Livestock loss due to death could affect household's decision in livestock market. Households could tend to buy livestock as a replacement if there is a loss due to death. This is usually unavoidable if the death loss is on productive animal types like oxen.

Thus, households losing livestock due to death could assume a net buyer's position in livestock markets.

4. Results

The analyses results are presented in two sub-sections. The first subsection presents results from descriptive analyses whereas empirical results are presented in the subsequent sub-section.

4.1. Descriptive analyses results

Table 1 below gives the distribution of sample households based on their position in crop and livestock markets. Accordingly, about 67% of the sample households are net sellers in livestock markets. There are also a reasonable number of sample households (22.3%) remaining autarkic in livestock (neither buy or sell, or they buy animals with equal amount of money received from livestock sale). Unlike in the livestock markets, in crops market, households are either net buyers (28.8%) or net sellers (71.2%), and no household was found to be autarkic in crops market.

Table 1. Sample households' position in crop and livestock markets

Position in Livestock Market	Position in Crop Market					
	Net buyer		Net seller		Total	
	Count	*%*	*Count*	*%*	*Count*	*%*
Net buyer	22	*2.0*	96	*8.9*	118	*11.0*
Autarkic	68	*6.3*	172	*16.0*	240	*22.3*
Net Seller	220	*20.5*	497	*46.2*	717	*66.7*
Total	310	*28.8*	765	*71.2*	1075	*100.0*

Both in crops and livestock markets, majority of the sample households are net sellers. From the total 1075 sample households, about 71% of the sample households are net sellers in crop market and 66.7% are also net sellers in livestock market. Looking at the joint position in both crop and livestock markets together, 46.2% are net sellers both in crop and livestock markets. The next market position assumed by larger proportion of

the sample households is net buyer in crop and net seller in livestock markets (20.5%). In addition table 1 below, detailed descriptive statistics on net market positions of the sample households are presented in table A1 (appendix) as well.

4.2. Empirical results

Table 2 presents summary of descriptive statistics on selected variables used in the empirical analyses. From the total 1075 sample households considered in this study, 76% is male headed households and 71% of them could read and write. The average family size is 6.84, which is close to the national average. There are sample households with no own land and livestock, though on average households own about 1.62 ha and 6.5 animals in Tropical Livestock Units (TLU). Close to half of the sample households are engaged in either renting or sharing in farmlands and there is a considerable amount of livestock loss due to death.

On average, the sample households produced crops worth Birr[3] 16,550 in 2007/08 production period and spent about Birr 1,510 on crop purchase. On average, the sample households generated about Birr 1,940 from live animals sale and spent about 580Birr on live animal purchase. Looking at the net balanced cash income (the difference between income from sale and expenditure on purchase), households got a positive net income of Birr 6,630 and Birr 1,360 from their participation in crop and livestock markets, respectively. Details are presented in table 2.

Simultaneity test

Hausman's endogeneity test between net buyer position in livestock and net seller position in crop markets could not reject the existence of endogeneity in both equations at 1% significance level, implying that the two positions have strong association and are jointly determined at a household level. Similar test between net buyer position in crop and net seller position in livestock shows that net buyer position in crop market is endogenous in the net seller poison in livestock markets equation but not the other way round. These all results call for estimating the determinants of net market positions in crop and livestock markets jointly using simultaneous equation models.

[3] Birr is an Ethiopian currency. During this analysis 1USD=13.45Birr.

Table 2. Descriptive statistics of selected variables used in the empirical analyses.

Variables	Obs	Mean	Std. Dev.	Min	Max
Age of household head *(years)*	1075	42.12	10.88	18	80
HHH age square *(year^2)*	1075	1892.30	988.07	324	6400
Sex of household head *(1=male; 0=female)*	1075	0.76	0.42	0	1
Education of household head *(1=literate; 0=illiterate)*	1075	0.71	0.45	0	1
Family size *(persons)*	1075	6.84	2.45	1	20
Family labor available for agriculture *(persons)*	1075	3.55	1.85	0	17
Land owned *(ha)*	1075	1.62	1.23	0	5
Animals owned *(TLU)*	1075	6.50	5.30	0	45.33
Animals lost due to death *(TLU)*	1075	0.46	0.97	0	11.03
Value of crop production *(1000Birr)*	1075	16.55	25.01	0	379.37
Income from crop sale *(1000Birr)*	1075	8.14	16.83	0	312.63
Expenditure on crop purchase *(1000Birr)*	1075	1.51	1.52	0	14.91
Net balanced cash income from crop sale *(1000Birr)*	1075	6.63	16.80	-10.521	306.79
Income from livestock sale *(1000Birr)*	1075	1.94	3.28	0	35.60
Expenditure on livestock purchase *(1000Birr)*	1075	0.58	1.59	0	19.80
Net balanced cash income from livestock sale *(1000Birr)*	1075	1.36	2.84	-8.77	35.60
Income from dairy products sale *(1000Birr)*	1075	0.74	3.18	0	67.26
Income from honey and its products *(1000Birr)*	1075	0.20	0.98	0	20.18
Off and non-farm income *(1000Birr)*	1075	3.12	9.08	0	213.50
Dummy_ land rented or shared in *(1=yes; 0=no)*	1075	0.49	0.50	0	1

Determinants of net positions in crop and livestock markets

In examining factors explaining the net positions households assume in crop and livestock markets, we followed two stages estimation procedure. First, the predicted values of each net position were obtained buy running a Probit model using all the exogenous variables specified in the simultaneous equation. Second, each specific equation in the simultaneous equations is estimated using a binary Probit model where the net positions in the explanatory variables are replaced by their predicted values obtained in the first step.

Estimation results of the coefficients and marginal effects obtained following the above procedure are presented in table 3 and 4, respectively. Results in the marginal effect analyses (Table 4) show that the likelihood of being a net buyer in livestock increases by 41.7% if the household is a net seller in crop and the likelihood of being a

net seller in livestock increases by 22.1% if the household is a net buyer in crop. On the other hand, being a net seller in livestock increases the probability of being a net buyer in crop by 29.9%. This shows the possible flow of household cash income from one market to the other.

Looking at the other variables, larger family size affects the probability of being a net buyer in both crop and livestock markets positively. The effect of family size is significant also on being a net seller both in crop and livestock markets, but negatively. This implies that households with larger family size buy more crops and livestock than they sell in these markets to satisfy home consumption. On the other hand, the availability of larger family labor for agriculture affects the likelihood of being a net seller both in crop and livestock markets positively. The effect is negative on the likelihood of being a net buyer in both markets. This might be due to the limited availability of labor market where households with more family labor could produce more outputs. The probability of being a net buyer both in crop and livestock markets decreases for male headed households. In both cases, compared to female headed households, the probability of being a net buyer is lower by 5% for male headed households.

The effect of value of crop production and livestock endowment in determining the market position of households are apparently reflected in the estimation results. On average, an additional crop production with value of Birr 10,000 increases the likelihood of being a net seller in crop markets by 14% and decreases the likelihood of a net buyer by 10%. Increased value of crop production has a negative effect on the likelihood of being a net seller in livestock. This might be due to the fact that households are less interested to sell livestock once they have sufficient cash income from crop sale. Households with larger livestock endowments are less likely to be a net buyer in crop market. Moreover, livestock endowment strongly determines the net position households assume in livestock market. Households with larger animal holding are more likely to be a net seller in livestock market and the fewer the holding the more likely to be a net buyer in livestock market.

Table 3. Simultaneity in household's net positions in crop and livestock markets

Explanatory variables	Crop market position				Livestock market position			
	Net buyer		Net seller		Net Buyer		Net seller	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Age of household head *(years)*	-0.006	0.028	-0.005	0.033	-0.047	0.034	0.034	0.025
HHH age square *(year2)*	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000
Sex of household head *(1=male; 0=female)*	-0.199	0.119*	0.180	0.119	-0.279	0.153*	0.131	0.115
Education of household head *(1=literate; 0=illiterate)*	0.039	0.108	-0.036	0.121	-0.131	0.127	0.008	0.098
Family size *(persons)*	0.075	0.027***	-0.059	0.033*	0.100	0.031***	-0.045	0.024*
Family labor available for agriculture *(persons)*	-0.126	0.035***	0.112	0.035***	-0.070	0.042*	0.053	0.032*
Land owned *(ha)*	-0.017	0.041	0.034	0.041	-0.017	0.050	-0.045	0.037
Animals owned *(TLU)*	-0.037	0.016**	0.017	0.014	-0.046	0.015***	0.068	0.011***
Value of crop production *(1000Birr)*	-0.051	0.004***	0.054	0.005***	-0.007	0.005	-0.006	0.002***
Income from honey and its products *(1000Birr)*	-0.020	0.058	0.028	0.062	0.019	0.047	-0.005	0.041
Off and non-farm income *(1000Birr)*	0.013	0.009	-0.018	0.010*	-0.012	0.014	0.010	0.006*
Income from dairy products sale *(1000Birr)*	0.036	0.017**	-0.036	0.017**				
Dummy_ land rented or shared in *(1=yes; 0=no)*	-0.315	0.102***	0.306	0.102***				
Animals lost due to death *(TLU)*					0.145	0.055***	-0.031	0.048
Net seller in livestock *(predicted value)*	1.137	0.565**						
Net buyer in livestock *(predicted value)*			0.105	1.845				
Net seller in crop *(predicted value)*					2.498	0.538***		
Net Buyer in crop *(predicted value)*							0.611	0.332*
Constant	-0.453	0.628	-0.053	0.850	-1.568	0.784**	-0.722	0.551
Number of observations	*1075*		*1075*		*1060*		*1060*	
LR Chi^2	*358.27*		*353.61*		*53.09*		*47.98*	
Prob > Chi^2	*0.000*		*0.000*		*0.000*		*0.000*	
Pseudo R^2	*0.2774*		*0.2738*		*0.0717*		*0.0355*	
Log likelihood	*-466.60*		*-468.93*		*-343.68*		*-652.56*	

Note: ***, ** and * are significant at 1%, 5% and 10% significance level, respectively.

Table 4. Marginal effects of the explanatory variables on the household net positions in crop and livestock markets

Explanatory variables	Net position in crop markets				Net position in livestock market			
	Net buyer		Net seller		Net buyer		Net seller	
	dy/dx [a]	Std. Err.	dy/dx	Std. Err.	dy/dx	Std. Err.	dy/dx	Std. Err.
Age of household head *(years)*	-0.002	0.007	-0.001	0.009	-0.008	0.006	0.012	0.009
HHH age square *(year2)*	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Sex of household head *(1=male; 0=female)*	-0.055	0.034	0.049	0.034	-0.051	0.031*	0.048	0.043
Education of household head *(1=literate; 0=illiterate)*	0.010	0.028	-0.010	0.031	-0.023	0.023	0.003	0.036
Family size *(persons)*	0.020	0.007***	-0.016	0.009*	0.017	0.005***	-0.016	0.009*
Family labor available for agriculture *(persons)*	-0.033	0.009***	0.029	0.009***	-0.012	0.007*	0.019	0.011*
Land owned *(ha)*	-0.005	0.011	0.009	0.011	-0.003	0.008	-0.016	0.013
Animals owned *(TLU)*	-0.010	0.004**	0.004	0.004	-0.008	0.002***	0.024	0.004***
Value of crop production *(1000Birr)*	-0.013	0.001***	0.014	0.001***	-0.001	0.001	-0.002	0.001***
Income from honey and its products *(1000Birr)*	-0.005	0.015	0.007	0.016	0.003	0.008	-0.002	0.015
Off and non-farm income *(1000Birr)*	0.003	0.002	-0.005	0.003*	-0.002	0.002	0.004	0.002*
Income from dairy products sale *(1000Birr)*	0.010	0.005**	-0.009	0.005**				
Dummy_ land rented or shared in *(1=yes; 0=no)*	-0.083	0.027***	0.080	0.027***				
Animals lost due to death *(TLU)*					0.024	0.009***	-0.011	0.018
Net seller in livestock *(predicted value)*	0.299	0.149**						
Net buyer in livestock *(predicted value)*			0.028	0.487				
Net seller in crop *(predicted value)*					0.417	0.087***		
Net Buyer in crop *(predicted value)*							0.221	0.120*

Note: [a] dy/dx refers to marginal effects.

***, ** and * are significant at 1%, 5% and 10% significance level, respectively.

5. Conclusions and Implications

Most studies on smallholder market participation are analyzing percentage of output sold or input purchased either in crop or livestock market. This type of analyses ignores the other side of market participation where output selling households may purchase the same output back sometimes later. To account for this, few studies considered net positions of households in markets but failed to consider both crop and livestock markets jointly, which this paper has tried to address. From the analyses results, the following major conclusions and implications could be drown.

Except for some households found to be autarkic in livestock market, most smallholders in a mixed crop-livestock systems participate both in crop and livestock markets. For those who participate in both markets, there found to be a strong linkage among the net market positions these households assumed in these two markets. However, the strength of linkage among these net market positions is not the same. Market positions in live animal markets are affected by household positions in crop markets but less strongly the other way round. This might imply that positions in crop market are more important to determine household positions in livestock market, which is the case in most households where they do not tend to sell live animals, particularly cattle, unless the cash demand could not be met by other income sources including crop sale.

There is a strong relationship between household's net seller position in crop markets and net buyer positions in livestock markets. This could be due to the fact that livestock purchase as an input for farm operation or home consumption necessitates crop sale and income from crop sale is saved in a form of livestock asset.

Position as a net buyer in crop market necessitates having a net seller position in the livestock markets. This implies that, in addition to the other sources of income, shortage in food crops production for home consumption is financed by livestock sale. However, position as a net seller in livestock market failed to necessitate taking a net buyer position in crop markets, which is the case in most pastoral and agro-pastoral areas.

In general, the existence of strong mutual dependence in household's net market positions in crop and livestock markets, particularly in a mixed crop-livestock system, implies that crop purchase is financed by livestock sale and excess income from crop sale

is saved in the form of livestock asset. Thus, policies/strategies enhancing smallholders' participation in crop and livestock markets in mixed crop-livestock system should pay attention to the production and marketing of both commodities simultaneously.

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Appendix

Table A1. Descriptive statistics of the net market positions of sample households.

Variables	Obs	Mean	Std. Dev.	Min	Max
Position in crop markets					
Net Buyers *(1=Yes , 0=No)*	1075	0.288	0.453	0	1
Autarkic *(1=Yes , 0=No)*	1075	0.0	0.0	0	0
Net sellers *(1=Yes , 0=No)*	1075	0.712	0.453	0	1
Position in livestock market					
Net Buyers *(1=Yes , 0=No)*	1075	0.110	0.313	0	1
Autarkic *(1=Yes , 0=No)*	1075	0.223	0.417	0	1
Net sellers *(1=Yes , 0=No)*	1075	0.667	0.472	0	1
*Joint positions **					
C_{NB} and L_{NB} *(1=Yes , 0=No)*	1075	0.020	0.142	0	1
C_{NB} and L_{A} *(1=Yes , 0=No)*	1075	0.063	0.244	0	1
C_{NB} and L_{NS} *(1=Yes , 0=No)*	1075	0.205	0.404	0	1
C_{A} and L_{NB} *(1=Yes , 0=No)*	1075	0.0	0.0	0	0
C_{A} and L_{A} *(1=Yes , 0=No)*	1075	0.0	0.0	0	0
C_{A} and L_{NS} *(1=Yes , 0=No)*	1075	0.0	0.0	0	0
C_{NS} and L_{NB} *(1=Yes , 0=No)*	1075	0.089	0.285	0	1
C_{NS} and L_{A} *(1=Yes , 0=No)*	1075	0.160	0.367	0	1
C_{NS} and L_{NS} *(1=Yes , 0=No)*	1075	0.462	0.499	0	1

*Note: * NS=Net sellers; A=Autarkic; NB=Net buyers; C=Crops; L=Livestock.*