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Full Length Research Paper

Interdependence of smallholders' net market positions in mixed crop-livestock systems of Ethiopian highlands

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Using simultaneous-equation models, this paper examines whether there is interdependence between smallholder's net market positions in crop and live animal markets under mixed crop-livestock system. Household level data collected in 2009 from 1075 sample households in 10 districts of Ethiopia are used for this analysis. Results confirmed the existence of interdependence between household's net positions in crop and live animals markets and relatively, the net position of households in the live animal market is more strongly affected by their net position in the crop market than vice versa. The interdependence between the two market positions showed that households stock live animal asset through selling of surplus crops produced and finance crop purchased through livestock sales. The relatively strong effect of net position in crop market in explaining household's net positions in live animal market shows the extent of household's reliance on its position in the crop market while dealing with its participation in live animal market. Thus, policies/strategies enhancing smallholders' participation in crop and live animal markets in mixed crop-livestock system should pay attention to the production and marketing of both commodities simultaneously.

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

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[1] markets separately (Lapar et al., 2003; Jaleta and Gardebroek, 2008; Negassa and Jabbar, 2008; Pavannello, 2010). Moreover, in explaining household participation in crop markets, amount or value of livestock owned usually enters the crop market participation equation as right-hand side variable and as a wealth indicator or as an alternative income source to crop sales, with the underlying assumption that household's decision in live animal markets is exogenous to the household's decision in crop markets. However, in mixed crop-livestock production systems, household market participation decisions in crop and live animal markets might be jointly made. The simultaneity of these decisions arises from the fact that income from one market could be used to finance purchase from the other or demand for cash in one market may necessitate the sale of commodities in the other. For example, cash from crop sales could deter the sale of live animals, and vice versa.

This paper examines how household net position in crop market affects its position in live animal markets and vice versa. Results are based on data collected from 1075

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[1] In this paper, livestock consists of all live animals kept on farm (cattle, small ruminants, equines, and poultry).

sample households in ten districts in four regional states of Ethiopia. Determinants of household net positions in crop and live animal markets were analyzed using simultaneous equation methods.

Key results showed that the decision to be a net buyer in crop market is associated positively with the decision to be a net seller in live animal markets. Similarly, the decision to be a net seller in crop market is associated positively with the decision to be a net buyer in live animal markets. Relatively, the effect of household's net positions in crop markets on its position in live animal markets was found to be stronger. These results imply that, market participation analysis in either crop or live animal markets should consider household's position in the other market.

The paper is structured as follows. Subsequently, the study describes the context of the study briefly, after which it presents the conceptual framework. This is followed by a discussion of the methods, hypotheses and data. The study further discusses the results from descriptive and empirical analyses, and finally conclusions and implications are drawn.

CONTEXT

Smallholders in most parts of the Ethiopian highland operate mixed crop-livestock enterprises with a strong interaction between the two sub-sectors both at production and marketing levels (McIntire et al., 1992). Draft power in crop production and manure for soil fertility are obtained from livestock, while crop residues are used to feed livestock (Upton, 2004). Availability of surplus crop production may encourage farmers to restock their livestock assets or substitute the sale of livestock to meet cash requirements. Similarly, households may finance crop purchase (if there is a deficit in the level of production for home consumption) through income from live animal sale given that the household is in a better position in livestock assets. Thus, in mixed crop-livestock farming systems of 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. Empirical evidence is required to establish the inter-dependencies and the relative strength of the inter-actions. However, there is a dearth of empirical evidence in the literature which analyzes this interdependence. This paper is aimed at contributing to redressing this gap in knowledge and draw policy implications.

CONCEPTUAL FRAMEWORK

There are a number of studies on smallholder's crop and livestock market participations in Ethiopia 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 (Renkow et al., 2004). This might be common under destitute sales to meet cash requirements and repurchase the same crop or animal type later. Households may also buy animals for resale at a later time or sell animals to replace with new stock. Under such cases, unless the net position of households in a given market is considered, analyses of one-side market participation alone may lead to erroneous conclusions and derived policy implications. More importantly, the pull and push factors[2] 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, a more sound analysis of the determinants of smallholders' market position requires considering household's net position decisions both in crop and live animal markets jointly. Controlling household income for livestock products, this paper is, thus, trying to assess how a household's net position in the two markets influence each other.

METHODS, HYPOTHESES AND DATA

Empirical models

For smallholders operating in a mixed crop-livestock farming systems, household decisions in selling either crop or live animals may not usually be independent since all sales contribute towards easing household's liquidity constraints. There could also be a linkage between crop and live animal markets participations as the cash income obtained from crop or live animals sale could be used to purchase the other. Given the proportion of crop and live animals 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[3], and net buyer) that a household could assume in a given market (be it in crop or live animal markets), the possible linkage in these net positions can be specified as follows:

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

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

Where M_{Ci}^{*} and M_{Li}^{*} are household's net positions in crop and

[2]Demand for cash requirements to purchase grain for home consumption or better market prices in live animals market could be a pull factor to sell live animals. On the other hand, surplus production of non-storable commodities, destocking of live animals as a coping strategy of drought or other shocks could be push factors to participate in crop and live animals markets, respectively.

[3]In this study, autarkic households are defined as households that neither sold nor purchased the particular product. Both in crop and live animals markets, there are no sample households who sold and re-purchased the same product at equal amount of money.

Table 1. Frequency and percentage of households based on their net position in crop and livestock markets (percentages in parentheses).

Position in live animals market	Position in crop market					
	Net buyer		Autarkic	Net seller		Total
	Count	(%)	Count	Count	(%)	Count	(%)
Net buyer	22	(2.0)	0	96	(8.9)	118	(11.0)
Autarkic	68	(6.3)	0	172	(16.0)	240	(22.3)
Net seller	220	(20.5)	0	497	(46.2)	717	(66.7)
Total	310	(28.8)	0	765	(71.2)	1075	(100.0)

A household is a net buyer (net seller) if its annual expenditure is greater (less) than its annual cash income in the specific market (crop or livestock). Autarkic households never sold or purchased during the specific year in the specific market.

live animals markets, respectively. X_C and X_L are vector of same explanatory variables except the instrumental variables used as identifier of each single equation in the system. α, β, and χ are parameters of the structural 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 value of the reduced form parameters (π and θ) in terms of parameters in the structural equation is given as:

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

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

The identification problem of the simultaneous equation is solved by considering at least one explanatory variable in each of Equations 1 and 2 that is not in the other (Maddala, 1983: 208, 233; van 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_{Ci} and v_{Li} are assumed to be bivariate normal. Hence, the error terms have a zero mean and a constant variance.

$$E[v_{Ci}] = E[v_{Li}] = 0; E[v_{Ci}^2] = \sigma_{Ci}^2 = 1; E[v_{Li}^2] = \sigma_{Li}^2 = 1;$$
$$E[v_{Ci}v_{Li}] = \sigma_{CLi}$$

Although, there are nine combinations of net market positions obtained from the possible mix of crop and live animal markets positions, three were not supported by our dataset as we found no autarkic position in crop market (Table 1). From the remaining six, two combinations have autarkic net positions in live animal markets where households neither bought nor sold live animals during the specific year and the net inflow of cash income from live animals' sale is zero. In this case, there is no possible cash flow from crop market to live animal markets or vice versa. There are other two combinations where households take net buyer position in both markets or net seller position in both markets. In the first case (net buyer position in both markets), there could be some interactions between the two markets but the negative net cash inflow (that is, more cash outflow to a specific market) shows more cash flow to the two markets from other sources such as on/non-farm income, remittances, sales of dairy products or honey. In the second case (net sellers in both markets), still, there could be some possible cash flows between the two, but the positive net inflow of cash income to a household from the two markets shows that these households are spending or saving or investing the extra money in other forms. Thus, in this paper, we focused only on the remaining two combinations (net seller in crop vs. net buyer in live animals, and net buyer in crop vs. net seller in live animals) where one expects household level potential interactions/interdependence in the net market positions and flow of money between crop and live animal markets exist in these combinations of net market positions. The two pairs of simultaneous equations hypothesized to examine whether the household positions in crop and live animals markets are jointly made are given as:

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

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

Where M_{Ci}^{NB} and M_{Li}^{NS} are binary dependent variables referring to net buyer in crop market and net seller in live animal markets, respectively. Similarly, M_{Ci}^{NS} and M_{Li}^{NB} are binary dependent variables referring to net seller in crop market and net buyer in live animal markets, respectively. HH is household characteristics (household head's age, sex, education, and family size). HR is household resource endowments (available family labor, land owned, and livestock owned in TLU[4]). $CROP_V$ 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-in or shared-in farmland, $u_{M_{Ci}}$ and $u_{M_{Li}}$ are error terms.

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

Econometrics approach

The simultaneity in households' net position in crop and live animal markets is estimated using 2SLS estimation method. Before proceeding with the 2SLS estimation, the existence of joint decisions in the possible combinations of crop and live animals 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 pre-determined exogenous variables using Probit model. In this specification, a dummy variable on land rented-in or shared-in and livestock loss due to death (in TLU) are used as identifying variables for net positions in crop and live animal markets, respectively. Here, the assumption is that once the value of total crop production is controlled for, the effect of livestock loss due to death has no direct effect on household's net position in crop market. Similarly, the effect of farmland shared in or rented in could have a direct effect on household's net positions in crop markets and less likely on household's position in live animal markets.

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 is tested using Hausman's test (Maddala, 2001: 381). The existence of endogeneity is a sign of joint household decision 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 to estimate the likelihood of assuming the particular net position in the other market instead of the actual dichotomous 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.

Hypotheses

In setting our hypotheses, we focus on testing whether the household level crop and live animals market positions are jointly determined. As such, we have the following:

(i) Net market position: Being a net buyer in crop or live animal market requires cash income from other sources. In the case of net buyer in crop market, the source of cash could be either from live animals 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 in selling livestock to secure home consumption in food crops. This could possibly put the household under a net seller position in live animal markets. On the other hand, there are two possible reasons that could influence households to be net sellers in crop and net buyers in livestock markets simultaneously. First, households with surplus production in perishable cash crops or grains that cannot be stored for longer periods due to pests could prefer to sell these crops and save the income in the form of livestock asset. Secondly, livestock loss due to death or other causes might influence households to restock by selling crop outputs.
(ii) Total production: Both in cop and livestock, total production affects households' market position positively due to availability of surplus for sale. It is very likely that households are in a net seller position when they produce larger volume of crop or hold more livestock herd (Bellemare and Barrett, 2006).
(iii) 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 be satisfied from owned production. Thus, the likelihood of being a net seller in crop markets decreases for households with larger family size (Gebremedhin et al., 2009).
(iv) Income from other sources: Income from non-crop and non-livestock sales might affect the position that one takes in crop or live animal market (Barrett, 2008). Usually, when a household earns sufficient income from other sources, it is less likely that the household sells either crop or live animals to meet cash requirements. Thus, under higher earnings from other sources, households might prefer to be autarkic in crop and live animal markets or take a net sellers position if engaged in surplus grain production or other cash crops, or a net buyer position if owned production falls short of consumption in crops or for asset building purpose in livestock.
(v) Land rented-in or shared-in: Households renting-in or sharing-in land are more likely to sell crops as they may have higher production or use the land to produce more market oriented crops with higher returns to pay back the rent or compensate their labor from the proportion of crop produce shared from the land[5].
(vi) Family labor: Under inefficient labor markets, availability of family labor is crucial for efficiency in crop and livestock productions (Sadoulet and de Janvry, 1995). Households endowed with larger family labour are expected to produce more and assume a net seller's position both in crop and live animal markets.
(vii) Livestock loss due to death: Livestock loss due to death could affect household's decision in live animal markets. Households could tend to buy live animals as a replacement if there is a loss due to death. This is usually the case if the death loss is on productive animal and the household could afford to buy. Thus, households losing livestock due to death are expected to assume a net buyer's position in live animal markets. This variable is considered as an identifier for the net market position in live animal market with the assumption that net position in crop market is not directly affected by the loss due to death of livestock but through the net position a household takes in live animal markets and whether this position is financed by income from crop market.

Data

A cross-sectional survey data used in this study was collected in 2009 from 1075 randomly selected sample households from 10 districts in four regional states of Ethiopia. These 10 districts are: Atsbi-Wemberta and Alamata from Tigray Region, Metema, Fogera and Bure from Amhara Regipon, Ada'a, Gomma and Miesso from Oromia Region, Alaba and Dale from Southern Nations, Nationalities and Peoples Regional State. Using experienced and trained enumerators, the survey data was collected on household production, consumption and marketing activities for the 2007/2008 production year. To be more specific, the survey data includes household characteristics, resource endowments, dynamics of live animals in 2007/2008 including beginning and ending of inventories, births, purchases, sales, deaths, gifts obtained and given out, dairy production and marketing, crop production and marketing, income from off-farm and non-farm sources, expenditures on agricultural and non-agricultural products, etc. Sample households were asked about the amount of their annual cash income generated from crop and live animal sales and money spent in buying crops and live animals in the same production year (2007/2008). This was systematically recorded by asking if the utilization of their crop produce the annual herd dynamics in livestock holdings (as indicated earlier). Based on this information, household specific cash income from crop and livestock sale and cash expenditure on crop and livestock purchase were used to compute the net cash inflow from crop and live animal sales (that is, the difference between cash income and cash expenditure in crop and live animals markets separately).

[5]Land rented-in or shared-in is used as an identifier variable for the net position in crop market with the assumption that it doesn't have a direct effect on the net position in the live animal market because the direct effect of expanding cultivated land would be on crop production and marketable surplus.

RESULTS

Analyses results are presented. Results of descriptive analysis are presented first, followed by empirical results.

Descriptive analyses results

Table 1 gives the distribution of sample households based on their position in crop and live animal markets. About 66.7% 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 market. The remaining 11% are net buyers in live animal markets. In the crop market, unlike in the live animal market, households are either net buyers (28.8%) or net sellers (71.2%), and no household was found to be autarkic.

Both in crop and live animal markets, majority of the sample households are net sellers. From the total of 1075 sample households, about 71.2% of the sample households are net sellers in crop market and 66.7% are also net sellers in live animal market. Looking at the joint position in both crop and livestock markets together, 46.2% are net sellers both in crop and livestock markets. These are usually the relatively rich sample households. The next market position assumed by larger proportion of the sample households is net buyer in crop and net seller in live animal markets (20.5%). There could be a possibility that these households sell live animals for the purpose of buying crops. On the other hand, 8.9% of the sample households are net sellers in crop and net buyers in live animal markets indicating the possibility of cash flow from crop sale to live animals purchase. Only 2% of the sample households are net buyers in the two markets simultaneously. Such households are usually dependent on off-farm and/or non-farm income sources for their livelihood. In addition to Table 1, detailed descriptive statistics on net market positions of the sample households are presented in Appendix 1.

Table 2 presents summary of descriptive statistics on selected variables used in the empirical analyses. From the total of 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 higher than the national average. There are sample households with no owned land and livestock, though on average households own about 1.62 ha and 6.5 TLU of animals. Close to half of the sample households (49%) are engaged in either renting-in or sharing-in farmlands and there is a considerable amount of livestock loss due to death.

On the average, the sample households produced crops worth Birr[6] 16,550 in 2007/2008 production period and spent about Birr 1,510 on crop purchase. On the average, the sample households generated about Birr 1,940 from live animals sales and spent about Birr 580 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.

Empirical results

Here, this study presents empirical results of a simultaneity/endogeneity test of the structural equations. Moreover, after accounting for simultaneity/endogeneity problems, we also present analysis of the determinants of net positions in crop and live animal markets.

Simultaneity test

In both combinations of net positions in crop and live animals markets specified earlier, Hausman's endogeneity test rejected the exogeneity of net market position explanatory variables in all equations at 1% significance level, implying that the net position in crop market is not exogenous to the net position in live animal markets and vice versa (Table Appendix A2). These results call for estimating the two simultaneous equations following a two stage procedure. First, the predicted values of each net position were obtained by running a Probit model using all the exogenous variables specified in the simultaneous equation. Secondly, each specific equation in the simultaneous equation 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.

Determinants of net positions in crop and live animals markets

Estimation results of the coefficients and marginal effects obtained following the ongoing procedure are presented in Tables 3 and 4, respectively. It is worth mentioning that in Tables 3 and 4, we reported all the estimation results though, the net buyer and net seller equations in a specific market are mirror images with opposite signs except for the net position explanatory variables from the other market added alternatively as specified in the aforementioned equations.

Results in the marginal effect analyses (Table 4) showed that the likelihood of being a net buyer in live animal market increases by 4.48% for a 10% increase with the probability of being a net seller in crop market. Similarly, the likelihood of being a net seller in live animal markets increases by the same percentage (4.48%) for a 10% increase in the probability of being a net buyer in

[6]Birr is an Ethiopian currency. During this analysis 1USD=16.85Birr.

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
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 (1000 Birr)	1075	16.55	25.01	0	379.37
Income from crop sale (1000 Birr)	1075	8.14	16.83	0	312.63
Expenditure on crop purchase (1000 Birr)	1075	1.51	1.52	0	14.91
Net balanced cash income from crop sale (1000 Birr)	1075	6.63	16.80	-10.521	306.79
Income from livestock sale (1000 Birr)	1075	1.94	3.28	0	35.60
Expenditure on livestock purchase (1000 Birr)	1075	0.58	1.59	0	19.80
Net balanced cash income from livestock sale (1000 Birr)	1075	1.36	2.84	-8.77	35.60
Income from dairy products sale (1000 Birr)	1075	0.74	3.18	0	67.26
Income from honey and its products (1000 Birr)	1075	0.20	0.98	0	20.18
Off and non-farm income (1000 Birr)	1075	3.12	9.08	0	213.50
Dummy land rented-in or shared-in (1 = yes; 0 = no)	1075	0.49	0.50	0	1

crop market. On the other hand, being a net seller (net buyer) in livestock increases the probability of being a net buyer (net seller) in crop by 8.2%. This shows the possible flow of household cash income from one market and spent in the other.

Looking at the other explanatory variables, larger family size affects the probability of being a net buyer in crop and live animal markets positively and being a net seller in both markets negatively is consistent with our expectations. This showed that households with larger family size buy more crops and livestock than they sell in these markets to satisfy home consumption.

The availability of larger family labor for agriculture affects the likelihood of being a net seller (buyer) in crop markets positively (negatively), as expected. This might be due to the inefficiency of labor market where households with more family labor could produce more outputs (Sadoulet and de Janvry, 1995). The probability of being a net buyer in live animal markets decreases with age of the household head. This could be due to the fact that elderly households have accumulated livestock assets over time. However, the likelihood of being a net buyer in crop market increases with the age of household head.

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 the average, an additional crop production with a value of Birr 10,000 increases the likelihood of being a net seller in crop market by 11%. Households with larger livestock endowments are less likely to be net buyers in crop market. In a mixed crop-livestock system, more livestock holding usually goes with more crop production due to the availability of draft power for crop production and the use of crop residue for livestock production. Moreover, livestock endowment strongly determines the net position households assume in live animal market as households with larger animal holdings are more likely to be net sellers in live animal markets and the fewer the holding, the more likely there will be net buyers in the same market.

Income from off-farm and/or non-farm sources affects the likelihood of households' net positions in the crop market. Households with higher income from these sources are tending to be net buyers in crop markets. Moreover, households renting-in or sharing-in farmlands are more likely to be net sellers in crop markets. Sharing-in or renting-in farmland, on average, increases the probability of being a net seller in crop market by 8.5%. A unit TLU loss of livestock due to death increases the likelihood of being a net buyer in live animals market by 3.4%.

CONCLUSIONS AND IMPLICATIONS

Most studies on smallholder market participation analyze determinants of the proportion of output sold or input purchased either in crop or livestock market. This type of analysis ignores the other side of market participation where output selling households may purchase back the output sometimes later (Renkow et al., 2004). To account for this, few studies considered net positions of households in markets but failed to consider both crop

Table 3. Interdependence (Simultaneity) of household's net positions in crop and livestock markets.

Explanatory variable	Crop market position				Live animals market position			
	Net buyer		Net seller		Net buyer		Net seller	
	Coef.	Std.	Coef.	Std.	Coef.	Std.	Coef.	Std.
Age of household head (years)	0.010**	0.005	-0.010**	0.005	-0.013**	0.006	0.013**	0.006
Sex of household head (1=male; 0=female)	-0.162	0.132	0.162	0.132	-0.193	0.157	0.193	0.157
Education of household head (1=literate; 0=illiterate)	0.049	0.120	-0.049	0.120	-0.176	0.133	0.176	0.133
Family size (persons)	0.059**	0.028	-0.059**	0.028	0.102***	0.034	-0.102***	0.034
Family labor available for agriculture (persons)	-0.136***	0.040	0.136***	0.040	-0.085*	0.048	0.085*	0.048
Land owned (ha)	-0.029	0.044	0.029	0.044	-0.001	0.051	0.001	0.051
Animals owned (TLU)	-0.021*	0.013	0.021*	0.013	-0.067***	0.017	0.067***	0.017
Value of crop production (1000Birr)	-0.038***	0.004	0.038***	0.004	-0.002	0.004	0.002	0.004
Income from honey and its products (1000Birr)	-0.021	0.058	0.021	0.058	0.023	0.047	-0.023	0.047
Off and non-farm income (1000Birr)	0.025***	0.009	-0.025***	0.009	-0.015	0.015	0.015	0.015
Income from dairy products sale (1000Birr)	0.013	0.025	-0.013	0.025	0.010	0.016	-0.010	0.016
Dummy_ land rented or shared in (1=Yes; 0=No)	-0.289**	0.112	0.289**	0.112				
Animals lost due to death (TLU)					0.168***	0.061	-0.168***	0.061
Net seller in live animals (1=Yes; 0=No)	0.305*	0.160						
Net buyer in live animals (1=Yes; 0=No)			0.305*	0.160				
Net seller in crop (predicted value)					2.196***	0.585		
Net Buyer in crop (predicted value)							2.196***	0.585
Constant	-0.426	0.275	0.121	0.247	-1.873***	0.460	-0.323	0.355
Number of observations		835				835		
LR Chi^2		222.8				44.71		
Prob > Chi^2		0.000				0.000		
Pseudo R^2		0.222				0.066		
Log likelihood		-391.26				-317.78		

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

and live animal markets jointly, which this paper has tried to address. From the analyses results, the following major conclusions and implications are drawn.

Except for some households found to be autarkic in live animal markets, most smallholders in a mixed crop-livestock systems participate both in crop and livestock markets. For those who participate in both markets, there is a strong linkage among the net market positions these households had taken in these two markets. However, the strength of linkage among these net market positions is not the same. The effect of net market positions in crop markets on market positions in live animal markets are stronger thanthe effect of net market positions in live animal markets on market positions in crop markets. This result is consistent with the descriptive data that showed that most households do not tend to sell live animals, particularly cattle, unless the cash demand could not be met by other income sources including crop sale.

Similarly, crop sales play important role in financing livestock purchase as seen by the strong

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

Explanatory variable	Net position in crop markets				Net position in live animals market			
	Net buyer		Net seller		Net buyer		Net seller	
	dy/dx	Std. err.	dy/dx	Std. err.	dy/dx	Std. err.	dy/dx	Std. err.
Age of household head (years)	0.003**	0.002	-0.003**	0.002	-0.003**	0.001	0.003**	0.001
Sex of household head (1 = male; 0 = female)	-0.049	0.041	0.049	0.041	-0.042	0.036	0.042	0.036
Education of household head (1= literate; 0 = illiterate)	0.014	0.035	-0.014	0.035	-0.038	0.029	0.038	0.029
Family size (persons)	0.017**	0.008	-0.017**	0.008	0.021***	0.007	-0.021***	0.007
Family labor available for agriculture (persons)	-0.040***	0.012	0.040***	0.012	-0.017*	0.010	0.017*	0.010
Land owned (ha)	-0.009	0.013	0.009	0.013	-0.000	0.010	0.000	0.010
Animals owned (TLU)	-0.006*	0.004	0.006*	0.004	-0.014***	0.003	0.014***	0.003
Value of crop production (1000 Birr)	-0.011***	0.001	0.011***	0.001	-0.000	0.001	0.000	0.001
Income from honey and its products (1000 Birr)	-0.006	0.017	0.006	0.017	0.005	0.010	-0.005	0.010
Off and non-farm income (1000 Birr)	0.007***	0.003	-0.007***	0.003	-0.003	0.003	0.003	0.003
Income from dairy products sale (1000 Birr)	0.004	0.007	-0.004	0.007	0.002	0.003	-0.002	0.003
Dummy_ land rented or shared in (1 = Yes; 0 = No)	-0.085***	0.033	0.085**	0.033				
Animals lost due to death (TLU)					0.034***	0.012	-0.034***	0.012
Net seller in live animals (1=Yes; 0 = No)	0.082**	0.038						
Net buyer in live animals (1=Yes; 0 = No)			0.082**	0.038				
Net seller in crop (predicted value)					0.448***	0.118		
Net Buyer in crop (predicted value)							0.448***	0.118

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

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

The interdependence between the two market positions shows that households stock live animal asset through selling of surplus crops produced and finance crop purchase through selling of live animals. The relative strength of the net market position in crop markets shows that prior their involvement in live animal market, farm households analyze their position in crop production, consumption, marketable surplus, and the household's ability to meet cash requirements through crop sale. 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 live animals 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

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

Table A2. Hausman's endogeneity test results of the simultaneous equations.

Explanatory variables	Position in crop market				Position in live animal market			
	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)	0.023***	0.007	-0.023***	0.007	-0.013**	0.006	0.013*	0.006
Sex of household head (1=male; 0=female)	-0.196	0.134	0.196	0.134	-0.184	0.157	0.184	0.157
Education of household head (1=literate; 0=illiterate)	0.198	0.134	-0.198	0.134	-0.175	0.133	0.175	0.133
Family size (persons)	0.025	0.031	-0.025	0.031	0.100**	0.034	-0.100***	0.034
Family labor available for agriculture (persons)	-0.146**	0.041	0.146***	0.041	-0.080*	0.048	0.080*	0.048
Land owned (ha)	-0.041	0.045	0.041	0.045	0.000	0.051	0.000	0.051
Animals owned (TLU)	0.003	0.015	-0.003	0.015	-0.066***	0.017	0.066***	0.017
Value of crop production (1000Birr)	-0.049***	0.005	0.049***	0.005	-0.001	0.004	0.001	0.004
Income from honey and its products (1000Birr)	-0.057	0.060	0.057	0.060	0.024	0.048	-0.024	0.048
Off and non-farm income (1000Birr)	0.040***	0.010	-0.040***	0.010	-0.015	0.015	0.015	0.015
Income from dairy products sale (1000Birr)	0.015	0.025	-0.015	0.025	0.010	0.017	-0.010	0.017
Dummy_ land rented or shared in (1=Yes; 0=No)	-0.262**	0.113	0.262**	0.113				
Animals lost due to death (TLU)					0.167***	0.061	-0.167***	0.061
Net seller in live animal (1=Yes; 0=No)	0.338**	0.162						
Net seller in live animals (predicted value)	-3.954**	1.553						
Net buyer in live animals (1=Yes; 0=No)			0.338**	0.162				
Net buyer in live animal (predicted value)			-3.954**	1.553				
Net seller in crop (1=Yes; 0=No)					0.126	0.161		
Net seller in crop (predicted value)					1.953***	0.661		
Net buyer in crop (1=Yes; 0=No)							0.126	0.161
Net buyer in crop (predicted value)							1.953***	0.661
Constant	1.387	0.860	1.097**	0.456	-1.804***	0.469	-0.276	0.360
Number of observations			835				835	
LR $chi^2(14)$			234.24				45.33	
Prob > chi^2			0.000				0.000	
Pseudo R^2			0.233				0.067	
Log likelihood			-385.54				-317.47	

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