

Measuring Smallholder Commercialization Decisions and Interactions in Ethiopia

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Abstract

This paper measures the market orientation in land allocation, crop choices and commercialization of smallholders in rural Ethiopia and estimates their intensity and interaction at agricultural enterprise levels. It employs different relevant econometric estimation techniques including seemingly unrelated regression (SUR), Tobit model, univariate and seemingly unrelated bivariate probit models. The results indicated that households' land allocation and crop choices between staples and cash crops were strongly and negatively correlated, suggesting that production of staples and cash crops were competing for limited resources but their crop choices were determined by similar underlying covariates. Moreover, crop and livestock commercialization scales were strongly and positively correlated, implying that the scale of commercialization in one enterprise enhanced commercialization in the other and households' scale of commercialization in the two enterprises was determined by common underlying factors. However, their crop and livestock commercialization status were independent and their determinants were basically different.

Key words: Market orientation, crop choice, commercialization, SUR model, bivariate probit.

1. Introduction

Commercial transformation of subsistence agriculture is a crucial policy choice in economic growth and development for many developing countries like Ethiopia, where smallholder farming is the dominant livelihood activity. Agricultural commercialization brings about sustainable food security and welfare and enhances vertical and horizontal market linkage (von Braun 1994; Timmer 1997; Pingali, 1997; Gebremedhin and Jaleta, 2010). A farm household is assumed to be commercialized if it is producing a significant amount of cash commodities, allocating a proportion of its resources to marketable commodities, or selling a considerable proportion of its agricultural outputs (Immink, *et al.*, 1995). However, the meaning of commercialization goes beyond supplying surplus products to markets. It has to consider both the input and output sides of production, and the decision-making behavior of farm households in production and marketing simultaneously. Commercialization is not restricted only to cash crops as traditional food crops are also frequently marketed to a considerable extent.

Policy discourses around various dimensions of agricultural commercialization tend to separate producers into different types of farms growing different types of crops with simple distinctions made between 'subsistence' and 'commercial' (Leavy and Poulton, 2007). Household commercialization level can be categorized into three as low, medium or semicommercial and high or commercial). Lack of clarity about what commercialization actually means may give rise to misconceptions. The commonly accepted concept of commercialization is that commercialized households are targeting markets in their production decisions, rather than being related simply to the amount of product they would likely sell due to surplus production (Pingali and Rosegrant, 1995). Production decisions of commercialized farmers are based on market signals and comparative advantages, whereas those of subsistence farmers are based on production feasibility and subsistence requirements, and selling only whatever surplus product is left after household consumption requirements are met. Accordingly, three types of commercialization indices at household level can be specified: output and input side commercialization, commercialization of the rural economy, and degree of a household's integration into the cash economy (von Braun *et al.*, 1994). Households in a subsistence production system are characterized by income and nutritional requirements predominantly generated from own agricultural production compared to those commercial households which purchase their nutritional requirements from nonagricultural sources (Braun, 1995; Pingali, 2001).

Commercial transformation of subsistence agriculture is an indispensable pathway towards economic growth and development for many agriculture dependent developing countries (von Braun 1994; Pingali and Rosegrant, 1995; Timmer 1997). Commercialization enhances the links between the input and output sides of agricultural markets. It is evidenced that policy, technological, organizational and institutional interventions aimed at promoting commercial transformation of subsistence agriculture should follow two-pronged approach: improving market orientation of smallholders at production level, and facilitating market entry and participation of households in output and input markets (Gebremedhin and Jaleta, 2010). The dynamics and feasibility of smallholder commercialization in improving income generation is an important policy issue. The commercial behavior of smallholders and the commercialization scale at which they are operating is also a critical research question to be addressed since smallholder commercialization policies are usually designed under such conditions. Various studies on smallholder commercialization generally suggest that there is very low scale of commercialization in Ethiopian agriculture and try to identify factors determining the market orientation and commercialization decisions (Jaleta and Gardebroek, 2008; Adane, 2009; Mamo *et al.,* 2009; Bedaso *et al.,* 2012).

This study was designed to measure market orientation and commercialization decisions and the interactions of these decisions to enhance commercial transformation of smallholders in Ethiopia. The study has generated new empirical information on the simultaneous interaction of household decisions of market orientation in resource allocation and their commercial behavior to participate in the agricultural output markets for enhancing household welfare in Ethiopia.

2. Research Methodology

2.1. The Data Set and Variables

Agricultural systems in Ethiopia can be classified into four as the highland mixed farming system, low plateau and valley mixed agriculture, pastoral livestock production of the arid and semi-arid zones, and commercial agriculture (Ayele, 1980). Following this classification, the study was conducted in two major sedentary sub-farming systems of Central and Eastern highlands which cover about 40 percent of the total sedentary farming systems in Ethiopia. The study used primary data collected from four districts representing the two major sedentary farming systems. To account for the problem of heterogeneity in the study area, stratified two-stage random sampling technique was employed and a total of 260 rural households were randomly and proportionately sampled.

The major endogamous variables considered in the analysis include crop market orientation scale (%) of staples and cash crops, value of crop and livestock output sales (log), crop and livestock commercialization scales or indices (%), and crop and livestock commercialization status (binary). A household's consumption and production quotient weighted by the marketability index of each crop aggregated at a farming system level was the percentage measure used to capture the market orientation scale. A large body of theoretical and empirical literature identifies many covariates for market orientation and commercialization measures as reported by Braun *et al*. (1994), Strasberg *et al*. (1999), Gabre-Madhin *et al.* (2007), Gebreselassie and Ludi (2007), Jaleta and Gardebroek (2008), Adane (2009), Mamo *et al* (2009), and Bedaso *et al.* (2012). Accordingly, the common factors of commercialization in Ethiopia were hypothesized to be family size (head count) as a proxy for labor availability, farming experience (years), literacy status of the household head (binary), cultivated land size (hectares), quantity of chemical fertilizer used for crop production (quintals), irrigation water use (binary) or proportion of irrigated land (%), livestock holding in tropical livestock unit (TLU), number of oxen owned (head count), value of assets owned (farm, non-farm and total),), income (total, agricultural, and non-farm), credit access (binary) or amount of credit received (monetary value), civic engagement as a proxy to social capital (binary), distance to the nearest market as a proxy for market access (kilo meter, km), distance to the nearest road (km) as a proxy for transaction cost, proximity to a major town (km) as a proxy for market information, distance to development station (km) as a proxy for government extension service, production of major cash crop like *khat* (binary), and a dummy for the farming systems to capture agro-climatic and other geographical differences of the samples.

2.2. Intensity of Market Orientation and Commercialization

The household's decisions as to which crop category to produce are interdependent for the fact that resources, particularly land, labor and capital, are limited. Households decide to allocate their land among different crops, depending on their level of commercial behavior. In this case two crop categories, staples and cash crops, were considered as the major indicators of land allocation behavior of households. Marketability indices of all crops produced by households were determined as the consumption and production quotient of each analyzed commodity in the farming systems. If the entire production was intended for the commercial market, the marketability index amounted to zero and if the consumption and production were identical, the coefficient had the value of one. For surplus products, the coefficients ranged from zero up to one and that being reversible in proportion to the strength of the surplus quantity, while for deficit products, the greater the deficit, the coefficients were over one, which means in proportion with the deficit. Therefore, the strength of marketability stands in reciprocal relation with the calculated coefficient.

A crop specific marketability index (α_k) is computed for each crop produced at farming system level as follows:

$$\alpha_k = \sum_{i=1}^{i=n} \frac{qc_{ki}}{qt_{ki}}; \qquad qt_{ki} \geq qc_{ki} \;\; and \;\; 0 \leq \alpha_k \leq 1. \tag{1}$$

where α_k is the proportion of crop *k* consumed (qc_{ki}) to the total amount produced (qt_{ki}) aggregated over the total sample households in a farming system. α_k takes a value between 0 and 1, inclusive. Crops mainly produced for markets usually have α_k values closer to 0.

Household's market orientation index in land allocation is computed from the land allocation pattern of the household weighted by the marketability index of each crop (α_k) derived from the above equation (Gebremedhin and Jaleta, 2010):

$$moicr_i = \sum_{k=1}^{k=k} \alpha_k \frac{l_{ik}}{tl_i}; \tag{2}$$

$$tl_i > 0 \;\; and \;\; 0 < moicr_i \leq 1$$

where $moicr_i$ is market orientation index of household i, l_{ik} is amount of land allocated to crop k, and tl_i is the total crop land cultivated by household i.

The higher proportion of land a household allocates to the more marketable crops, the more the household is market oriented. The equation for households' market orientation scale was assumed to have some correlation with the equation of market orientation scales between staples and cash crops. Accordingly, they were simultaneously estimated by a two-equation SUR model (Zellner, 1962; Greene, 2012):

$$moist_i = \mathbf{x}_1\boldsymbol{\beta}_1 + e_{1i} \qquad moic_i = \mathbf{x}_2\boldsymbol{\beta}_2 + e_{2i} \tag{3}$$

where $moist_i$ and $moic_i$ are market orientation scales of staples and cash crops (%) of household i, respectively; and $\mathbf{x}_1$ and $\mathbf{x}_2$ are their respective vectors of factors determining the scale of household market orientation; $\boldsymbol{\beta}_1$ and $\boldsymbol{\beta}_2$ are the respective vectors of coefficients, and e_{1i} and e_{2i} are their random terms.

The intensities of households' commercialization in the two enterprises (crop and livestock) were estimated by the same linear SUR combination of output sales value and their covariates:

$$\ln crops_i = \mathbf{x}_1\boldsymbol{\beta}_1 + v_{1i} \qquad \ln livs_i = \mathbf{x}_2\boldsymbol{\beta}_2 + v_{2i}, \tag{4}$$

where $\ln crops_i$ and $\ln livs_i$ are log of crop and livestock output sales value, respectively; and $\mathbf{x}_1$ and $\mathbf{x}_2$ are vectors of variables explaining the respective intensity of commercialization; $\boldsymbol{\beta}_1$ and $\boldsymbol{\beta}_2$ are the respective vectors of coefficients; and v_{1i} and v_{2i} are their random terms.

Nonetheless, about 44.2% and 49.2% of the sample households didn't participate, respectively, in crops and livestock output markets. Estimation of output market participation of households measures the status of a household whether or not it is commercializing or selling its outputs into the market. It does not capture the extent to which a household is commercializing. On the other hand, linear SUR estimation of these variables may lead to biased results. If the amount a household sells into the market was negative or very small, all we observe them is selling nothing. To account for both of these problems, intensity of farm output commercialization was represented by a censored regression model. The most common censored regression technique is the Tobit model which expresses the observed level in terms of an underlying latent variable. The intensity of commercialization in each enterprise was, therefore, estimated by the following separate Tobit models (Tobin, 1958; Long, 1997; Cameron and Trivedi, 2009).

$$y_i = \mathbf{x}\boldsymbol{\beta} + \varepsilon_i \tag{5}$$

$$y_i = \begin{cases} \mathbf{x}\boldsymbol{\beta} + \varepsilon_i, \; if \;\; y_i^* > 0 \\ 0 \qquad\qquad\quad if \;\; y_i^* < 0 \end{cases} \tag{6}$$

where y_i is the log value of crop or livestock output sales, and the $\mathbf{x}$'s are vectors of covariates determining intensity of crop or livestock commercialization; and ε_i is normally distributed error.

2.3. Market Participation and Commercialization Status

The commercial scale of farm households can usually be divided into two binary values or three ordinal scales (as noncommercial, semicommercial, and commercial), depending on the distribution of the commercialization scale (Bedaso *et al.*, 2012; Pingali 2001). In this study, the distribution of the sample households' scale of commercialization was left-skewed. About 93% of crop producers and 92% of livestock owners of the sample households had commercialization index less than or equal to 60%, indicating the majority of them to be either semicommercial or noncommercial. To account for this skewed distribution, their commercialization status was assumed to be binary (semicommercial or noncommercial). Accordingly, the crop and livestock market participation and commercialization statuses of households were estimated by the following univariate probit model (Maddala, 1983; Long, 1997; Cameron and Trivedi, 2009; Long and Freese, 2005; Greene, 2012):

$$y_i^* = \mathbf{x}'\boldsymbol{\beta} + u_i \tag{7}$$

where y_i^* is binary latent variable for crop or livestock market participation or commercialization status; and $\mathbf{x}$'s are vectors of household specific and other socioeconomic factors determining the respective endogenous variables; $\boldsymbol{\beta}$ is the respective vector of coefficients; and u_i is the random term.

Like the case in simultaneous estimation of intensity of crop and livestock commercialization by the linear SUR model, the interdependence of crop and livestock commercialization status was simultaneously estimated by the seemingly unrelated bivariate probit model specified as (Hardin, 1996; De Luca, 2008; Greene, 2012):

$$\begin{aligned} comst_i^* &= \mathbf{x}_1'\boldsymbol{\beta}_1 + u_{1i} \\ comls_i^* &= \mathbf{x}_2'\boldsymbol{\beta}_2 + u_{2i} \end{aligned} \tag{8}$$

where $comst_i$ and $comls_i$ are crop and livestock commercialization status, respectively; u_{1i} and u_{2i} are their respective error terms in the bivariate probit and assumed to be normally distributed. Accordingly, the latent variables, observed and unobserved, were specified as:

$$\begin{aligned} \mathrm{comst}_i &= \begin{cases} \mathrm{comst}_i^* = \mathbf{x}_1'\boldsymbol{\beta}_1 + \mathrm{v}_{1i} \quad \text{if } comst_i^* > 0; \\ 0 \qquad\qquad\qquad\quad \text{if } comst_i^* \le 0. \end{cases} \\ comls_i &= \begin{cases} comls_i^* = \mathbf{x}_2'\boldsymbol{\beta}_2 + v_{3i} \quad if \;\; comls_i^* > 0 \\ 0 \qquad\qquad\qquad\quad if \;\; comls_i^* \le 0 \end{cases} \end{aligned} \tag{9}$$

3. Results and Discussion

The view that households' commercialization behavior can be reflected by their land allocation pattern and the marketability of crops was used as an indicator of household market orientation. The market orientation indices were computed for staples and cash crops. The crop market orientation index was right-skewed, reflecting that the land allocation decision of households was designed for household consumption. The translation of this land allocation behavior into commercialization was measured at an enterprise level (crop and livestock). Commercialization scale computed for the two enterprises were left-skewed since households had low level of commercialization scale. The mean commercialization scale of households was 16.5% for crop and 15.6% for livestock outputs, suggesting insignificant difference in the scale of commercialization between enterprises. However, commercialization scale was largely different between farming systems. The scale of crop commercialization was 34% and 4%, respectively, in Eastern and Central highlands while livestock commercialization scale was 21% and 11% in Eastern and Central highlands. In both enterprises, households in Eastern highlands were relatively more commercial. Most households were semicommercial when their commercialization status was determined by taking 30% as a cutoff point. Households falling above this threshold were considered semicommercial and the rest noncommercial. Based on this, about 23.5% and 20% of the households were semicommercial, respectively, in their crop and livestock outputs.

3.1. Intensity of Market Orientation and Commercialization

The SUR model estimation results of market orientation and commercialization are reported in Table 1. The estimation results of market orientation scale verified that the negative cross-equation correlation of residuals was strongly significant in the crop choice between staples and cash crops implying that the two equations of staples and cash crops had similar underlying determinants. The variation explained in households' market orientation of land allocation was 77% for staples and 15% for cash crops. The predicted scale of market orientation of households in their land allocation decision was 52% for staples and 25% for cash crops production. The results generally signify that households allocate the largest proportion of their land to production of staples and make less market-oriented land allocation decisions. Households' market orientation decision to produce staples was primarily determined by family size, proportion of irrigated land, distance to nearest market, the farming system and other shocks. They consider their family size, distance to nearest market, the farming system, and other shocks to produce cash crops.

Crop and livestock commercialization are normally expected to have linear correlation since intensity of commercialization in one enterprise is dependent on the result of household commercialization decisions in the other enterprises. To account for the expected cross-equation correlation in crop and livestock commercialization scales, the two equations were simultaneously estimated by a linear SUR model. As expected, the residuals from the two equations were strongly and positively correlated and the SUR model explained about 47% and 11% of the variation in intensity of crop and livestock commercialization, respectively. The scale of commercialization in the two entyprises was reinforced between each other. The results suggested that crop commercialization was enhanced by quantity of fertilizer used, total assets, distance to major town (unexpected sign), and production of major cash crop. A unit change in quintals of fertilizer used increased crop commercialization by about 1.3%. However, the largest contribution in households' crop commercialization was that of major cash crop (*khat)* production (4.4%). Livestock commercialization was improved by family size (0.4%), fertilizer used (0.7%), livestock holding (0.2%), and other exogenous shocks (3.7%), and negatively affected by size of cultivated land (0.8%), and distance to development station (0.2%). The predicted intensity of commercialization was 4.1% for crops and 3.8% for livestock, suggesting that households were noncommercial. However, households with and without major cash crop production were significantly different in their intensity of commercialization.

Intensity of crop and livestock commercialization was estimated by separate Tobit models and the results reported in Table 2. Accordingly, the residuals from the estimation of intensity of crop commercialization were normally distributed while those of livestock were not (interpretation omitted). The Tobit estimation results for crop commercialization equation suggest that the factors enhancing intensity of crop commercialization were quantity of fertilizer used, value of total assets, distance to major town, and production of major cash crop. A unit change in the use of fertilizer increased the marketed crops output by about 2.1%. If households were major cash crop producers, their marketed crop output would be increased by 6.3%. However, there were other exogenous factors negatively affecting intensity of crop commercialization. These shocks were able to reduce the marketed crop output by 5.2%. The predicted values of intensity of crop and livestock commercialization were 2.5% and 1.3%, respectively, suggesting that agricultural outputs were generally used for household consumption. Households in Eastern highlands were relatively better in their crop commercialization (3.1%), compared to their counterparts in Central highlands (2%). Households producing major cash crop were relatively more commercial (6.9%) than non-cash crop producer households (0.6%). On the other hand, intensity of livestock commercialization was influenced by family size, cultivated land, fertilizer used, livestock holding, and distance to development station with very low intensity (1.3%).

3.2. Market Participation and Commercialization Status

The expected interdependence of market participation decisions of households in their crop and livestock outputs was estimated by a bivariate probit model as reported in Table 3. The null that crop and livestock market participation decisions of households are independent was rejected at 5% level, suggesting that households considered both enterprises to participate in the output markets and their decisions were determined by similar underlying covariates. The model results suggested that crop market participation was determined by quantity of fertilizer used, distance to major town (unexpected sign), production of major cash crop, and other exogenous shocks. On the other hand, participation in the livestock market was determined by family size, cultivated land, livestock holding, access to credit, distance to major town and development station. As indicated by the joint marginal effects, the underlying common determinants of market participation decision of smallholders in Ethiopia were family size (3%), cultivated land (9%), livestock holding (2%), quantity of fertilizer used (12%), access to credit (18%), distance to development station (2%), and production of major cash crop (22%), all of which were in line with theoretical and empirical expectations. The predicted probabilities to participate in crop and livestock output markets were 67% and 50%, respectively. The likelihood of households to participate in the markets of both outputs was 37%, implying that households were less likely to simultaneously participate in markets of outputs from both enterprises.

Households' commercialization status for both crop and livestock outputs was estimated by univariate probit models and the results reported in Table 4. The factors determining crop commercialization were distance to road and major town, production of major cash crop, and other factors. Livestock commercialization, on the other hand, was influenced by family size, quantity of chemical fertilizer used for crop production, and proximity to development station. The signs of the coefficients for both equations were consistent with theory and other results generated in this study. The probability of households to commercialize in crop outputs was largely improved (15%) by production of major cash crops like *khat.* However, their likelihood to commercialize in crops output was very small (only 4%), as compared to their probability to commercialize in livestock outputs (16%). These predictions were increased to 33% for crops and reduced to 14% for livestock if households produced major cash crops in Eastern highlands. Livestock commercialization was relatively higher in Central highlands (18%).

4. Conclusion

The market orientation and commercialization scales and statuses of smallholders in rural Ethiopia were measured as both continuous and categorical levels. The SUR model estimation results of market orientation scale of households in land allocation between staples and cash crops were strongly and negatively correlated suggesting that production of staples and cash crops were competing for limited resources which influenced the scale of market orientation of households. Households allocate the largest proportion of their land to production of staples and their choices were driven by less market oriented land allocation decisions. Their crop choice decisions were determined by similar underlying covariates like family size, proportion of irrigated land, distance to nearest market, the farming system and other shocks. On the other hand, crop and livestock commercialization scales were strongly and positively correlated, verifying that the scale of commercialization in one enterprise enhances commercialization in the other. Households' scale of commercialization in the two enterprises was determined by common underlying factors including family size, cultivated land, quantity of fertilizer used, livestock holding, total assets, distance to development station, production of major cash crop and other exogenous shocks. The predicted intensity of commercialization was 4.1% for crops and 3.8% for livestock, suggesting that households in rural Ethiopia were generally noncommercial.

The Tobit model estimation results indicated that intensity of crop commercialization was determined by quantity of fertilizer used, value of total assets, distance to major town, production of major cash crop, and other shocks. Intensity of livestock commercialization was influenced by family size, cultivated land, fertilizer used, livestock holding, and distance to development station. The predicted intensities of commercialization in both enterprises was very low or subsistence. Households' decisions to participate in crop and livestock output markets were positively correlated and commonly determined by similar underlying covariates such as family size, cultivated land, livestock holding, quantity of fertilizer used, access to credit, distance to development station, and production of major cash crop, all of which were theoretically and empirically justifiable. The probabilities to participate in crop and livestock output markets were 67% and 50%, respectively. However, the likelihood of households to participate in the markets of both enterprises was less likely (37%). On the other hand, households' crop and livestock commercialization status were independent and their determinants were basically different. Crop commercialization status was determined by distance to road and major town, production of major cash crop, and other factors while livestock commercialization was influenced by family size, quantity of chemical fertilizer used, and proximity to development station. The probability of households to commercialize in their crops output was very small (only 4%), as compared to their probability to commercialize in their livestock outputs (16%).

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Table 1: Simultaneous estimation results of market orientation and commercialization scales

Variables	Coefficients (Equations)			
	Market orientation scale		Commercialization scale	
	Staples	Cash crops	Crop	Livestock
Family size	-0.01*	0.01*	0.07	0.36***
Literacy status	-0.02	0.002	-	-
Farming experience	-0.0004	0.0003	0.01	-0.01
Land cultivated	-	-	-0.30	-0.84**
Proportion of irrigated land	0.07*	-0.04	-	-
Quantity of fertilizer	-0.01	0.01	1.30***	0.66**
Livestock holding (TLU)	-	-	-0.001	0.24**
Number of oxen	0.002	0.0004	-	-
Value of total assets (log)	0.007	-0.003	0.23*	-0.07
Distance to nearest market	0.007***	-0.01*	-	-
Proximity to major town	0.0003	-0.0003	0.05***	-0.001
Distance to nearest roads	-	-	-0.06	-0.06
Distance to development station	-	-	-0.06	-0.19***
Production of major cash crop	-	-	4.42***	-0.25
Farming system	-0.54***	0.12***	0.68	-0.71
Constant	0.70***	0.20**	-0.85	3.65**
R^2	0.77	0.15	0.47	0.11
Predicted value (base run)	0.52	0.25	4.14	3.81
Predicted value (with *khat*)	-	-	7.26	3.63
Predicted value (without *khat*)	-	-	2.85	3.88
Cross-equation correlation of residuals	-0.67		0.18	
Breusch-Pagan LM test of independence, $\Pr(\chi^2(1))$	0.00		0.00	

Note: ***, **, and *, respectively, signify significance levels of 1%, 5% and 10%.

Table 2: Tobit estimation results of intensity of commercialization (%) by enterprises

Variables	Coefficients (Equations)	
	Crop	Livestock
Family size	0.09	0.67***
Farming experience	0.03	-0.02
Land cultivated	-0.51	1.73**
Quantity of fertilizer	2.12***	1.13*
Livestock holding (TLU)	-0.02	0.46**
Value of total assets (log)	0.40*	-0.11
Distance to major town	0.08***	-.01
Distance to nearest road	-0.13	-.07
Distance to development station	-0.11	-.52***
Production of major cash crop	6.34***	-.32
Farming system	1.17	-1.77
Constant	-5.24**	1.49
Sigma	4.43	6.48
Predicted value (base run)	2.45	1.29
Predicted value (Hararghe highlands)	3.12	0.27
Predicted value (Central highlands)	1.95	2.04
Predicted value (with *khat*)	6.94	1.07
Predicted value (without *khat*)	0.59	1.38
Log likelihood	-496.39	-527.77
$LR\ (11)\chi^2$	145.34	27.63
Pseudo R^2	0.13	0.03
Left censored observations	115	128
Normality test of residuals, $P > \chi^2(2)$	0.97	0.00

Note: ***, **, and *, respectively, signify significance levels of 1%, 5% and 10%.

Table 3: Bivariate probit estimation results of crop and livestock market participation status

Variables	Coefficients (Equations)		Marginal effects		
	Crop	Livestock	Crop	Livestock	Joint effect
Family size	0.03	0.10**	0.01	0.04**	0.03**
Farming experience	0.01	-0.003	0.002	-0.001	0.0001
Land cultivated	-0.13	-0.24*	-0.05	-0.10*	-0.09*
Livestock holding (TLU)	-0.03	0.10***	-0.01	0.04***	0.02*
Quantity of fertilizer	0.52***	0.11	0.19***	0.04	0.12**
Value of total assets (log)	0.09	-0.01	0.03	-0.003	0.01
Access to credit	0.32	0.44**	0.11	0.17**	0.18**
Distance to nearest road	-0.02	-0.02	-0.01	-0.001	-0.01
Distance to major town	0.02***	-0.0004	0.01***	-0.0002	0.003
Distance to development station	-0.03	-0.08**	-0.01	-0.03***	-0.02**
Production of major cash crop	2.45***	-0.13	0.59***	-0.05	0.22**
Farming system	0.19	-0.11	0.07	-0.04	0.00
Constant	-1.59***	-0.23			
Ath rho			0.25**		
Rho			0.24		
Log psuedolikelihood			-274.03		
Wald $\chi^2(24)$			93.57		
Wald test of $\rho = 0$, $\Pr > \chi^2(1)$			0.05		
Predicted probability			0.67	0.50	0.37

Note: ***, **, and *, respectively, signify significance levels of 1%, 5% and 10%.

Table 4: Univariate probit estimation results of agricultural commercialization status

Determinants	Coefficients (Equations)		Marginal effects	
	Crop	Livestock	Crop	Livestock
Family size	0.10	0.11**	0.01	0.03**
Farming experience	0.02	0.01	0.002	0.001
Land cultivated	-	-0.32	-	-0.08
Land allocated to staples	-0.30	-	-0.03	-
Land allocated to cash crops	-	0.41	-	0.10
Proportion if irrigated land	-	-	-	-
Quantity of fertilizer	0.18	0.41***	0.02	0.10***
Livestock holding (TLU)	-0.07	-0.07	-0.01	-0.02
Access to credit	-	-	-	-
Value of total assets (log)	0.11	-0.07	0.01	-0.02
Social capital		-	-	-
Distance to major town	-0.05*	-0.01	-0.01*	-0.002
Distance to nearest market	-	-	-	-
Distance to nearest road	-0.07*	-0.02	-0.01	-0.01
Distance to development station	-0.10	-0.10*	-0.01	-0.02**
Production of major cash crop	1.12***	-	0.15*	-
Farming system	0.90	-0.15	0.09	-0.04
Constant	-2.51*	-0.12	-	-
Log likelihood	-64.51	-114.90		
$LR\ (11, 12)\chi^2$	154.27	30.41		
Pseudo R^2	0.54	0.12		
Predicted probability (base run)			0.04	0.16
Probability (Hararghe highlands with *khat*)			0.33	0.14
Probability (Hararghe highlands without *khat*)			0.06	0.14
Probability (Central highlands with *khat*)			0.09	0.18
Probability (Central highlands without *khat*)			0.01	0.18

Note: ***, **, and *, respectively, signify significance levels of 1%, 5% and 10%.