Analysis of the effects of livestock market participation on food security and welfare of smallholder farmers in Ethiopia

Ahmed Kasim Dube*, Burhan Ozkan*

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Abstract

In Ethiopia, where a large proportion of rural households depend on livestock for livelihood, food security remains a significant concern for large portions of the population. The commercialization of the livestock sector is expected to play an important role in stimulating economic growth, reducing poverty and achieving food security. This study evaluates the effect of livestock market participation on household's food security and welfare using a nationally representative cross-sectional survey data of rural households in Ethiopia. The endogenous switching regression model which accounts for both the selection and endogeneity bias is employed to examine the effect of livestock market participation. The robustness of the results is checked using propensity score matching. The results indicate that participation in livestock market improved food security and welfare of the participating households. Participation in the market also would have increase food security and welfare of non-participants had they decided to participate in the market. Furthermore, in rural areas where alternative income possibilities are scant, livestock market participation has smoothed food consumption by providing income in times of harvest failure or other shocks striking households. However, building a more sustainable market-oriented production system is critical for the improvement of household food security and welfare.

Keywords*: Food security, Livestock, Market participation, Endogenous switching regression, Ethiopia.*

1. Introduction

In Africa, livestock is central to the livelihoods of rural population and is strategically important to the continent's food and nutritional security. It is estimated that the livestock sector contributes between 20 to over 80 percent of the agricultural value added in African countries, averaging at 35% across the continent (LiDeSA, 2015). It is noted that in many developing countries, achieving the UN Sustainable Development Goals (SDG) would depend greatly on how livestock production systems are managed to meet the needs of massive surges in the human population (Herrero & Thornton, 2013). The subsector has the potential to deliver both agricultural-led growth and socio-economic transformation for improved livelihoods (LiDeSA, 2015). In this regard, livestock represents a potential pathway out of poverty and food insecurity for many of the poor in developing countries (Aklilu & Cat-

* Akdeniz University, Faculty of Agriculture, Department of Agricultural Economics, Antalya, Turkey.
Corresponding author: aburushdakasim@gmail.com

ley, 2014; Herrero & Thornton, 2013). It enables poor people to secure current and future assets, improve the productivity of agricultural systems in which livestock are important and facilitate greater participation of the poor in livestock-related markets (Njuki & Sanginga, 2013). Moreover, livestock offers an alternative source of capital that the poor can accumulate as a 'savings account' to hedge against income fluctuations (Kazianga & Udry, 2006). Keeping livestock is then considered as an alternative form of insurance, providing the household with assets that can be sold in times of shocks (Mogues, 2011).

The livestock sector in Ethiopia occupies an important place in the economy and pro-poor development strategies of the country (Kuma *et al*., 2015).The country has the largest population of livestock in Africa (Kuma *et al*., 2015). In 2014, 18% of the total cattle population and 8.2% of the sheep and goat population in Africa are found in Ethiopia (Enahoro *et al*., 2019). With these figures, livestock account to about 40-50% of agricultural GDP. It is also an important contributor to export earnings, accounting for 15% of total export earnings (FAO, 2017). Furthermore, at the household level, the livelihoods of a large proportion (70%) of rural households in the country depends on livestock (FAO, 2019). Hence, any shocks that affect livestock will have an adverse effect on the overall economy and on household welfare (Kuma *et al.*, 2015).

Food insecurity (22.7 percent) and poverty (27.1 percent) remains a significant concern for large portions of the population in the rural areas of the country (WFP & CSA, 2019). In this case, significant number of the country's rural population (28.36 percent) were classified as livestock keepers living under the national poverty line (Enahoro *et al.*, 2019). In addition, there is also a significant interrelationship between mixed crop and livestock farming in the country (FAO, 2017). This shows that, with appropriate management interventions, livestock have an important role in improving food security and reducing poverty in Ethiopia (Shapiro *et al.*, 2015). Therefore, the sector needs to be considered among any options aimed at transforming present and future welfare outcomes at the household, sectorial and national levels (Enahoro *et al.*, 2019).

In all Ethiopian government agricultural policies and strategies, prioritization of livestock development is pursued for stimulating economic growth, reducing poverty and achieving food security (MoA and ILRI, 2013). Under the Ministry of Agriculture, Ethiopia launched a Livestock Master Plan for the transformation of the livestock sector in July 2015. By strengthening the livestock sector and spurring growth, the goals were to enhance nutrition and food security and to lift 2.36 million households out of poverty by 2030 (Shapiro *et al.*, 2015). Besides raising their productivity, the plan has adopted market participation of smallholder agriculture as a strategy for its economic transformation (Shapiro *et al.*, 2015). This is because unless smallholder linkages to markets are strengthened simultaneously, the mere attempts to raise productivity will have limited success (Arias *et al.*, 2013). Besides its impact on rural people, the commercialization of the livestock sector has also potential impact on urban dwellers through enhancing supply of agricultural inputs for industrial production (Enahoro *et al.*, 2019).

Hence, the potential contribution of the livestock sector for economic development and welfare improvement in low income countries depends on the extent to which the livestock sector is thriving at the marketing level (IGAD, 2017). When market access is guaranteed, the general welfare of smallholding farm households is improved through increased productivity and income and better consumption choices (IFAD, 2010). It is also noted that, besides inadequate entitlements, lack of access to reliable markets for farm produce and inputs are equally important in defining the food security status of the farm households (Burchi & Muro, 2012). This shows that increasing participation of farm households in agricultural markets is a key factor to lift rural households out of poverty. As a result, the role of market participation as the determinant of the household food security and welfare has attracted the attention of researchers in different parts of the world. The results of Gani & Adeoti (2011) indicated that poor market participation was found to have positive correlation with poverty in Nigeria. Interventions reducing the barriers of market participation and

facilitating the improvement of productivity to generate consistent levels of marketable surplus will often have greater payoffs in living standards of smallholder farmers and poverty reduction (Arias *et al.*, 2013).

Other studies have also indicated that enhancing smallholder participation in markets has significant potential to increase the income potentials, especially for poor and land-constrained farmers (Hichaambwa *et al.*, 2015). According to their results, income gains were more pronounced for small and poor households. In addition, market participation was an important instrument to alleviate extreme poverty. Participation in markets was also seen to reduce the gender gap in rural household income (Hichaambwa *et al.*, 2015). Results also showed that household commercialization was associated with a reduced risk of being chronically food poor (Kirimi *et al.*, 2013). Expansion of smallholder market participation and ensuring that farmers are not trapped in low productivity and low return farming activities are crucial in helping households graduate out of food insecurity (Kirimi *et al.*, 2013). Furthermore, different studies (Abdullah *et al.*, 2019; Mmbando *et al.*, 2015) have also indicated a positive and significant impact of market participation on household food security and welfare.

Most of these studies in smallholder market participation have models on the decision of smallholder market participation in staple crops. Among the few works modeling the impact of livestock market participation, Mulford (2013) studied the welfare effects of smallholder market participation on Kenya's dairy sector. By analyzing households' asset dynamics, the study highlights a strong association between high milk sales levels and improved welfare. But due to the qualitative nature of the work, the causal direction was not evident. Lubungu (2013), by employing propensity score matching and decomposition techniques on data collected from smallholder farmers in Zambia, examined the effect of participation in cattle markets on cattle-raising households' incomes. The findings showed that on average participation in cattle markets raises household income by over 50%. However, the propensity score matching approach may understate the magnitude of the effects leading to a downward bias relative to methods which also account for unobserved heterogeneity (Tesfaye & Tirivayi, 2018). In addition, the model fails to account for the potential systematic difference between participants and non-participants (Khonje *et al.*, 2015). Furthermore, the empirical studies that evaluated the impact of livestock suffer from the absence of control groups and endogeneity problems associated with the selection bias (Jodlowski *et al.*, 2016). Hence, the objectives of this study would be filling these gaps by estimating the food security and welfare effects of livestock market participation using a different set of identification and estimation strategies that address the selection and endogeneity problems.

The rest of the paper is organized in three sections. The next section describes the impact estimation problems, conditional expectations, and treatment and heterogeneity effects, data and the description of the variableas. The third section presents and discusses the empirical results of the study. Finally, the conclusion and the implication of the results are presented.

2. Materials and methods

2.1. *Impact estimation problems*

The estimated impact of market participation on the selected outcome variables can be calculated by directly comparing the average treatments between the participants and nonparticipants if the farmers were randomly assigned to each group (Khonje *et al.*, 2015). However, participation in livestock markets by smallholder farmers is non-random as the farmers themselves decide (self-select) whether to participate or not in the market. In addition, these decision are influenced not only by observable characteristics but also by non-observable characteristics (such as a farmer's innate abilities) that may be correlated with the outcome variables (Olwande & Smale, 2014). In the regression framework, this means that the error terms in the decision and outcome equations are correlated (Ma & Abdulai, 2015) and the mean outcomes of the two groups may differ even in the absence of treat-

ment. Consequently, the non-randomness poses a well-known dilemma of missing data in which the counterfactual outcome cannot be observed for both groups (Olwande & Smale, 2014).

Estimation of the impact of market participation without considering the problem of missing data will result in biased estimates. Different approaches for dealing with this problem include propensity score matching (PSM), the Heckman selection method, Instrumental variables (IV) and Endogenous switching regression models (ESR) (Khonje *et al.*, 2015; Olwande & Smale, 2014). Among these models, the ESR model has some advantages over the other models. First, the method addresses the issues of selection bias by accounting for both observable and non-observable characteristics. Second, the ESR approach simultaneously estimates the participation decision and outcome equation for both participants and non-participants and calculates the actual and counterfactual expected values of outcome variables for both groups(Lokshin & Sajaia, 2004). However, the results from ESR model may be sensitive to selection of instrumental variables (Khonje *et al.*, 2015). Thus, as each model has its own limitations which cannot be corrected individually, the estimates are not robust by using a single model (Khonje *et al.*, 2015). Therefore, the effect of market participation on the binary and continuous outcome measure of food security and welfare was estimated by using the Endogenous Switching Probit Model (ESP) and Endogenous switching regression model respectively. The robustness of the results is checked by using the PSM model. These models were widely applied in the literatures and general specifications of these models can be seen in Lokshin & Sajaia (2004), Wooldridge (2010) and Maddala (1983).

2.2. *Conditional expectations, and treatment and heterogeneity effects*

Though the endogenous switching regression models can be estimated using a two stage method, the more efficient version of the models is obtained by using the full information maximum likelihood method (FIML) (Lokshin & Sajaia, 2004). Consequently, the study used the FIML method which estimates the decision and outcome equations simultaneously. After estimating the model's parameters, the conditional expectations are computed as follows (Lokshin & Sajaia, 2004).

For participants who participated:

$$E(y_{1i}|P_i = 1, x_{1i}) = x_{1i}\beta_1 + \sigma_1\rho_1 f(\gamma Z_i)/F(\gamma Z_i) \quad (1a)$$

For participants had they decided not to participate (counterfactual):

$$E(y_{1i}|P_i = 0, x_{1i}) = x_{1i}\beta_1 - \sigma_1\rho_1 f(\gamma Z_i)/\{1 - F(\gamma Z_i)\} \quad (1b)$$

For nonparticipants had they decided to participate (counterfactual):

$$E(y_{2i}|P_i = 1, x_{2i}) = x_{2i}\beta_2 + \sigma_2\rho_2 f(\gamma Z_i)/F(\gamma Z_i) \quad (1c)$$

For nonparticipants who did not participate:

$$E(y_{2i}|P_i = 0, x_{2i}) = x_{2i}\beta_2 - \sigma_2\rho_2 f(\gamma Z_i)/\{1 - F(\gamma Z_i)\} \quad (1d)$$

Equations 1a and 1d represent the actual expectations observed in the sample while equations 1b and 1c represent the counterfactual expected outcomes. Table 1 presents the summary of the conditional expectations, and treatment, and heterogeneous effects. Following Di Falco *et al.*, (2011) and Heckman *et al.*, (2001), the effect of market participation on outcome variables of households that actually participated in the market was computed by calculating the difference between a and c:

$$\begin{aligned} TT &= E(y_{1i}|P_i = 1, x_{1i}) - E(y_{2i}|P_i = 1, x_{2i}) \\ &= x_{1i}\beta_1 + \sigma_1\rho_1 f(\gamma Z_i)/F(\gamma Z_i) - x_{2i}\beta_2 \\ &\quad + \sigma_2\rho_2 f(\gamma Z_i)/F(\gamma Z_i) \end{aligned} \quad (2)$$

Similarly, the difference between b and d was used to calculate the treatment effect on households that did not participate in the market:

$$\begin{aligned} TU &= E(y_{1i}|P_i = 0, x_{1i}) - E(y_{2i}|P_i = 0, x_{2i}) \\ &= x_{1i}\beta_1 - \sigma_1\rho_1 f(\gamma Z_i)/\{1 - F(\gamma Z_i)\} - \\ &\quad x_{2i}\beta_2 - \sigma_2\rho_2 f(\gamma Z_i)/\{1 - F(\gamma Z_i)\} \end{aligned} \quad (3)$$

The effect of base heterogeneity for households that participated in the market (BH_1) was computed by calculating the difference between a and b:

$$\begin{aligned} BH_1 &= E(Y_{1i}/P_i = 1) - E(Y_{1i}/P_i = 0) \\ &= x_{1i}\beta_1 + \sigma_1\rho_1 f(\gamma Z_i)/F(\gamma Z_i) - x_{1i}\beta_1 - \\ &\quad \sigma_1\rho_1 f(\gamma Z_i)/\{1 - F(\gamma Z_i)\} \end{aligned} \quad (4)$$

Table 1 - Conditional expectations, and treatment, and heterogeneous effect.

Sub-samples	*Decision stage*		*Treatment effects*
	To participate	*Not to participate*	
Households that participated	(a) $E(y_{1i}\|P_i = 1, x_{1i})$	(c) $E(y_{2i}\|P_i = 1, x_{2i})$	TT
Households that did not participated	(b) $E(y_{1i}\|P_i = 0, x_{1i})$	(d) $E(y_{2i}\|P_i = 0, x_{2i})$	TU
Heterogeneity effects	BH_1	BH_2	TH

Note: Y_{1i} *= outcome variables if households participated*
Y_{2i} *= outcome variables if households did not participate*
TT = the effect of the market participation on the households that participated
TU = the effect of the market participation on the households that did not participate
BH = the effect of base heterogeneity for households that participated (i = 1), and did not participate (i = 2)
TH = (TT-TU), i.e., transitional heterogeneity.

Similarly, the effect of base heterogeneity (BH_2) for households that did not participate in the market was calculated by taking the difference between c and d:

$$BH_2 = E(Y_{2i}/P_i = 1) - E(Y_{2i}/P_i = 0) = x_{2i}\beta_2 + \sigma_2\rho_2 f(\gamma Z_i)/F(\gamma Z_i) - x_{2i}\beta_2 - \sigma_2\rho_2 f(\gamma Z_i)/\{1 - F(\gamma Z_i)\} \quad (5)$$

Another important statistic is transitional heterogeneity (TH) which is the difference between TT and TU and measures whether the effect of market participation is larger or smaller for households that participated or for households that did not participate, in the counterfactual case that they did participate (Di Falco *et al.*, 2011). Similarly, the treatment effect of binary outcome variables was calculated in the framework of the endogenous switching probit model (Lokshin & Sajaia, 2004).

For the ESR and ESP models to be properly identified, a variable that has a direct effect on the decision to participate in the market but does not have direct effect on the outcome variables of interest (i.e., food security and welfare) should be included in the decision model. Consequently, following the studies on the impact of market participation (Mmbando *et al.*, 2015; Muricho *et al.*, 2018), the information source variables were hypothesized as candidates for the instruments. This is based on the fact that access to reliable sources of marketing information either through formal or informal institutional arrangement is critical for commercialization of agriculture (Jagwe *et al.*, 2010). In this regard, extension services, by linking households with markets and providing the right marketing information (Rehima *et al.*, 2013), enables the households to commercialize their agricultural products. In addition, a household's ownership of a mobile phone is also an important determinant of marketing participation (Mmbando *et al.*, 2015). However, the mere access of farmers to marketing information without participating in the market does not affect the outcome variables of interest (Mmbando *et al.*, 2015). Information variables are thus expected to affect the outcome variables only when the households are participating in the market. However, according to the results of a simple falsification test conducted for the statistical admissibility of these selection instruments (Di Falco *et al.*, 2011), only access to the extension service was found as a valid instrument significantly explaining the market participation decision but not the outcome equation of the households that did not participate in the market (Table A.4). Consequently, access to extension services was used as the instrument in both ESR and ESP models.

2.3. *Data*

The study used data from the Ethiopian Socioeconomic Survey (ESS), a nationally representative cross-sectional survey of rural households of Ethiopia in 2015/16. The data were collected under the Living Standards Measurement Study-Integrated Surveys on Agriculture Initiative (LSMS-ISA) in collaboration with Central Statistical Authority (CSA). In the collection of these data a two-stage probability sampling

technique was used. The first stage of sampling entailed selecting primary sampling units, or CSA enumeration areas (EAs). A total of 433 EAs were selected based on probability proportional to size of the total EAs in each region. For the rural sample, 290 EAs were selected. A total of 43 and 100 EAs were selected for small town and urban areas, respectively. The second stage of sampling involved the selection of households from each EA. For rural and small town EAs, a total of 12 households were sampled from each EA. However, 15 households were selected in each large town EA. Finally, a total of 4,954 households were interviewed. As the study is interested in the rural farmers in Ethiopia, by excluding the capital and the provincial capital cities and deleting some missing observations, the analysis here is based on a sample of 2655 households. The survey questionnaire collected information on basic demographics; education; food and nonfood expenditures; household nonfarm income-generating activities; food security and shocks; safety nets; assets; credit; and other sources of household income. The community questionnaire gathered information on access to infrastructure and community organizations. The post-planting and post-harvest agriculture questionnaires focused on farming activities and solicited information on land ownership and use and crop harvest and utilization. The livestock questionnaire collected information on animal holdings and sales of livestock.

2.4. *Variables and descriptive statistics*

2.4.1. *Outcome variables*

Different proxy indicators were used to measure the outcome variables of interest including food security and welfare of households. The household dietary diversity score (HDD) measuring the number of different food groups consumed over a given reference period (FAO, 2013) is the first proxy indicator used to measure the household's food security. It reflects the economic ability of the household to access a variety of foods (Swindale & Bilinsky, 2006). In addition, as HDD is strongly related to other measures of food security (FAO, 2013), it is an efficient proxy measure widely employed to measure food security (FAO, 2013; Headey & Ecker, 2013).

Following FAO (2013) and Swindale & Bilinsky (2006), the food groups chosen to create the HDD were categorized into 12 food groups.[1] The results of the descriptive statistics tests presented in Table 2 show that the average dietary diversity score of 6.972 for the market participating households was significantly higher than the score of 6.649 for the nonparticipants. In addition, the experience based proxy indicators reflecting the household's subjective feelings about food insecurity were used to complement dietary diversity measures (D'Souza & Jolliffe, 2016). These proxy measures were developed from coping strategies used against food insecurity[2] and self-reported food insecurity. Following the work of D'Souza & Jolliffe (2016) and Tesfaye & Tirivayi (2018), two dummy variables were created and labeled "negative change in diet" and "reduced food intake". The first two questions of coping strategies used against food insecurity were used to create a negative change in diet variable while the remaining questions were used for the construction of the reduced food intake variable. The descriptive statistics for both the negative change in diet and reduced food intake show that there is no significant difference between the market participant and nonparticipant households (Table 2).

The self-reported food insecurity dummy variable was created based on the household's response to the question, 'In the last 12 months,

[1] The twelve food groups used for the calculation of the HDD include cereals; white tubers and roots; vegetables; fruits; meats; eggs; fish and other seafood; legumes, nuts and seeds; milk and milk products; oils and fats; sweets; spices, condiments; and beverages (FAO, 2013).

[2] Questions used to derive the two indicators from the copping strategies include (1) relied on less preferred foods, (2) limited the variety of foods eaten, (3) limited portion size at mealtimes, (4) ate fewer meals in a day, (5) restricted adult consumption to benefit small children, (6) borrowed food or relied on help from a friend or relative, (7) had no food of any kind in the household, and (8) went a whole day and night without eating anything (D'Souza & Jolliffe, 2016).

Table 2 - Outcome variables.

Outcome Variables	*Participants (N= (1,432)*	*Non-participants (N= 1,223)*	*t/X²-value*
	Mean (St.dev.)	*Mean (St.dev.)*	
Household Dietary Diversity	6.972 (0.047)	6.649 (0.0535)	4.539***
Negative change in diet (%)	29.469	29.354	0.0649
Reduced food intake (%)	17.2486	15.454	-1.2443
Self-reported Food insecurity (%)	28.581	27.892	0.1544
Per-capita consumption expenditure	224.981 (457.375)	209.704 (494.656)	3.48**

*Note: *** and ** denotes significance at 1% and 5% level, respectively. Values in the parenthesis represent the standard deviation. Per capita consumption is expressed in Ethiopia Birr.*

have you been faced with a situation when you did not have enough food to feed the household'. The results in Table 2 show that more than one quarter of both the market participants and non-participant households have reported facing the problem of food insecurity. Finally, per capita consumption expenditure, constructed by adjusting the summation of the food consumption expenditure and non-food consumption expenditure by per month, was used as a proxy measure of the household's welfare. Average per capita consumption expenditures by participating household was significantly higher than that of nonparticipating households.

2.4.2. *Independent variables*

The important variables of interest were selected based on the empirical studies on market participation and the impacts of market participation on food security and welfare (Gani & Adeoti, 2011; Gebremedhin *et al.*, 2015; Seng, 2016; Lubungu, 2013; Mmbando *et al.*, 2015; Muricho *et al.*, 2018; Olwande & Smale, 2014). Variables were categorized as household characteristics and assets (age, gender, education level of the household head, household size, land size, asset ownership, access to non-farm income opportunities and household commercialization index); herd characteristics and shocks (number of livestock owned by type (TLU), number of dead animals and shocks in the households); transaction cost variables (distance to main road and livestock market); institutional variables (access to social safety nets and access to credits); and information variables (mobile ownership and access to extension). The results of the descriptive statistics tests are presented in Table A.1. Most market participants were male and their households owned a significantly larger herd than nonparticipants (Table A.1). There was also significantly more livestock lost for market participants than for nonparticipants. This was expected to increase the likelihood that the household became food insecure by decreasing the marketable surplus of the household. The results presented in Table A.1 also showed that there was a statistically significant difference between the household crop intensification index (HCI) of the two groups, suggesting that nonparticipants rely more on the sale of crops. Furthermore, about 65% of market participants were negatively affected by shocks (usually the death of family members or drought). Access to major roads and markets were used to capture the effect of transaction costs on the smallholder farmers' market participation and food security as higher transaction costs often arise from the problems of poor infrastructure (Takeshima 2008). Accordingly, the results presented in Table A.1 show that participants were closer to major roads and markets than nonparticipants.

3. Results and discussion

In this section, results of the econometric model estimations are presented and discussed. The first section is devoted to the discussion of the propensity score matching results and the sensitivity analysis of the treatment effects to the hidden bias. Following this, the results of the

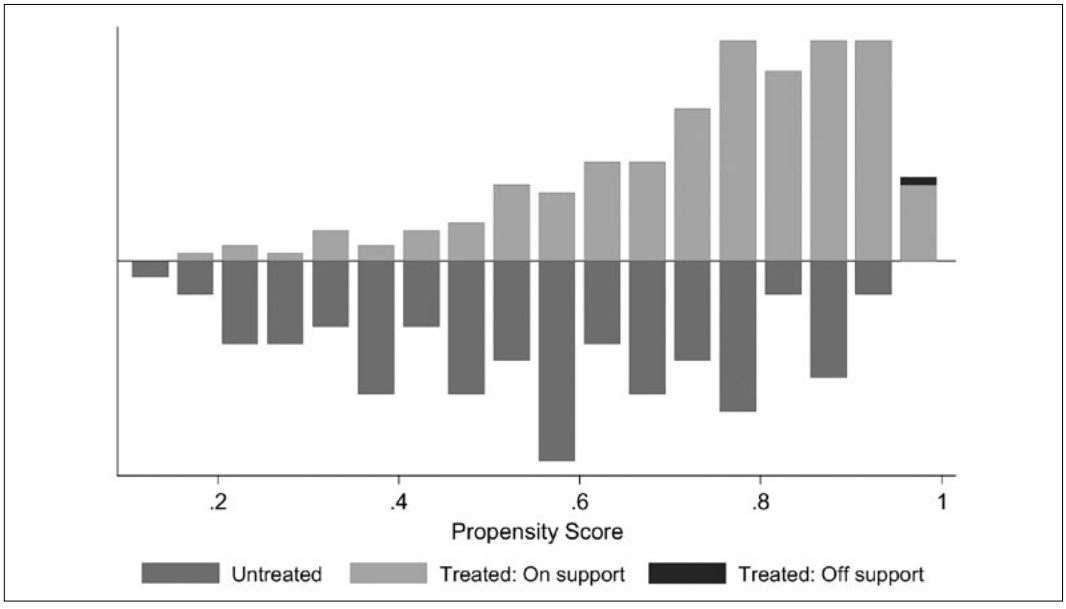
determinants of market participation and the estimation results of the treatment effects obtained by using the endogenous switching regression model and endogenous switching probit model are discussed.

3.1. *Propensity score matching results and sensitivity analysis of the treatment effects*

In the current study, the PSM model is used as a robustness check (Caliendo & Kopeinig, 2008). However, the validity of the model must first be examined by verifying the common support or overlap condition. This is important to ensure that households with the same x-values have positive probability of being both market participants and nonparticipants (Caliendo & Kopeinig, 2008). Consequently, the distributions of the propensity scores for both groups were estimated and are presented in Figure 1. A visual inspection of the propensity score distribution in Figure 1 indicates that the common support condition is satisfied as there is a substantial overlap in the distribution of the propensity scores for both market participants and nonparticipants.

After verifying the overlap condition, the next step is checking the balancing of propensity scores and covariates in the groups of participants and nonparticipants. This was done by implementing a variety of diagnostics tests (Leuven and Sianesi, 2003). The results of the diagnostic tests are presented in Table A.2. According to the results, the standardized mean difference for overall covariates used in the estimation process reduced from 21% before matching to a range of 3.1- 3.3% after matching. The total bias was also reduced significantly through the matching process which clearly indicates that the matching process effectively reduced biases in the estimates. In addition, the p-values of the likelihood ratio tests also showed that the joint significance of covariates was rejected after matching while it was not rejected before matching. Moreover, the pseudo-R^2 was decreased significantly from 17 percent before matching to 2.1 percent after matching. This low value of the pseudo-R^2 indicates that there was no systematic difference in the distribution of covariates between the two groups after matching. These results indicated that the matching quality was fairly good. There-

Fig. 1 - Propensity score distribution and common support for propensity score estimation.



Note: Treated on support indicates individuals participating in the market that have a suitable match. Treated off support indicates individuals participating in the market that have no suitable match.

fore, the proposed specification of the propensity scores is successful in terms of balancing the distribution of propensity scores and covariates between the two groups and it can be used to evaluate the effect of market participation.

After verifying both matching and balancing tests, the PSM model was used to evaluate the effect of market participation on outcome variables. The estimates of the average treatment effects (ATT) obtained by using Kernel Based Matching (KBM) and Nearest Neighbor Matching (NNM) techniques are presented in Table A.3. The propensity score matching results could be sensitive to the hidden bias if selection is affected by unobserved characteristics (Smith & Todd, 2005). Hence, the results of the sensitivity analysis obtained by using the Rosenbaum bounds tests (DiPrete & Gangl, 2004) and the Mantel-Haenszel (MH) bounding approach (Becker & Caliendo, 2007) for binary and continuous outcomes are presented in the last columns of Table A.3. These are the critical levels of gamma (Γ) at which the causal inference of a significant effect of participation in the market may be questioned. Accordingly, the estimates showed that farmers who participated in the market have a 20 to 22% higher HDDs compared to nonparticipants. However, this conclusion of the market participation effect on HDD would be questioned at the critical level of Γ falling in the range of 1.15-2.35. The results also showed that per capita consumption expenditures increased in the range of 5% to 7% for market participants. These results would also be questioned for Γ values falling in the range of 1.40 to 1.90. Similarly, though the results showed market participating households have better food security status than nonparticipants as manifested by the low percentage of negative changes in diet and reduced food intake for market participants compared to nonparticipants, the results would be questioned for value of Γ ranging between 1.1-1.35 and 1.1-1.85, respectively. A value of Γ closer to 1 show that the impact estimates are highly sensitive to hidden bias while a larger value of Γ indicates less sensitivity of the impact estimates to the hidden bias. These results of PSM model suggest that the estimated average treatment effects of market participation on outcome indicators are sensitive to the hidden bias and there is a need to control for the hidden selection bias through endogenous switching regression models. The ESR and ESP models, which account not only for the observable characteristics but also for the effect of the unobservable characteristics, are presented in the next sections.

3.2. *Determinants of market participation*

The estimated results of market participation jointly estimated using the FIML procedure is presented in Table A.5. The results showed that the likelihood of participating in the market is significantly affected by the gender of the household heads. Male-headed households have a higher probability of participating in the market than female-headed households. The descriptive results also supported this result. This is due to the fact that male-headed households have better access to productive assets to increase the chances of producing a marketable surplus, which in turn increased the chance of participating in the market (Awotide *et al.*, 2016). In addition, as men are more responsible for providing cash incomes to the households, male-headed households are more market oriented than female (Sigei *et al*., 2014). Furthermore, as opposed to their counterparts**,** female-headed households are more negatively affected by the transaction costs of searching for buyers and enforcing a sale transaction (Jagwe *et al.*, 2010). The finding in this study is consistent with the results of different studies (Awotide *et al.*, 2016; Sarma *et al.*, 2014). However, the finding is different from the finding of other studies (Asfaw *et al.*, 2012; Olawuyi & Mushunje, 2018), which found a higher probability of participating in the market for female-headed households than their male counterparts. These could be because production of some goods is an important source of income for women smallholders.

Household size is significantly and positively correlated with the likelihood of participating in the market. This shows that the probability of participation in the livestock market increases as household size increases. This could be because livestock's most important contribution to food security is more in income generation than in

food production (Njuki & Sanginga, 2013). In this case, a large household size implying availability of cheaper labour can also help households increase the possibility of producing marketable surplus which in turn increase the likelihood of farm households participation in the market (Alene *et al.*, 2008). In this regard, livestock is a crucial source of income for poor households to access their food. This suggests that more family members encourage households to sell their livestock, which in turn is used to meet the increased needs of the family. However, according to the findings of Awotide *et al.* (2016) larger household size reduced the probability of households participating in the rice market. They reasoned that larger households consume most of the rice output in the home and this tends to reduce the tendency to produce a marketable surplus as rice is the most important staple food crops in Nigerian diets. Similarly, the findings of Olawuyi & Mushunje (2018) also indicated that an increase in household size tends to decrease the likelihood of participating in the output market, which could be a result of overdependence on the limited resources of farmers.

The household crop commercialization index has a significant and negative correlation with the likelihood of participating in the market. This suggests that households getting the needed income from the sale of their crops have less incentive to sell their livestock. The result is consistent with the findings of Lubungu (2013) who found that high crop commercialization dampens the farmers' likelihood of participating in the livestock market.

Distance to roads and market have a significant and negative correlation with the likelihood of participating in the market. The further the household resides from the nearest road and livestock market, the less likely it will be involved in the selling of the livestock. Increased distance to roads and the market increase transaction costs and discourage the household from entering the market (Umar & Baulch, 2007). These transaction costs will be more significant especially in the marketing of live animals from distant areas because transaction charges are not limited to transport alone but include local taxes and the costs of holding, fodder, and water (Umar & Baulch, 2007). Therefore, farmers are more inclined to build larger herds as drought-coping mechanisms than to build a large herd for increased commercial off-take (Asfaw *et al.*, 2012). In this case livestock would be taken to the market at times when their value has decreased significantly as a result of their age added to the shocks like drought. Consequently, improving market infrastructure by building the marketplace and constructing and improving roads to reduce transportation cost should be an important consideration in promoting market-oriented production (Gebremedhin *et al.*, 2015). The result of the study is consistent with the findings of Asfaw *et al.* (2012) and Mmbando *et al.* (2015) who found for households located far away from market were less likely to participate.

Access to extension services and mobile ownership as a source of marketing information affected the likelihood of participating in the market positively and significantly. This suggests that households with better access to marketing information are more likely to participate in the market. The extension service provides required technical assistance and marketing information and can link households with markets (Rehima *et al.*, 2013). These services help households to improve their productivity and to produce a marketable surplus. This suggests that, inadequate access to extension services are among the hindrances to participation in the market (Ndoro *et al.*, 2014). Mmbando *et al*. (2015) obtained similar results in which farmers with better access to extension services and mobile phones as the sources of market information were more likely to participate in markets.

Herd size is the other important variable significantly and positively affecting the likelihood of participating in the market. Households with larger herd size are more likely to produce a marketable surplus, as there will be more potential in the stock to participate in the market. The result suggests the significant importance of helping the households to increase their herd size. The result is consistent with the results of different studies (Gebremedhin *et al.*, 2015; Lubungu *et al.*, 2012; Ndoro *et al.*, 2014) stating that households with bigger livestock herd sizes are more likely to sell their livestock than those

with smaller herds. Related to this, the results of the study indicated that the numbers of dead animals in the year have a significant and negative correlation with the likelihood of participating in the market. The more livestock that the households are losing, the less marketable surplus is available for the market. The finding is consistent with the finding of another study (Gebremedhin *et al.*, 2015) which found a negative correlation between the number of dead animals in the year and the probability of market participation in the market.

Shocks the household faced positively and significantly affected the likelihood of participation in the market. This implies that households facing shocks like death, illness and other asset-related shocks have a higher probability of participating in the market. Livestock is a form of insurance that provides the household with assets that can be sold in times of shocks (Do *et al.*, 2019; Mogues, 2011). Andersson *et al.* (2011) indicated that shocks appear to lead households to disinvest in livestock. In addition, the results of Börner *et al.* (2015) also indicated that households tend to deplete financial and durable assets in response to death, illness or asset-related shocks. Remittances were found to affect the likelihood of households participating in the market negatively and significantly. Farmers regularly receiving more unearned incomes such as remittances from their family members and friends are not likely to participate in the market (Ndoro *et al.*, 2014; Olawuyi & Mushunje, 2018).

3.3. *Endogenous switching regression model*

The estimated parameters of the endogenous switching regression model are presented in Table A.6. In the second and third columns of Table A.6, determinants of HDD are presented. These results indicate that there is a systematic difference between market participants and nonparticipants. In this case, household size was negatively and significantly affected HDD for non-participant households. This suggests that the household's food security declines with the increase in its size. This could be because larger households have higher consumption, which requires more food and generates food security issues. Seng (2016) found that household size negatively and significantly affected HDD of both market participants and non-participants, though the effects were greater among nonparticipating households. The coefficient of the age of the household head was significantly negative for both the market participants and nonparticipants. This implied that an older household head might be associated with lower labor force participation in other income generating activities, which in turn increases the exposure to food insecurity. Farm size, reflecting the ownership of important resources, significantly and positively affected the HDDS of only market participants. This could because, households with large farms are less likely to become food insecure through minimizing their production risk and increasing productivity. In the findings of Seng (2016) the coefficient of farm size was significantly positive for the participants but negative for the nonparticipant, suggesting that nonparticipants use their own land in a less productive way than do the participants.

Distance to road and market was found to negatively affect the HDD of both the market participants and nonparticipants. This suggests that the further the household is from main road and market the higher the likelihood that it is food insecure. This could be because proximity to main roads and a major market by creating access to additional income through providing non-farm employment and easy access to inputs, extension and transportation enhances households' food security. Distance to the administration center affected significantly and negatively the HDD of only non-participants.

The herd size was significantly positive for the both the market participants and nonparticipants, indicating that households with more livestock have a better chance to be food secure. A large herd size contributes to the household's food security and dietary diversity through their use as food, a source of income, as a hedge against risks and as a means of capital accumulation that can be exchanged for food in times of deficit (Do *et al.*, 2019). However, the number of animal deaths in the year and shocks the household faced affected the HDDs signifi-

cantly and negatively. In this case, the potential of households to cope with shocks and smooth households' consumption and incomes would decline. The implication of this result is that the government and private sector can increase food security by controlling the high livestock mortality rate in the smallholder farmers (Do *et al.*, 2019; Lubungu, 2013). Muricho *et al.* (2018) also found that the coeficient of the herd size was positive and significant supporting the argument that livestock can provide a pathway out of poverty or at least a way to reduce the poverty gap for livestock owners (Do *et al.*, 2019). Though access to a safety net was significantly positive only for nonparticipants, the results indicate that a safety net program could play a positive role in reducing asset depletion and enhancing productive investment for food insecure households (Adimassu & Kessler, 2015). Access to remittances was positive and significant for both market participants and nonparticipants. This indicates that, households with access to remittances are more likely to be food secure. The result is consistent with the findings of Seng (2016) who suggested the importance of remittances in reducing rural poverty.

Table A.6 also reports the results when per capita consumption expenditures are used as a proxy for the household welfare. The results indicated that household size affected the welfare of the households negatively and significantly for both the market participants and nonparticipants. This suggests that farmers with large households have lower welfare due to a higher number of dependents requiring higher consumption and more expenditure (Abdullah *et al.*, 2019). In addition, large households are more likely to expand farming operations by using available family labor, which could lead to over-dependency on limited resources of farmers (Olawuyi & Mushunje, 2018). The findings are in conformity with findings of different studies (Abdullah *et al.*, 2019; Awotide *et al.*, 2016; Olawuyi & Mushunje, 2018). The age of the household head was also revealed to be negatively and significantly correlated with the household's welfare. In the finding of Awotide *et al.* (2016), the age of the household head was obtained positively and significantly affecting the household welfare. Distance to roads and market were also found to significantly and negatively affecting the welfare of the households for participants and nonparticipants. The finding is consistent with results of different studies (Abdullah *et al.*, 2019; Mmbando *et al.*, 2015). The herd size owned and access to remittances was also significant for both the market participants and nonparticipants. However, the number of dead animals in the year and the farm size owned was significant only for nonparticipants. Access to nonfarm income opportunities affected positively and significantly only the welfare of participants.

In the ESR estimation, the likelihood ratio test and correlation coefficients of the covariance terms between the error terms in decision and outcome equations also have important economic interpretations (Fuglie & Bosch, 1995). The estimation results are presented in the lower part of Table A.6. The results of likelihood ratio test for joint independence of the participation and outcome equations were significant, suggesting that the participation and outcome equations are jointly dependent and endogeneity needs to be controlled in the specification of the outcome equations. The correlation coefficients were also statistically significant which indicates the presence of the selectivity bias. These results thus confirmed that both observable and unobservable characteristics influenced both the decision to participate in the market and the outcome variables. Failing to account for these factors may result in biased estimates. The sign of the correlation coefficients between market participation and outcome variables had the same sign in the case of HDD equation. This suggests that the HDDs for participants are above the average level whether they participate or not, but farmers are better off by participating. On the other hand, the HDDs of nonparticipant are below the average level in both cases, but farmers are better off by not participating (Fuglie & Bosch, 1995). In the case of per capita consumption expenditures, the opposite signs of correlation coefficients indicated that both the participant and nonparticipant households had an above-average value of the outcome by participating in the market.

Table 3 - Treatment and heterogeneity effects based on endogenous regression models.

Outcomes	*Households/Treatment effects*	*Decision to*		*ATE*
		Participate	*Not to participate*	
Household Dietary Diversity score	Participating households (ATT)	6.985	6.735	0.250 (0.058)***
	Non-participating households (ATU)	7.800	7.661	0.139 (0.040)***
	Heterogeneous effect (BH)	-0.815	-0.926	0.111
Per capita consumption expenditure (ln)	Participating households (ATT)	8.740	8.423	0.311 (0.035)***
	Non-participating households (ATU)	9.11	8.45	0.667 (0.023)**
	Heterogeneous effect (BH)	-0.37	-0.027	-0.349

*Note: Ethiopia Socio-economic Survey (ESS) (2015-2016); ATT-Average Treatment Effect on the Treated, ATU-Average Treatment Effect on the Untreated, ATE- Average Treatment Effect, *** p<0.01.*

3.4. *Estimation of treatment effects based on endogenous regression models*

The ESR model results of the average treatment effects (ATT), accounting for selectivity bias arising from both the observable and unobservable characteristics, is presented in Table 3. The results reveal that the expected HDD score for the participant household was 6.985. The score would be 6.735 had they decided not to participate in the market. Thus, the participant households' dietary diversity score would decline by 0.250 units had they decided not to participate in the market. For non-participants the dietary diversity score was 7.661. The households' dietary diversity score would have increased by 0.139 had they decided to participate in the market. In this regard, livestock being a key income source for the poor plays an important role in improving the dietary diversity of households, as dietary diversity increases with income (Sandford & Ashley, 2008). Livestock also affects dietary diversity through the increase in total consumption expenditures (Rawlins *et al.*, 2014) that can contribute to their owner's ability to access food of all kinds. The result of model thus shows that participation in the market is the important determinants of households' food security. The result was consistent with the other finding (Seng, 2016) who showed that by participating in markets, farm households enjoyed higher dietary diversity scores. However, Asfaw *et al.* (2012) found that although participation in the output market has a positive and significant effect on reducing food insecurity, there was no significant impact on dietary diversity.

Table 3 also shows that market participation positively and significantly affected households' welfare. The increase in per capita consumption expenditure was 31 percent for participants and households that did not participate in the market would gain 67 percent had they decided to participate in the market. These results show that participation in the market increased the welfare of the participants and would have helped households that did not participate. The result was consistent with the findings of Mmbando *et al.* (2015) who found that participation in the maize and pigeon pea market increased per capita consumption expenditures by 19.2-20.4% and 28.3-29.4%, respectively. Results from Lubungu (2013) also indicated that participation in cattle markets raises household income by over 50%, though poor households derive relatively smaller benefits from participation than their non-poor counterparts. A study conducted in South Africa (Chaminuka *et al.*, 2014) also showed that commercialization of cattle and cattle products increased total household cash income by 29%.

The results of the base heterogeneity were negative for both HDDs and per capita consumption expenditures indicating that house-

holds are better off by participating in the market (Table 3). However, the transitional heterogeneity effect was positive for HDDS implying that the effect was greater for farm households that did participate in the market than to the ones that did not. But this result was negative for per capita consumption expenditures which indicates that the effect was higher for nonparticipants had they decided to participate in the market. Thus, these results suggest that with appropriate interventions, participation in livestock markets can enhance both food security and welfare of farm households. One possible strategy is to promote livestock production because increasing livestock ownership may increase the number of animals sold, thus increasing household income (Lubungu, 2013). In this case, intervention aimed at increasing production in the livestock sector should emphasize the farmers use of the innovative livestock technologies (Dhraief *et al.*, 2019).

3.5. *Endogenous switching probit regression model*

The results of the endogenous switching probit model obtained by using FIML method are presented in Table A.7. In this section, for the brevity, we discuss only the impact of market participation on the binary outcome of food security. According to the results presented in Table 4, market participation reduces the probability of reporting food insecurity by 32% for market participating households. The likelihood of reporting food insecurity would be 29% for non-market participants had they participated in the market. In this instance, the sale of livestock being an important outlet for smallholders households (Saxena *et al.*, 2017) reduces the hardest challenges of food insecurity by ensuring that households can have a way to purchase food when volatile economies and natural disasters make already weak livelihoods even more unstable (FAO, 2017).

The results also show that market participation reduces the probability of a negative change in diet by 49% for market participant households. Similarly, the probability that the household would reduce food intake during the period of food shortage declines by 71%. The probability of reducing food intake would decline by 15% for nonparticipants in the market had they participated in the market. This implies that, despite the fact that households usually smooth their consumption using variety of methods, the substantial food gap remaining would force households to liquidate their assets (especially livestock) during times of food shocks (Hänke & Barkmann, 2017). Livestock thus plays an important role in contributing to food security through providing cash income from livestock sales that can be used to purchase food, especially during times of food deficit (Dorward *et al.*, 2005; Hatab *et al.*, 2019; Njuki & Sanginga, 2013).

This suggests that livestock serve as a financial source, that can be drawn upon in the season when lower production and income are insufficient to support consumption needs (Dorward *et al.*, 2005). Studies conducted in rural Ethiopia also indicated that livestock is an alternative coping mechanism as it provides the household with assets that can be sold in times of shocks (Mogues, 2011; Yilma *et al.*, 2014). The study in Niger further indicated that 60% of the households relied on livestock sales to cope with food shortages or unexpected medical expenditures (Alary *et al.*, 2011). Sim-

Table 4 - Treatment effects based on switching-probit model.

Outcome	*ATT*	*ATU*	*ATE*	*MTE*
Self-reported food insecurity	-0.325***	0.296***	-0.042***	-0.017***
Negative change in diet	-0.488***	-0.279***	-0.389***	-0.327***
Reduced food intake	-0.711***	-0.148***	-0.450***	-0.139***

*Source: Ethiopia Socio-economic Survey (ESS) (2015-2016); ATT-Average Treatment Effect On The Treated, ATU-Average Treatment Effect On The Untreated, ATE- Average Treatment Effect and MTE-Marginal Treatment Effect, *** denotes significance at 1% level.*

ilarly, Hänke & Barkmann (2017) also found that approximately 54% of total cash income came from livestock sales and accounted for around 57% of cash food expenditures on average. Thus, livestock, by providing products for income generation and quick cash when emergencies and shocks occur, occupies an integral part of smallholder farming systems.

4. Conclusion

In Ethiopia, where a large proportion of rural households depend on livestock for livelihood, food security remains a significant concern for large portions of the population. However, with a significant number of poor people depending on livestock production for their livelihood and incomes, the livestock sector is expected to play an instrumental role in achieving sustainable food security in the country. The sector has the potential to improve food and nutrition security and to promote more inclusive agricultural sector growth (Aklilu & Catley, 2014, ILRI, 2019). Furthermore, the potential size of livestock population in the country also implied that livestock sector intervention in Ethiopia will have significant socio-economics importance not only for the country but also for the region at large (Enahoro *et al.*, 2019). Hence, the livestock sector in Ethiopia, after several years of neglect, was recently recognized as one of the key sectors in the broader economic development plans of the country (Shapiro *et al.*, 2015). In this plan of development, market participation of the smallholder agriculture was adopted as a strategy for the economic transformation of the country.

The current study uses an endogenous switching regression model framework combined with the propensity score matching strategies to evaluate the determinants of livestock market participation and their subsequent effect on household's food security and welfare in Ethiopia. As the study had used a nationally representative household survey data, the results of the study have the most favorable scale for the strategic orientation of policy makers (Jeder *et al.*, 2020). The results of the study indicate that livestock market participation by smallholder farmers in Ethiopia has increased household food security and welfare, with both outcomes substantially greater for households participating in the market. In addition, livestock sales have smoothed out food consumption by providing income in times of harvest failure or other household shocks. This is very important in rural areas of Ethiopia where households with few social protections frequently experience economic hardship. Consequently, the results of the study suggest the transformation of livestock production system into a more sustainable, market-oriented production system would benefit farmers.

In this endeavor, the important variables for the transformation of livestock production system were also identified in the results of the study. As indicated in the results, most of the farmers are far from market centers and major roads, indicating the absence of an assured effective livestock market near the farmers' residence. The absence of assured markets for the farmers produces lead to distress sales and thus reduces revenues from sales by increasing the transaction cost of marketing. These circumstances would in turn hinder the effort of the transformation of livestock production system into a sustainable market-oriented system. Besides poor market infrastructure, the results of the study also indicated that control of animal disease would help households increase their herd size. Systems for better disease control are important policy considerations in promoting both the market orientation and the food security of the households. In addition, as illiteracy among the producers was prevalent, provision of market information through strengthening the extension system is desirable. Furthermore, though the institutional factors like cooperatives and credit are insignificant in the current study, formations and strengthening of farmers' institutions are critically important to improve the market orientation and market linkages of the smallholder farmers. Otherwise, individual livestock producers may find it difficult to use the improved market linkages. Therefore, the effort to improve market linkages for livestock producers should integrate the market-oriented livestock production system with a system of livestock health, breeding and marketing services. Finally, since livestock sales not only provide

cash income for farm households but also generate a significant number of jobs, especially in rural areas where other income opportunities are limited, the future research of interest in livestock marketing should consider the effect of livestock market participation on other elements of livestock value chains.

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Appendix

Table A.1 - Descriptive statistics of the independent variables used in the study.

Variables	*Participants (N= (1,432)*		*Non-participants (N= 1,223)*		*t/X²-value*
	Mean	*St.dev.*	*Mean*	*St.dev.*	
Households' characteristics and asset ownerships					
Gender (=1 if male)	82.47		75.72		-4.301***
Age (in Years)	47.70	0.37	48.02	0.43	0.590
Educational level (in Years)	0.448	0.448	0.392	1.889	0.4671
Adult equivalent household size	4.55	0.048	4.33	0.05	-3.044***
Household size (Numbers)	5.61	0.059	5.34	0.07	-3.051***
Nonfarm (=1 if it owns non-farm enterprise)	21.51		21.51		-0.002
HCI (%)	10	0.005	21.7	0.0819	2.150**
Asset index[3]	0.26	0.04	0.039	0.04	-3.742***
Farm size (hectare)	1.64	0.08	1.27	0.05	-3.852***
Transactions cost factors					
Distance to road (Km)	15.04	0.54	17.16	0.61	2.490**
Distance to market (Km)	65.83	1.29	68.25	1.49	1.212
Distance to administration (Km)	175.42	3.66	156.25	3.43	-3.837***
Information variables					
Mobile phone ownership (=1 if head owned)	58.14		52.51		-2.906***
Access to extension (=1 if it has access)	45.87		41.62		-2.203**
Herd characteristics and shocks					
Herd size owned in TLU	6.817	0.204	4.085	0.135	-10.781***
Dead animals (No.)	4.37	0.18	2.74	0.07	-7.867***
Shocks (= if HH affected negatively by shock)	65.36		60.75		-2.458**
Institutional factors					
Access to social safety net (=1 if received)	7.12		4.82		-2.476**
Access to remittance (=1 if received)	10.55		8.26		-2.004*
Cooperative (=1 if available in the community)	15.57		14.96		-0.435
Credit (=1 if received credit)	18.65		17.33		-0.875

*Source: Ethiopia Socio-economic Survey (ESS) (2015-2016); ***, ** and * denotes significance at 1%, 5% and 10 % level respectively.*

[3] The asset index was computed by applying the first principal component to household assets' including farm implement, furniture, personal items and other assets.

Table A.2 - Matching quality test indicators before and after matching.

Matching algorithm	*Pseudo R2*		*LR X^2 (p-values)*		*Mean standardized Bias*		*Total % bias reduction*
	Before matching	*After matching*	*Before matching*	*After matching*	*Before matching*	*After matching*	
Kernel based matching (KBM)	0.168	0. 02	247.40 (0.000)	9.84 (0.971)	21.3	3.1	85
Nearest neighbor Matching (NNM)	0.167	0. 04	229.23 (0.000)	14.78 (0.737)	21.2	3.6	83

Source: Ethiopia Socio-economic Survey (ESS) (2015-2016).

Table A.3 - Results of average treatment effects (ATT) and sensitivity analysis.

Matching algorithms	*Outcomes variables*	*Participants*	*Non-participants*	*ATT (S.E)*	*Critical value of the hidden bias(Γ)*
Kernel based matching (KBM)	HDD	6.972	6.754	0.218 (0.081)***	1.15-2.35
	Self-reported food insecurity	0.286	0.279	0.007 (0.018)	1.05-1.15
	Negative change in diet	0.259	0.297	-0.037 (.020)*	1.05-1.1
	Reduced food intake	0.144	0.172	-0.037 (0.022)*	1.05-1.25
	Percapita consumption Expenditure (ln)	8.508	8.448	0.059 (0.03)**	1.45-1.9
Nearest neighbor Matching (NNM)	HDD	6.972	6.769	0.203 (.086)**	1.2-2.0
	Self-reported food inssecurity	0.288	0.256	0.030 (0.028)	1.05-1.35
	Negative change in diet	0.240	0.297	-0.057 (.028)**	1.05-1.35
	Reduced food intake	0.120	0.172	-0.052 (0.021)**	1.25-1.85
	Percapita consumption Expenditure (ln)	8.519	8.444	0.075 (0.033)**	1.40-1.80

*Source: Ethiopia Socio-economic Survey (ESS) (2015-2016); ***, ** and * denotes significance at 1%, 5% and 10 % level respectively. The Number in brackets show bootstrapped standard errors with 100 replication samples.*

Table A.4 - Test for the validity of selection instruments for endogenous regression model.

Variables	*(1) Market participation*	*(2) Percapita consumption expenditure (ln)*	*(3) HDDS*	*(4) Self-reported food insecurity*
Extension services	0.103 (0.050)**	0.026 (0.024)	0.011 (0.074)	0.114 (0.070)
Mobile ownership	0.038 (0.0057)***	-0.169 (0.025)***	0.416 (0.076)***	0.095 (0.071)
Other variable	Yes	Yes	Yes	Yes
Constant	0.242 (0.139)*	9.182 (0.059)***	7.496 (0.181)***	(1.513) (0.169)***
Wald chi2(2) F	254.62***	F = 16.55	19.90	235.26***
Observations	2655	1223	1223	1223

*Note: Models (1) and (4) are Probit model, Models (2) and 4) are Ordinary least squares; ***, ** and * represents the significance level of p value at a probability of 1, 5 and 10 respectively; values in the parenthesis are the standard errors. The reports of control variables included in the model were not reported to save the space.*

Table A.5 - The determinants of market participation.

Variables	*Coefficients*	*Std. Err.*	*P>z*
Gender	0.234 ***	0.067	0.000
Age	-0.002	0.002	0.185
Educational level	0.017	0.013	0.191
Household size	0.028 **	0.013	0.027
Nonfarm	0.002	0.063	0.975
HCI	-0.135 ***	0.072	0.0063
Farmsize	0.022	0.012	0.162
Cooperative	0.003	0.003	0.355
Distance to road	-0.001 ***	0.002	0.004
Distance to market	-0.002 ***	0.001	0.002
Distance to administration	0.002	0.002	0.296
Extension	0.094 *	0.054	0.085
Mobile ownership	0.102 **	0.048	0.032
Asset index	0.091	0.022	0.482
TLU	0.047 ***	0.008	0.000
Dead animals	- 0.117*	0.067	0.083
Shocks	0.195 *	0.113	0.083
safety net	0.041	0.054	0.447
Remittance	-0.149 *	0.089	0.093
Credit	0.004	0.009	0.624
_cons	0.017	0.161	0.918

*Source: Ethiopia Socio-economic Survey (ESS) (2015-2016); ***, ** and * denotes significance at 1%, 5% and 10 % level respectively.*

Table A.6 - Endogenous switching regression model for continuous outcomes.

Variables	*Household dietary diversity (HDD)*				*Percapita consumption expenditure (ln)*			
	Participants (N= (1,432)		*Non-participants (N= 1,223)*		*Participants (N= (1,432)*		*Non-participants (N= 1,223)*	
	Coef.	*P>z*	*Coef.*	*p>z*	*Coef.*	*p>z*	*Coef.*	*p>z*
Gender	0.069 (0.137)	0.611	0.163 (0.139)	0.240	0.067 (0.043)	0.114	0.038 (0.046)	0.408
Household size	-0.004 (0.023)	0.856	-0.049 (0.027) *	0.068	-0.090 (0.008)***	0.000	-0.103 (0.009)	0.000
Age	-0.013 (0.003) ***	0.000	-0.011 (0.004) ***	0.002	-0.002 (0.001)*	0.084	-0.004 (0.001)***	0.001
Educational level	0.005 (0.023)	0.839	0.042 (0.027)	0.128	0.006 (0.007)	0.400	0.009 (0.009)	0.344
Nonfarm	-0.002 (0.004)	0.571	0.006 (0.002)	0.722	0.141 (0.037)***	0.000	0.063 (0.043)	0.141
HCI	0.006 (0.001)	0.346	0.370 (0.127) ***	0.004	-0.0022 (0.001)	0.239	-0.0073 (0.0001)	0.188
Asset index	0.318 (0.114) ***	0.005	0.350 (0.040) ***	0.000	0.097 (0.011)***	0.000	0.100 (0.013)***	0.000
Farmsize	0.336 (0.034) ***	0.000	0.034 (0.033)	0.295	0.003 (0.001)	0.825	0.032 (0.013)	0.015
Distance to road	-0.004 (0.002)**	0.067	-0.006 (0.003)**	0.041	-0.002 (0.001) ***	0.004	-0.002 (0.001)*	0.064
Distance to market	-0.004 (0.001)***	0.000	-0.004 (0.001)***	0.002	-0.002 (0.004)***	0.000	-0.003 (0.000)***	0.000
Distance to administration center	-0.003 (0.004)	0.946	-0.01 (0.001)*	0.064	-0.002 (0.001)***	0.053	-0.003 (0.000)*	0.060
TLU	0.034 (0.009)***	0.000	0.030 (0.017)*	0.069	0.012 (0.004)***	0.002	0.029 (0.007)***	0.000
Dead of animals	-0.001 (0.010)	0.909	-0.041 (0.024)*	0.084	-0.006 (0.003)***	0.065	-0.022 (0.008)***	0.004
Shocks	-0.333 (0.130)**	0.010	-0.045 (0.108)	0.679	-0.065 (0.033)***	0.048	-0.061 (0.037)***	0.099
safety net	-0.086 (0.193)	0.656	0.287 (0.151)*	0.057	-0.002 (0.063)	0.974	-0.095 (0.049)***	0.053
Remittance	0.585 (0.155)***	0.000	0.420 (0.191)**	0.028	0.173 (0.051)***	0.001	0.221 (0.064)***	0.001
Mobile ownership	0.415 (0.101)	0.000	0.428 (0.120)	0.000	0.168 (0.033)	0.000	0.152 (0.040)	0.000
Credit	-0.094 (0.124)	0.447	-0.192 (0.140)	0.171	-0.064 (0.040)	0.114	-0.121 (0.047)***	0.010
Cooperative	0.094 (0.101)	0.351	0.017 (0.249)	0.945	-0.083 (0.043)	0.052	0.013 (0.081)	0.878
_cons	6.930 (0.382)	0.000	7.464 (0.364)	0.000	9.247 (0.105)	0.000	9.505 (0.117)	0.000
σ	0.580 (0.050)	0.000	0.620 (0.047)	0.000	-0.587 (0.036)	0.000	-0.514 (0.068)	0.000
ρ	0.539 (0.1949)	0.006	0.494 (0.163)	0.002	-0.416 (0.152)	0.006	0.590 (0.223)	0.008
LR test of indep. eqns.: chi2(1) = 25.95 Prob > chi2 = 0.0147								
Wald X^2	=		187.57***			315.35***		
LR test of indep. eqns.:			chi2(1) = 22.86			Prob > chi2 = 0.0000		

*Note: Ethiopia Socio-economic Survey (ESS) (2015-2016); * p<0.01, ** p<0.05, *** p<0.01.*

Table A.7 - Endogenous switching probit regression model.

Variables	*Self-reported food insecurity*		*Negative change in diet*		*Reduced food intake*	
	Participants (N= (1,432)	*Non-participants (N= 1,223)*	*Participants (N= (1,432)*	*Non-participants (N= 1,223)*	*Participants (N= (1,432)*	*Non-participants (N= 1,223)*
	Coeff. (Std. Err.)	*Coeff. (Std. Err.)*	*Coeff. (Std. Err.)*	*Coeff. (Std. Err.)*	*Coeff. (Std. Err.)*	*Coeff. (Std. Err.)*
Gender	-0.035 (.088)	-0.093 (0.112)	-0.083 (0.092)	0.153 (0.093)*	-0.194 (0.111)*	-0.203 (0.079)**
Age	-0.001 (.002)	-0.0022 (0 .003)	-0.001 (0.002)	-0.002 (0.02)	-0.005 (0.003)*	-0.004 (0.002)*
Education level	-0.04 (.015)***	-0.037 (0.018)**	0.056 (0.015)***	0.024 (0.017)	-0.026 (0.021)	0.016 (0.015)
Household size	-0.003 (.015)	-0.006 (0.021)	0.006 (0.016)	-0.010 (0.018)	0.013 (0.018)	-0.005 (0.017)
Cooperative	0.126 (.090)	-0.093 (0.104)	-0.140 (0.094)	0.102 (0.10)	-0.661 (0.151)	0.06 (0.090)
Distance to road	0.008 (.002)***	0.009 (0.003)***	0.08 (.002)***	0.010 (0.003)***	0.006 (0.002)***	0.005 (0.002)**
Distance to market	0.0001 (001)	0.003 (0.002)*	0.004 (0.001)	0.002 (0.001)*	0.001 (0.001)	0.009 (0.001)
Distance to administration center	0.001 (.000)***	0.0008 (0.0003)**	0.002 (0.003)***	0.001 (0.003)***	0.002 (0.003)***	0.001 (0.003)***
Mobile ownership	0.131 (0.064)**	0.150 (0.090)*	0.105 (0.067)	0.144 (0.088)	0.311 (0.077)***	0.033 (0.067)
safety net	-0.316 (.120)***	-0.258 (0.160)	0.373 (0.124)***	0.329 (0.150)**	0.360 (0.138)***	0.349 (0.137)**
Remittance	-0.182 (.098)*	-0.177 (0.127)	0.202 (0.101)**	0.105 (0.123)	0.221 (0.117)*	0.105 (0.109)
Nonfarm	0.099 (.076)	0.063 (0.088)	-0.122 (0.080)	-0.024 (0.082)	-0.093 (0.095)	-0.065 (0.077)
Credit	-0.147 (.081)*	-0.038 (0.105)	0.243 (0.085)	0.059 (0.096)	0.162 (0.107)	0.093 (0.083)
HCI	-0.001 (.0004)	0.0003 (0.0004)	-0.343 (0.174)**	-0.036 (0.117)	-0.234 (0.212)	-0.304 (0.140)
Dead animals	-0.012* (.007)	-0.028 (0.020)	0.007 (0.007)	0.012 (0.016)	0.016 (0.007)**	0.021 (0.016)
TLU	0.012 (0.008)	0.00247 (0.033)	-0.002 (0.009)	-0.023 (0.029)	0.006 (0.009)	0.007 (0.018)
Farmsize	-0.004 (.003)	0.057 (0.042)	-0.025 (0.016)	-0.051 (0.037)	-0.062 (0.028)**	-0.033 (0.034)
Shocks	0.497 (.075)***	0.524 (0.149)***	0.448 (0.076)***	0.467 (0.135)***	0.497 (0.095)***	0.285 (0.107)***
Asset index	0.084	0.057	0.015	0.021	0.074***	0.024
_cons	1.285 (.161)***	0.403 (0.479)	-1.425 (0.169)***	-0.346 (0.366)	-1.424 (.201)***	-0.248 (0.245)
Wald chi2	= 276.09***		280.63***			
LR test of indep. eqns. (rho1=rho0=0): chi2(2) = 21.26 Prob > chi2 = 0.0000			LR test of indep. eqns. (rho1=rho0=0): chi2(2) = 18.12 Prob > chi2 = 0.0001		LR test of indep. eqns. (rho1=rho0=0): chi2(2) = 14.61 Prob > chi2 = 0.0007	

*Source: Ethiopia Socio-economic Survey (ESS) (2015-2016); * p<0.01, ** p<0.05, *** p<0.01.*