


# Drivers of crop commercialization in central and southern Oromia, Ethiopia

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## Abstract

More than 95% of crop production in Ethiopia comes from smallholder farmers operating on a farm size of less than 2 hectares. This implies that agriculture is dominantly operated by smallholders nationally. Agricultural commercialization is believed to improve farmers' livelihoods; hence, commercializing agriculture in Ethiopia means contributing to the smallholder farmer's welfare. To do so, a study of participation and level of commercialization and their determinant factors is vital. Hence, this study was initiated to evaluate crop output commercialization status and its determinants in rural Ethiopia. Heckman's two-step model was employed for the analysis. The mean commercialization index (CI) for the sample was 43.40% while 26% and 35% of households were commercially oriented and subsistent farmers respectively. The decision to participate in crop output marketing was affected by age, market distance, and instrument for the level of farm mechanization negatively. In contrast, it was affected positively by livestock size (TLU), being in mid-highland agroecology, ownership of equines, amount of annual income, and access to market information. The intensity of commercialization was positively affected by annual income, access to market information, and number of oxen; while it was negatively affected by operational land, level of crop diversification, and market distance significantly. Improving the resource endowment, and minimizing transaction costs by improving access to market centers, market information, and means of transportation can further enhance commercialization. Improving access to farm mechanization and enhancing productivity in highland areas are also issues that shall get policy and development practitioners' focus.

**Keywords** Commercialization · Market participation · Subsistent farmers · Heckman's two-step

## 1 Introduction

The mainstay of the Ethiopian economy is agriculture. Over time, the absolute value of agriculture's contribution to the GDP is increasing. For example, the value of ETB 686.4 in 2020 was ETB 728.4 billion in 2021, an increase of approximately 6.12%. In 2021, the sector contributed about 31.98% to the national GDP, but it is decreasing over time [1]. Small-scale farming is the dominant type of agriculture in Ethiopia. Around 67.5% of farmers are holding farmland of less than 4 hectares whereas only 1.8% of farming households are operating on farm size of more than 15 hectares and the average small farm size is 0.9 ha [2]. Hence, while we are talking about agriculture in Ethiopia, we are generally talking about small-scale farmers in one or other way that produce around 95% of the total national production of the main crops [3].

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Agricultural commercialization can be viewed in many forms and defined in different ways. It can be considered as a static form or as a dynamic process over time. Considering the static form of smallholder farm commercialization, it could be seen as the measure of the strength of the linkage between farm households and markets at a given point in time. This household-to-market linkage could relate to output or input markets either in selling, buying, or both, including labor [4]. Considering farm commercialization as a dynamic process, it could be seen as a process in which speed the proportion of outputs sold and inputs purchased is changing over time at the household level. Based on this premise agricultural commercialization occurs when agricultural enterprises and/or the agricultural sector as a whole rely increasingly on the market for the sale of produce and for the acquisition of production inputs [5]. Generally, three approaches can be followed to define farm commercialization: in terms of the type of crops grown, participation in commercial input and output markets, and goals of production.

Based on the types of crops grown a farm household is considered as commercialized if it produced a significant amount of cash commodities, allocates a proportion of its resources to marketable commodities, or selling a considerable proportion of its agricultural output [6, 7]. However, defining commercialization based on this may be misleading as the farmers are not marketing only the so-called cash commodities or home consuming of those non-cash crops [8–10]. In the central and southern Oromia, cereals like wheat and malt barley are no more considered as staples only due to the presence of agro-processing factories like malt factories, flour-mill factories, biscuit, pasta, and macaroni factories in most districts and zonal towns and hence, are both staple and commercial crops. However, this does not mean that there are no subsistent farmers who are producing entirely for household consumption. Hence, the commercial nature of the crop does not guarantee the full commercialization of farmers. For instance, only 34.34 and 30.96% of wheat were sold in West Arsi and Arsi zones respectively in 2020/21 production season while from total barley produced in the two zones only 19.22 and 20.31 portions were sold respectively [11]. Even though forced sale of some crop may even exist in cases of subsistent farming, a household may also have other options to meet its financial obligations like livestock especially small ruminants, poultry and non-farm income sources.

Regarding input/output market participation, agricultural commercialization goes beyond producing and allocating a considerable proportion of farm products to market rather it refers to the choice of what to produce and the decision about the input use based on the principles of profit maximization both for staple cereals and high-valued commercial crops [8, 9]. From the input side, commercialization refers to valuing both traded and non-traded inputs like family labor and manure in terms of their market prices while from the output side, it is defined as the proportion of agricultural production that is marketed [12, 13]. In this regard, the degree of participation of a household in the output market with much focus on cash incomes is widely used to define agricultural commercialization [14].

From the view of the goal of production, considering the dynamic process, [8] argue that as the degree of participation of farmers in commercialization increases, it passes through the process of commercialization from a subsistence system to a semi-commercial system and finally to a commercial system where the objective of production change from food self-sufficiency to surplus production and finally to profit maximization. Inputs are non-traded and household generated in the first stage and it is mixed of traded and non-traded in the second stage finally in the commercial system inputs are predominantly traded. Based on this argument, [15] defined agricultural commercialization as “a process involving the transformation from production for subsistence in production for the market”. Hence, production goals change from utility maximization to profit maximization as household production moves from subsistence to commercial production [16].

However, the focus of commercialization of smallholders is mainly on increased output market participation to solve food insecurity through improving agricultural productivity in developing countries [4, 17–19]. Hence, like any other agriculture-dependent country, commercial transformation is an essential footpath toward economic growth and development [8, 12, 20] for Ethiopia too [21]. To this end, the Government of Ethiopia (GoE) is also promoting agricultural commercialization through different means with the main objective of transforming the subsistence supply-led agriculture sector to organized, high-tech, safe, and demand-driven agriculture. To achieve this goal, the GoE is expanding the integrated agro-industrial parks and promoting cluster-based mechanization-supported production system, and this action is believed to accelerate the commercialization of smallholder agriculture and support the structural change of the national economy as a whole [22]. Accordingly, the GoE has prioritized agricultural commercialization as a policy agenda included in the Poverty Reduction Strategy Paper (PRSP) since 2005 [23]. The expansion of agro-industrial parks throughout the country in general and around the study area, in particular, are also examples of such actions. However, the level and determinants of smallholders' commercialization are not well studied.

Studies revealed that different factors affect both households' market participation and level of participation (crop output commercialization). Among others, household characteristics like age, sex, and educational background of the household

head, family size, dependency ratio, and others are important factors at the household level [24–26]. Other factors like agroecology, resource ownership of households, institutional service provision, infrastructural facilities and others are the most important factors that determine participation and level of commercialization [26–34]. However, little has been studied about level of crop output commercialization and determinants of both market participation and level of commercialization in the proposed area. Furthermore, most of the studies in Ethiopia are crop specific. Hence, this research aimed to contribute in filling the gap by trying to estimate the overall crop output commercialization level of the smallholders considering the major crops. Furthermore, major socioeconomic and institutional determinant factors of commercialization. Hence, this research was initiated with the objectives of estimating the level of crop output commercialization and identifying factors that affect the level of crop output commercialization for combined major crops. In nutshell, this research will answer the research questions: (1) what is the commercialization status of smallholder farmers? (2) what are the major determinants of participation in crop commercialization and level of commercialization in central and southern Oromia, Ethiopia?

## 2 Level and determinants of crop commercialization: empirical review

Theoretically it is explained that there are different factors determining level of crop output commercialization of smallholders. Generally, market imperfection has a broad-spectrum effect on crop commercialization directly or indirectly by limiting smallholders' access to inputs, output market and technologies and then in turn affects production and productivity. Based on literature review, [4] broadly categorized factors affecting crop commercialization of subsistent farmers. The first one is external factors which are beyond the control of smallholders' including population growth and demographic change, technological change and introduction of new commodities, development of infrastructure and market institutions, development of the non-farm sector and the broader economy, rising labour opportunity costs, macroeconomic, trade and sectoral policies affecting prices and other driving forces. Smallholder farmers' individual specific factors are the second category of factors that affect commercialization. Resource endowments such as land and other natural capital, labor, physical capital, human capital, and others are included in these factors.

Importance of review of literatures related to the topic is twofold; helping in identifying the gap and to hypothesize the factors that affect the issues under study. Different authors studied the level and determinant factors of commercialization in Ethiopia. For instance, commercialization of *teff* was studied by Anteneh and Endalew [35] and Gidelew et al. [36] in Guji and Hulet Eju Enesie districts while potato and malt barley West Arsi zone [37] and Arsi and West Arsi zone [38], respectively. Commercialization of wheat was also studied in major crop producing regions of Ethiopia, that includes Oromia region [39]. Cherinet et al. [40] Also studied the determinants of market participation and its intensity in Amhara region Este district. The study by [41] was conducted at national level by considering six cereal crops. The econometric models used in commercialization studies include ordered probit, double hurdle, Heckman two-step, truncated model, Tobit, were Beta regression models in Ethiopia.

The findings of those research outputs revealed that resource ownership and proportion of its allocation for the crop under study of the smallholder farmers especially farm size, size of livestock possession including equines (for transportation purposes), and number of oxen were the main determinants factors that affected decision to participate in crop output commercialization and intensity of commercialization [35–42]. Similarly, demographic characteristics of households and heads of households like age, sex, educational background, and family size are some of the variables that significantly affect participation or intensity of participation. Access to institutional services and the distances to those service centers like extension contact, distance to extension service centers and market centers [36, 42, 43], access to credit services, access to market information, and the use of communication technologies [37, 38, 41], access to physical infrastructures like all-weather roads [41] were important determinants of level and decision to sale crop outputs. Yield and quantity and value of crop produced [38, 39, 41, 43], market-related issues like price and household's perception of lagged price, participation of contract farming [38, 43] other variables that were significant in determining commercialization participation and intensity of commercialization. Farmers' experience in the production of specific crops [35], input, and improved technology utilization practices like the quantity of chemical fertilizer [36, 38] and row planting [36] were also affecting commercialization; At the same time, economic activities like participating in off-farm income generating activities [42] and external factors like Agroecology were important factors in determining the level of sale and participation in output crop marketing.

As to the researchers' knowledge, the only research that was conducted based on whole crops produced by smallholder farmers was Minot et al. [44] which used three waves of national data from Ethiopia Agricultural Commercialization Cluster Surveys. According to this finding, the commercialization level of smallholders was increasing between 2012 and 2019 significantly at national level while it was not significant for some regional states at a disaggregated level as a whole

where the increasing rate of commercialization in Amhara region is leading. In general, the significant gap identified by the review of literature was that almost all authors' approaches were single crop-based approaches, implying focusing on one crop at a time except [41, 43] which conducted an analysis for only major cereal crops. Hence, there is dearth of study on estimation of level of commercialization, identifying determinants of participation and level (intensity) of commercialization considering whole or major crops in Ethiopia.

### 3 Methodology of the research

#### 3.1 Research location (study area)

This research was conducted in two purposively selected zones from Central and Southern Oromia Regional State. The Central and Southern parts of Oromia region, which includes East Shewa, Arsi, West Arsi, Bale, and East Bale administrative zones, is the most important cereal-producing part of the Ethiopia. The two administrative zones that are selected for this study, namely West Arsi and Arsi, are found in the central and southern parts of Oromia national regional state, respectively. Geographically, the Arsi Zone lies between 6° 45' N to 8° 58' N latitude and 38° 32' E to 40° 50' E longitude while the West Arsi zone lies between 6° 12' 29" to 7° 04' 55" latitude and 38° 04' 04" to 39° 04' 08" longitude [45]. The two zones are known for better farm mechanization practices due to previous government-initiated intervention during the Haile-Selassie regime and projects called Arsi Rural Development Unit and Chilalo Agricultural Development Unit (ARDU and CADU) implement by the *Dergue* regime. The area was known for large private and state-owned farms during the two regimes respectively [46–48]. Cereals like wheat and barley are the most dominant crops and they cover around 84% of the total land covered by grain [11]. Both zones are known for crop-livestock mixed farming systems.

#### 3.2 Sampling design and sample size

The study considered farm households as a decision-making unit and considered farm household heads as key respondents and decision points of the household's farm and non-farm activities. Hence, the sampling unit of analysis in this study was a farm household. A multi-stage sampling procedure was employed to draw the target sample households. At the first stage, West Arsi and Arsi zones were selected purposively from Southern and Central Oromia. At the second stage, the districts were selected based on stratified random sampling technique. For this purpose, the districts in each zone are stratified into two as highland and mid-highland districts. Then four districts, two from each zone, were selected based on systematic random sampling from the list of mid-highlands and highland districts. The two agroecology, highland and mid-highlands, have different types of crops grown. For instance, the highland part is majorly producing barley, while the mid-highland parts are known for wheat production [11]. Systematic random sampling technique was preferred over other sampling techniques because it is simple to execute and is also an equal probability selection method [49]. Accordingly, Kofele and Gedeb-Asasa from West Arsi and Lemu-bilbilo and Hetosa from the Arsi zone were selected. Kofele and Lemu-bilbilo are highland districts whereas the rest are mid-highland districts. At the third stage, from each district, two kebeles<sup>1</sup> were selected randomly while the sample size was determined based on the [50] formula, which provides a representative size to ensure the desired precision, and finally, the total sample households were selected from each kebele based on simple random sampling method. The formula to determine sample size was given as follows:

$$N = \frac{Z^2 pq}{e^2} = \frac{(1.96)^2 (0.5)(0.5)}{(0.05)^2} \approx 385$$

where N is the desired sample size; Z is the standard cumulative distribution that corresponds to the level of confidence with the value of 1.96; e is desired level of precision; p is the estimated proportion of an attribute present in the population with the value of 0.5 as suggested by [51] to get the desired minimum sample size of households at 95% confidence level and ± 5% precision; q = 1 – p. Accordingly, a sample of 385 was proposed and finally, 385 household heads were selected and interviewed using random sampling with probability proportional to size. However, 12 households were added for contingency purpose and seven were excluded from analysis due to data missing and only 390 samples were considered in the analysis.

<sup>1</sup> Kebele is the lowest administrative unit in Ethiopia.

### 3.3 Data sources, types, and methods of collection

The smallholder farming households are the main sources of data in this study. Both qualitative and quantitative data were collected from primary and secondary data sources. Secondary data were collected from published and unpublished sources like journals and official reports while primary data were collected from smallholder farming household. The data collected includes but is not limited to socioeconomic characteristics of the households, demographic characteristics of the household and its head, crop, and livestock production and marketing, etc. The qualitative data were collected by using focus group discussions (FGD) and key informant interviews (KII). One FGD and one KII were conducted at each kebele to enrich the primary data from individual interviews at each kebele.

### 3.4 Methods of data analysis

Both descriptive statistics and econometric models were used to analyze the data collected. Descriptive statistics like mean and t-test were used to estimate and summarize the level of commercialization. Mean comparison of explanatory variables for market participants and non-market participants was conducted. The level of crop output commercialization was estimated by using crop output market participation index (COMPI).

#### 3.4.1 Measuring crop output market participation index (COMPI)

The level of crop output commercialization at a household level was computed as the ratio of the value of agricultural outputs sold to the total value of agricultural outputs produced by a household [7, 24, 52]. For this study, major crops: wheat, barley, potato, and pulse crops (faba bean, peas, and chickpeas) were considered. Hence, the crop output side commercialization index for a household (COMPI) was computed as (1):

$$COMPI_k = \sum_{i=1}^6 \frac{\bar{P}_k S_{ik}}{\bar{P} Q_{ik}}; Q_{ki} \geq S_{ki} \quad (1)$$

where  $COMPI_k$  is the proportion of crop  $k$  sold ( $S_{ki}$ ) to the total amount produced ( $Q_{ki}$ ) by a household  $i$  evaluated at an average price ( $\bar{P}$ ) given and reported by a household during selling.

The index measures the intensity of a household's participation in the market. A value of zero would signify a totally subsistence-oriented household; the closer the index is to 100, the higher the degree of commercialization. Based on suggestions of some authors [53–55] a household is commercially oriented if the crop output commercialization index (COCI) is a minimum of 65% whereas values in between 30 and 65% termed as semi-commercial and otherwise non-commercial.

Household level market participation (COMP) and intensity of market participation are modeled as a function of household characteristics (sex, age, and educational background of household head), household resource endowment, and technology use which are family labor supply, household size, landholding, land cultivated, working animal availability (draft power, equines, and other livestock, level of mechanization), access to physical infrastructures (distance to main market and access to all-weather road), access to institutional services (extension, credit, and market information), and land fragmentation, the spatial location of the household (zone), level of crop diversification, total annual household income.

#### 3.4.2 Model selection and specification

The most widely used models to investigate a household's decision for market participation and its level of participation (level of commercialization) are the double hurdle model (DHM), Heckman's two-stage model, Tobit model, and multinomial logit models [56–58]. However, each model has its own limitations and advantages while the choice of one over the others depends on the objectives of the study and data type. The censored regression or Tobit [59] model is appropriate when the dependent variable is censored at some upper or lower bounds. Tobit model is criticized due to the fact that it cannot separate the participation and intensity of participation decisions. It assumes that factors affecting market participation also affect the intensity decision in the same way. Second it assumes the zero values in the intensity equation as a corner solution. However, the zero value of the level of commercialization may be due to a discrete choice of not to participate in the commercialization decision. Hence, Heckman two-step and Cragg's models are the two best options for this analysis.

There are also critical assumption differences between the Heckman's model and Cragg's model. In Heckman model the estimation of the first stage equation of the model as a probit model assumes that the errors are Homoscedastic [60].



Furthermore, Heckman assumes that there is no zero observation in the dependent variable of the second stage once the first stage is passed whereas the Craggit model still considers that there might be a possibility of zero observation. However, in this study once a household decide to participate in the crop output market, there is no possibility that the amount of crop sold can be zero. Hence, based on this assumption Heckman is better for this data. The second assumption of Craggit model is that there is independence of hurdles while Heckman's two-step assumes that there is dependence of the hurdles [61]. The dependence between the two hurdles can be tested based on the significance of Inverse Mill's Ratio (IMR).

In this case, even though this model assumes that the decision to participate in the market and the intensity of market participation may not necessarily be jointly determined [62], the Heckman selection model is appropriate if there is a censoring process in measuring the intensity of participation. This implies that the Heckman procedure assumes that there are some potential market levels in the sample population that is not observed due to sample selection problems. In general, Heckman's sample selection model is designed to account for the fact that the observed sample may be non-random and the market participation equation can be specified as (2):

$$\Pr(Z_i = 1 | w_i, \alpha) = \Phi(h(w_i, \alpha)) + \varepsilon_i \quad (2)$$

where  $Z_i$  is an indicator variable equal to unity for households that participate in crop sales;  $\Phi$  is the standard normal cumulative distribution function;  $w_i$  is a vector of factors affecting market participation;  $\alpha$  is a vector of coefficients to be estimated; and  $\varepsilon_i$  is the error term assumed to be distributed normally with a mean of zero and variance of  $\sigma^2$ . The variable  $Z_i$  takes the value of 1 if the marginal utility that the household  $i$  gets from participating in the crop market is greater than zero, and zero otherwise. So, we have Eq. (3):

$$Z_i^* = \alpha w_i + v_i \quad (3)$$

where  $Z_i^*$  is the latent level of utility that the household gets from crop market participation,  $v_i \sim N(0,1)$  and,

$$Z_i = \begin{cases} 1 & \text{if } Z_i^* > 0 \\ 0 & \text{if } Z_i^* \leq 0 \end{cases} \quad (4)$$

In the second stage, the Inverse Mills Ratio (IMR) will be added as a regressor in the sales function or level of participation to correct for potential selection bias. To get rid of endogeneity problem this selection bias, Heckman suggested first to estimate  $\alpha$  via maximum likelihood estimation (MLE) probit, typically using an exclusion restriction (only households who participate in the market are included in the second stage), then to estimate an IMR, which essentially tells us the probability that household decide to participate in the market over the cumulative probability of a household's decision, i.e.

$$\hat{\lambda} = \frac{\varphi(h(w_i, \hat{\alpha}))}{\Phi(w_i, \hat{\alpha})} \quad (5)$$

where  $\varphi(\cdot)$  is the normal probability density function. The second-stage (level of sales) equation is then given by:

$$E(Y_i | Z = 1) = f(X_i, \beta) + \gamma \frac{\varphi(h(w_i, \hat{\alpha}))}{\Phi(w_i, \hat{\alpha})} \quad (6)$$

where  $E$  is the expectation operator,  $Y$  is the (continuous) extent of market participation (level of commercialization), or sales,  $X$  is a vector of independent variables affecting sales, and  $\beta$  is the vector of the corresponding coefficients to be estimated. Then,  $Y_i$  can be explained as:

$$Y_i = \beta' X_i + \gamma \hat{\lambda} + v_i \quad (7)$$

where  $u \sim N(0, \sigma_u^2)$ ,  $Y_i^*$  is only observed for crop sellers ( $Z_i = 1$ ), in which case  $Y_i = Y_i^*$

### 3.5 Hypotheses and variable definitions for econometric models

Variables included in the econometric model were summarized as follows with their expected sign in the model outputs (Table 1).

**Table 1** Summary of variables included in the model with their expected signs

Determinant factors	Dependent variables	
	Market participation (yes/no)	Intensity of participation (CI)
Household head sex (1 = male)	+	
Household head Age (year)	–	–
Household head education (year)	+	+
Landholding (ha)	+	+
Cultivated land (ha)	+	+
Household family size (No.)	±	±
Family labor (man-equivalent)	+	+
Number of oxen	+	+
Other livestock (TLU)	±	±
Agroecology (1 = mid; 0 = low)	+	+
Road access	+	+
Distance to the main market	–	–
Crop diversification (SDI)	–	–
Level of mechanization (MI)	+	+
Equines (1 = yes/0 = no)	+	+
Income (ln)	+	+
DA contact	+	+
Credit access	+	+
Access to market information (yes = 1)	+	+

## 4 Result and discussion

### 4.1 Descriptive statistics analysis

Households' level of crop output commercialization was estimated by using ratio of values of crop sold to values of total crop produced by a household. The Table 2 below presents the categories of the level of crop output commercialization for sample households. Around 67% of the households are wheat producers while around 60% of them are barley producer households. However, it should be noted that the number of producers for all crops is not mutually exclusive. The study result showed that wheat and barley are grown by majority of the households and 41.60 and 37.70% of their total production are supplied to market respectively (Table 2). FGD also revealed that there is high commercialization level difference among crops. For instance, barley and potato are mainly produced for consumption purposes in small amount in mid-highland areas while wheat is for market purpose. The result further showed that the mean commercialization index for all crops is 43.4%, whereas potato producers' commercialization index is around 61% implying potato is the most commercialized crop in the study area. Ayele et al. [43] also found that average level of cereal crops commercialization was 48.33% in Guji zone of Oromia region. Our findings further showed that pulses and potato are relatively more commercialized and the result is consistent with the result of [44] where the mean commercialization index for all crops was better than national average which was 33.5%. However, only 13.59% and 22.56% of the sample households are producing potato and pulse crops respectively.

The result also showed that around 35% of the households are subsistent farmers implying they are mainly producing only for home consumption out of which 75 (19.23% of the total households or 55.55% of subsistent farmers) are non-market participants (Table 3). The zero level of commercialization is due to the random sampling procedure we employed which provides equal probability of selection for each household in a sample frame. Furthermore, the zero level of commercialization of a household may attributed to availability of other financial sources for a household to meet their household financial obligations like livestock especially the small ruminants and poultry, non-farm income source activities and remittance. The result further revealed that a considerable number of farmers are supplying more proportion of their products to the market. Accordingly, around 26% of farmers are supplying more than 65% of their products to the market while the rest around 40% of them are supplying 30 to 65% of their produce to the market or they are semi-commercial farming households.

**Table 2** Mean commercialization levels for different crop types

Crop type	Obs	Mean	Std. dev	Min	Max
Commercialization index for barley	262	0.377	0.280	0	0.960
Commercialization index for wheat	233	0.416	0.290	0	0.998
Commercialization index for WB	390	0.397	0.290	0	0.998
Commercialization index for Potato	53	0.609	0.305	0	1.000
Commercialization index for pulse	88	0.539	0.278	0	0.975
Commercialization index for all crops	390	0.434	0.279	0	0.998

Pulse crops include faba bean, field pea, and chickpea  
WB wheat, and barley

**Table 3** Households' level of crop output commercialization

Description	Level of commercialization	Frequency	Percentage
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Mean difference of commercialization index across agroecology was also assessed and it was found that the mean mid-highland area was slightly greater than the highland agroecology (Table 4). However, the mean difference was not statistically significant. Similarly, crop diversification was also higher in highland areas implying mid-highland households are tending more to specialization.

## 4.2 Description of variables used in the econometric model

Market participation status of a household is explained by different variables and hence, the values for these variables are expected to be different for participants and non-participants of the market. Accordingly, the definition and summary of variables that are used in the econometric model were presented in Table 5. The result revealed that, from household characteristics, the age of the household head is significantly different for market participants and non-market participants. Only about 2% of the sample households are female-headed while the rest 98% are male-headed. Non-participant farmers are older than market participants implying relatively younger are more market-oriented. Similarly, livestock possession (TLU) is higher for households who do not participate in crop-output market and the value is significant at the 1% level. Livestock may also be an alternative source of household income and negatively affects market participation. Distance of household residence to the main market also affects the participation of a household in the crop output market participation negatively. Institutional services like contact with development agents (DA) and access to market information also positively affect crop output market participation significantly while resource ownership like land and income also affect market participation positively as expected.



**Table 5** Statistical summary of variables used in Heckman two-step model

Variable description	Mean				t-value
	Non-participant	Participant	Combined		
Sex of household head	0.97 (0.02)	0.98 (0.01)	0.98 (0.01)		- 0.23
Age of household head	47.01 (1.71)	43.31 (0.72)	44.01 (.67)		2.18**
Education of HH head	5.72 (0.47)	6.08 (0.23)	6.01 (0.20)		- 0.70
Livestock holding (TLU)	3.51 (0.46)	5.61 (0.23)	5.20 (0.21)		3.99***
No. of oxen	1.43 (0.13)	1.44 (0.07)	1.44 (0.06)		- 0.02
Distance to main market	8.18 (0.67)	6.38 (0.26)	6.73 (0.25)		2.90***
Contact DA(Yes/No)	0.67 (0.05)	0.78 (0.02)	0.76 (0.02)		- 2.09**
DA contact per month	2.20 (0.16)	2.27 (0.08)	2.26 (0.07)		- 0.36
Credit accessed	0.13 (0.04)	0.15 (0.02)	0.15 (0.02)		- 0.35
Crop diversification (SDI)	0.46 (0.03)	0.48 (0.01)	0.48 (0.01)		- 0.48
Cultivated land (ha)	1.34 (0.13)	1.55 (0.07)	1.51 (0.06)		- 1.36
Total land possessed	1.61 (0.16)	2.01 (0.07)	1.93 (0.06)		- 2.40**
Soil fertility	1.44 (0.07)	1.41 (0.03)	1.41 (0.03)		0.46
Have equines	0.58 (0.08)	0.59 (0.03)	0.59 (0.03)		- 0.08
Have mobile phone	0.88 (0.04)	0.92 (0.01)	0.91 (0.01)		- 1.12
Get market information	0.61 (0.06)	0.76 (0.02)	0.73 (0.02)		- 2.50**
Household income (ln)	10.39 (0.22)	11.29 (0.05)	11.14 (0.05)		- 6.41***
Family labor (man-equiv.)	2.48 (0.19)	2.30 (0.09)	2.33 (0.08)		0.90
Household size (person)	8.63 (0.58)	8.35 (0.26)	8.40 (0.23)		0.47
Dependency ratio	1.50 (0.18)	1.38 (0.08)	1.40 (0.07)		0.7
Road access	0.85 (0.04)	0.88 (0.02)	0.88 (0.02)		0.69
Variable	Mean	Std. dev	Min		Max
Commercialization index	0.434	0.279	0		0.998

Standard errors given in parenthesis; \*\*, \*\*\* t-value significant at 5 and 1% respectively

### 4.3 Results of the econometric model

Determinants of the smallholder farmers' crop output market participation decision and level of commercialization (level of participation) were analyzed by using the Heckman two-step model. Even though there are different alternatives for this analysis, Heckman's two-step model is selected since the IMR value is significant at a 10% level of significance. The result shows that the two equations (selection model/market participation and commercialization levels/intensity of participation) are interdependent. As a result, the two equations are estimated simultaneously using the Heckman selection model. In general, the likelihood ratio test of the model indicates that the overall goodness of fit of the Heckman two-step model is statistically significant at  $P < 0.01$  significance level. This indicates that explanatory variables jointly explained the probability of participating in the crop output market participation.

Prior to running the Heckman two-step model, the data was tested whether it is suffering from multicollinearity, heteroscedasticity and endogeneity problem. According to the result of the test, the data is free from serious problem of multicollinearity and heteroscedasticity and the result of the test is given in appendix part (Appendixes 1, 2). However, endogeneity was tested for level of farm mechanization (MI) using Hausman's specification test method. Based on the result (Appendix 3), we are unable to reject for the endogeneity problem. Hence, instrumental variables (farm mechanization technologies unavailability, price of the technologies, land topography, training and demonstration on farm mechanization) were selected as instrumental variables and index of farm mechanization was regressed on these variables including other variables in the structural model. Then prediction of farm mechanization (index) was taken and included in the original model (Heckman two-step) model.

**Table 6** Heckman selection model two-step estimates the result of market participation

Determinant factors	Market participation		Intensity of participation	
	Coe cient	Z-value	Coe cient	Z-value
HHH sex(1 = male)	0.821 (0.575)	1.43	–	–
HHH Age (year)	– 0.020 (0.008)	– 2.34***	– 0.001 (0.001)	0.36
HHH education (year)	– 0.038 (0.026)	– 1.46	– 0.006 (0.003)	1.51
Landholding (ha)	– 0.021 (0.107)	– 0.19	0.009 (0.014)	0.59
Cultivated land (ha)	0.016 (0.131)	0.12	– 0.031 (0.016)**	1.95
HH family size (No.)	– 0.004 (0.029)	– 0.13	– 0.003 (0.004)	0.82
HH labor (man-eqvt)	– 0.079 (0.084)	– 0.94	0.007 (0.012)	0.58
Number of oxen	0.089 (0.088)	1.00	0.019 (0.011)*	1.81
Other livestock (TLU)	0.074 (0.034)	2.15**	– 0.004 (0.004)	1.07
Agroecology (0 = high)	0.651 (0.277)	2.35**	0.036 (0.045)	0.80
Road access	0.344 (0.312)	1.10	0.053 (0.041)	1.28
Main market distance	– 0.065 (0.019)	– 3.46***	– 0.007 (0.004)**	1.98
Crop diversi cation (SDI)	– 0.113 (0.388)	– 0.29	– 0.099 (0.053)	1.87*
Instrument for MI	– 2.007 (1.239)	– 1.64*	– 0.177 (0.180)	– 0.98
Equines (1 = Yes/0 = No)	0.348 (0.203)	1.71*	0.001 (0.029)	0.02
Income(ln)	0.381 (0.074)	5.10***	0.180 (0.021)***	8.40
DA contact	0.273 (0.207)	1.31	– 0.027 (0.032)	0.85
Credit access	– 0.208 (0.261)	– 0.79	– 0.017 (0.035)	0.50
Market information access	0.547 (0.193)	2.82***	0.124 (0.038)***	3.24
Constant	– 3.116 (1.029)	– 3.03***	– 1.462 (0.247)***	– 5.92
Mills/lambda	0.222 (0.122)	1.82*		
Rho	1.000			
Sigma	0.222			

\*, \*\*, \*\*\* values signi cant at 10, 5, and 1% level of signi cance respectively; Market participants = 315; non-participants = 75; Wald  $\chi^2(18) = 123.80$ ; Prob > chi2 = 0.000; Standard Errors given in parenthesis

#### 4.3.1 Crop output market participation

The Heckman's two-step model was fitted with 18 explanatory variables. According to the first step model output, the household head's age, livestock ownership (TLU), agroecological location, household residence's distance to the main market (km), availability of equine animals for transportation purposes, total household income (in natural log), instrumental variable for farm mechanization, and access to market information are significant in determining crop output market participation. The value of Wald  $\chi^2(18)$  equals 123.80 with a Chi-square ( $\chi^2$ ) value significant at 1% and lambda ( $\lambda$ ) significant at a 10% level of significance implying that data best fits Heckman's two-step model (Table 6).

It was believed that aged households are more deprived from up-to-dated production technologies, labor and others. Risk aversion nature of older farmers to accept new technologies and ideas were the main possible argument for their low market participation [3, 32]. Hence, their focus is mainly for food self-sufficiency. In line with this assumption, the finding revealed that the age of the household head has a negative effect on crop output market participation. The result is significant at a 1% level of significance. Similar results were reported by researchers in other rural parts of Ethiopia for bulla and pineapple crops [63, 64] while similar result was also found in Zambia [65].

Transaction cost is one of the important determinant factors for market participation [4]. Household's residence distance to the market center has a direct implication of marketing cost and access to means of transportation which directly affects market participation [24, 29–32, 40]. The result revealed that distance to the main market center negatively and significantly affects crop output market participation significantly. The variable is statistically significant at 1% level of significance. The result implies that the nearer the household is to the main market center, the higher the probability of participation in crop output marketing. This finding is consistent with others' findings in Ethiopia and somewhere in the world where distance of market center from household's residence affects probability of participation in a market [65–69].

As expected, the amount of a household income per annum (transformed in natural log) has also a positive and significant impact on the probability of a household's participation in the crop output market. The result is significant at a 1% level of significance. This can also be explained as if a household has more income, it will have more capital to invest in crop production to purchase inputs like fertilizer and improved seeds, to rent machinery for farm mechanization, and even rent more land that will enable it to produce a surplus product for market purposes. Our finding from the model tallies that the higher the amount of household's annual income, the higher the probability of participation in crop output market and the result is statistically significant at 1% level of significance.

Lack of access to means of transportation in rural area is one of the hindering factors in market participation [4]. As it is known, equine animals (donkey, horse and mules) are the most important means of transportation both for goods and human beings in rural Ethiopia [70] and it is also hypothesized that its presence can positively influence market participation [24]. Hence, its availability in a given household will definitely affect probability of market participation. The result also showed that the probability of market participation is positively and significantly affected by the availability of transportation means which is the equine animal in our cases at a 10% level of significance. According to the finding, households having equine animals have more probability of participation in the crop output market participation. For instance, availability of motor cycles and cycles facilitates access to market information and market participation in rural Kenya [33]. According to this finding, households possessing equines have better probability of crop output market participation significant at 10%. Similar researches, [33, 55] also reported that the availability of transportation means mainly, equines, was among the significant variables in determining the market participation in Ethiopia and maize crop output market participation in Kenya respectively.

Livestock are one of means for asset accumulation in rural areas. In addition, livestock are sources of manure that can increase production and productivity which in turn increases probability of market participation. The result showed that livestock size other than oxen, measured in tropical livestock unit (TLU) is another important variable that positively determined the probability of participation in the crop output market participation significantly at a 1% level of significance. The result implied that farmers who owned a greater number of livestock has more probability of crop output market participation. This result is in consistent with the findings of others [71] who found that households owning a greater number of livestock are more participants in crop output marketing in the Oromia region, Ethiopia. However, [34] found that livestock ownership has a negative impact on market participation in Afar region, Ethiopia. This result may be attributed to the production system in the area where households having more size of livestock are pastoralists and less involved in crop production.

Households in mid-highland agroecology are tending to specialization towards cereals especially, wheat and therefore, they have to sell some amount of their produce at least to buy some grain that they do not produce for their own consumption (Table 4). Hence, as expected, market participation is significantly affected by agroecological location of the households at 5% level of significance. According to the result, a shift from highland agroecology to mid-highland, can increase probability of market participation significantly. This finding also in lined with other researchers' findings which revealed that there is difference in probability of market participation across spatial location which may affect the production potential, access to input or transportation and others [56]. The finding of this author also showed that mid-highland farmers are less commercialized and have low probability of market participation in South West Oromia region.

Farm mechanization can enhance crop output market participation through increasing production and productivity. Hence, any factor that affects level of farm mechanization either positively or negatively can affect market participation the same way it affects farm mechanization [72]. Five instrumental variables (IV), (technology unavailability, high price, topography, training and demonstration participation on farm mechanization) were used in the ordinary least square regression to estimate their effect on level of farm mechanization (the endogenous variable) and the test for endogeneity showed that farm mechanization was endogenous variable. Hence, Heckman two-step model was fitted by instrumenting the variable by taking the predicted value for farm mechanization. The IV was found to be significant in determining probability of participation. Hence, the result revealed that the application of farm mechanization technologies especially, tractors and combine harvesters, significantly affects probability participation in crop output commercialization.

#### 4.3.2 Participation intensity of crop output market

Once a household decides to participate in a crop output market, the next issue is by how much to participate or to answer what is the intensity of participation. The intensity of participation was estimated based on the ratio of value of crops sold to the value of total crop produced by a farmer. For this objective, market participation and level/

intensity of crop output market participation was calculated by taking the major crops of the area namely wheat, barley, potato and pulse crops (faba bean, field bean, chickpea and haricot beans). Different factors are found to affect levels of crop output market participants. The result of Heckman's second step showed that six variables explained the intensity of crop output commercialization in this study. The result revealed that the educational background of the household head, total land size cultivated, distance to the main market center, crop diversification level (Simpson Diversification Index), household annual income, and access to market information are significantly affecting the intensity of crop output market participation. Negative signs for explanatory variables education and cultivated land size (ha) were unexpected findings of this model that can be explained differently opposite to the hypothesis.

According to the model output, Lambda (IMR) or selectivity bias correction factor has a positive impact on farm households' crop output market participation at a 10% significance level. The existence of unobserved factors that positively influence both participation decision and level of marketed crop output is indicated by the positive sign of the IMR. Moreover, the positive relationship (correlation) between the unobservable factors is justified by positive sign of rho.

A household operating on larger farm size is expected to produce more surplus and its supply is expected to be more. And hence, the size of operational farm size is expected to have positive effect on level of commercialization. The finding of other authors also revealed that land size has positive effects on level of commercialization of wheat in Ethiopia [73]. However, the size of land cultivated has negative effects on the level of market participation which is unexpected result of this finding. The variable is significant at the 10% level. In similar ways, even though it was not statistically significant, Worku et al. [40] found that farm size has negative effects on level of commercialization.

In most cases of less developed countries, crop diversification is practiced for the purposes of food self-sufficiency. The result from descriptive statistics (Table 4) also showed that highland areas are more diversified and at the same time are less commercialized. Crop diversification, measured in Simpson Diversification Index (SDI), as expected has negative significant effect on the intensity of crop output market participation at a 10% probability level of significance. Assessments at different countries also revealed that commercialization at national level leads to diversified crop production while it ends with specialization at regional and household level [8]. Hence, the result posited that an increase in SDI value will decrease market participation intensity significantly. The result from KII and FGD also revealed that in highland areas, farmers are producing everything to feed their families and striving not to buy anything from outside.

The annual income of a household comes from different sources like sale of crops, livestock, and non-farm income sources such as remittance, working on others farm as labor etc. The higher the household's income implies, the more it can invest on agricultural production activities to purchase input, employ labor and farm machineries and that increases surplus production to be supplied to the market. Accordingly, total annual income of the household showed a positive and significant effect on the volume of crop output supplied to the market with a P-value significant at the 1% level. This result is also consistent with others findings [74, 75]. The coefficient of the variable revealed that an increase in ln of annual income by one unit will increase the volume of crop output supplied to the market by 18% *ceteris paribus*.

**Access to market information:** The presence of intermediaries in the agricultural value chain will increase transactions and that will lower the actual price of the products for the farmers. Access to direct market information will have the advantages of bypassing middlemen and direct marketing with agricultural product buyers and will reduce transaction costs. That will also enhance the market participation and intensity of market participation [7]. Hence, the result of our finding revealed that access to market information has a positive and significant effect on the intensity of market participation where the value is significant at a 10% probability. The finding of the research is consistent with others findings [64, 75–77].

Households' distance to the main market area (center) is another determinant of market participation intensity which is significant at a 10% probability level with a negative sign as expected. Distance from market center has a direct implication on transactions which affects intensity of market participation negatively. Hence, the result implied that as a household distance from market center increases, volume of surplus supplied to market decreases and vice versa. This finding is also consistent with other researchers' findings [66, 73] who found that distance of households' residence to main markets has negative effect on intensity of commercialization.

In Ethiopian agriculture the major sources of traction power are oxen. As a result, households having more units of oxen can perform its agricultural operation and meet the average cultivation rate of crop production than their correspondent. Hence, having a greater number of oxen implies that the household has more potential to produce more crops and participate intensively in crop output market. The finding from econometric model also revealed that intensity of crop commercialization intensity was significantly affected positively by number of oxen owned. The result was also similar with the findings of other in rural Ethiopia [35, 78].

## 5 Conclusion and recommendation

The research was conducted in the Oromia region, Ethiopia. Commercialization status for crops wheat, barley, potato and pulse crop mainly, faba bean, field pea and chickpea were considered in this study. The result also showed that only smaller percent of households are producing potato and pulse crop and wheat and barley crops are the most dominant crops of the study area. The result depicted that considerable percent of sample households are non-market participants while 81% are participating in the crop output market. The result further showed that the mean commercialization index of the household for the combined crops was 43.40% while for the major crops, which are wheat and barley, was 39.70%. The commercialization index is little greater than the major crops due to the high commercialization proportion of potato and pulses. Around 26% and 35% of the households are commercial oriented and subsistent farmers respectively. Heckman's model results also showed that households' age, and market distance are negatively affecting market participation while livestock size, being in mid-highland Agroecology, availability of transportation means animals (equines), access to market information and total household annual income are positively affecting market participation. Instrumental variables for farm mechanization is also important variables implying farm mechanization has a significant effect on the decision to participate in crop commercialization. Intensity of commercialization was positively affected by household annual income, number of oxen, and availability of market information while it was negatively affected by household heads' operational land, crop diversification level and market distance of household residence significantly. In nutshell, means of transportation, access to market centers and market information are the most important variables in determining the commercialization of crop output in the study area.

Hence, improving levels of livestock ownership which can be achieved by introducing modern ways of livestock production, access to market centers and availing means of transportation should get focus to improve the market participation of the smallholders. Furthermore, the intensity of commercialization can be enhanced by raising access to market information and improving access to market centers. It can be concluded that farmers are producing considerable amounts of crop outputs that can be supplied to agro-processing plants and investors can plan for establishment of agro-processing plants in the study area. To get the whole commercialization picture of the study area, additional study shall be conducted by including sample districts from lowland Agroecology.

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**Data availability** The datasets generated and analyzed during this research (study) are not publicly available for the sake of respondents' privacy. However, they can be available from the corresponding author on reasonable request.

## Declarations

**Competing interests** The authors declare no competing interests.

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## Appendix

### Collinearity diagnostics

Variable	VIF	Tolerance	Variable	VIF	Tolerance
Age	1.67	0.5981	DA contact	1.09	0.9167
Education	1.35	0.7431	Land cultivated	2.41	0.4152
Landholding	2.22	0.4504	Agroecology	1.46	0.6854
Family labor	2.49	0.4014	Family size	2.40	0.4160
Road access	1.12	0.8904	Number of oxen	1.05	0.9511
Crop diversification	1.26	0.7947	Main market distance	1.10	0.9130
Number of equines	1.15	0.8702	Mechanization level	1.28	0.7822
Access credit	1.05	0.9487	Income (ln)	1.13	0.8852
Livestock (TLU)	1.50	0.6662	Access market information	1.06	0.9412
Mean	VIF	1.49			

### Breusch–Pagan/Cook–Weisberg test for heteroskedasticity

Assumption: Normal error terms.



Explanatory variables	Coefficients			
	(b)	(B)	(b-B)	$\sqrt{\text{diag}(V_b - V_B)}$
	bIV	BOLS	Difference	Std. err
Access credit	-0.0291	-0.0116	-0.0175	0.0152
Access market information	0.1596	0.0004	0.1592	0.0119

*b* Consistent under  $H_0$  and  $H_a$ ; obtained from regress.

*B* Inconsistent under  $H_a$ , efficient under  $H_0$ ; obtained from regress.

Test of  $H_0$ : Difference in coefficients not systematic.

$\chi^2(17) = (b - B)'[(V_b - V_B)^{-1}](b - B) = 773.17$ ; Prob >  $\chi^2 = 0.0000$ .

## References

1. Trading Economics. <https://tradingeconomics.com/ethiopia/gdp-from-agriculture>. Accessed 28 Apr 2023.
2. Kiru OK. The Agricultural Mechanization in Africa: micro-level analysis of state drivers and effects, ZEF—Discussion Papers on Development Policy No. 272, Center for Development Research, Bonn, April 2019; 2019. p. 56.
3. Rapsomanikis G. The economic lives of smallholder farmers: an analysis based on household data from nine countries. Food and Agriculture Organization of the United Nations Rome; 2015.
4. Jaleta M, Gebremedhin B, Hoekstra D. Smallholder commercialization: processes, determinants and impact. In: Discussion Paper No. 18. Improving productivity and market success (IPMS) of Ethiopian Farmers Project. ILRI: Nairobi, Kenya; 2009.
5. Poulton C. What is agricultural commercialization, why is it important and how do we Measure it? Agricultural policy research in Africa, Working paper 06; 2017.
6. Immink MDC, Alarcon JA. Household income, food availability, and commercial crop production by smallholder farmers in the western highlands of Guatemala. *Econ Dev Cult Change*. 1993;41:319–42.
7. Strasberg PJ, Jayne TS, Yamano T, Nyoro J, Karanja D, Strauss J. Effects of agricultural commercialization on food crop input use and productivity in Kenya. In: MSU international department of agricultural economics development department of economics. Working paper number 71. Michigan, USA: MSU; 1999.
8. Pingali PL, Rosegrant MW. Agricultural commercialization and diversification: process and policies. *Food Policy*. 1995;20(3):171–85.
9. von Braun J. Agricultural commercialization: impacts on income, and nutrition and implications for policy. *Food Policy*. 1995;20:187–202.
10. Alemu D, Gabre-Madhin E, Dejene S. From Farmer to market and market to farmer: characterizing smallholder commercialization in Ethiopia. In: Paper submitted for ESSP 2006 policy conference on “bridging, balancing, and scaling up: advancing the rural growth agenda in Ethiopia” 6–8 June 2006, Addis Ababa, Ethiopia; 2006.
11. CSA (The Federal Democratic Republic of Ethiopia Central Statistical Agency). Agricultural sample survey 2020/2021 (2013 E.C.) (September–January 2020/2021) volume vii report on area and production of major crops (private peasant holdings, Meher season); 2021.
12. Timmer CP. Farmers and markets: the political economy of new paradigms. *Am J Agr Econ*. 1997;79(2):621–7.
13. Pingali PL. From subsistence to commercial production system: the transformation of Asian agriculture. *Am J Agr Econ*. 1997;79(2):628–34.
14. Leavy J, Poulton C. Commercialization in agriculture: a typology. In: Paper presented at the fifth international conference on the Ethiopian economy, Ethiopian Economic Association (EEA), USA; 2007. p. 79–99.
15. Sokoni CH. Commercialisation of smallholder production in Tanzania: implications for sustainable resources management. *Geogr J*. 2008;174(2):149–75.
16. Gebreab N. Commercialization of Smallholder Agriculture in Ethiopia. Note and papers series 3; 2007. [http://policydialogue.org/files/events/Gebre-ab\\_Commercialization\\_of\\_smallholder\\_agriculture\\_in\\_Ethiopia.pdf](http://policydialogue.org/files/events/Gebre-ab_Commercialization_of_smallholder_agriculture_in_Ethiopia.pdf).
17. Thurlow J, Kiringai J, Gautam M. Rural investments to accelerate growth and poverty reduction in Kenya. In: IFPRI discussion paper 00723. Development Strategy and Governance Division, Washington DC; 2007.
18. Olwande J, Mathenge M. Market participation among poor rural households in Kenya. Tegemeo Institute of Agricultural Policy and Development. In: Working paper series (WPS 42/2011). Egerton University; 2011.
19. Wickramasinghe U, Weinberger K. Smallholder market participation and production specialization: evolution of thinking, issues and policies. In: CAPSA working paper No. 107, CAPSA—ESCAP 2013; 2013.
20. von Braun J, Bouis H, Kennedy E. Conceptual framework. In: von Braun J, Kennedy E, editors. Agricultural commercialization, economic development, and nutrition. Maryland: The Johns Hopkins Press Ltd.; 1994. p. 11–36.
21. Byerlee DR, De Janvry AF, Klytchnikova II, Sadoulet EML, Townsend R. World development report 2008: agriculture for development (English). World Development Report; no. 30 Washington, D.C.: World Bank Group. <http://documents.worldbank.org/curated/en/587251468175472382/World-development-report-2008-agriculture-for-development>.
22. MoARD (Ministry of Agriculture and Rural Development. Food security program 2010–2014. Addis Ababa: Ministry of Agriculture and Rural Development; 2014.
23. Brascero F, Asgedom D, Sommacal V, Casari G. Strategic analysis and intervention plan for wheat and wheat products in the Agro-Commodities Procurement Zone of the pilot Integrated Agro-Industrial Park in Central-Eastern Oromia, Ethiopia. Addis Ababa. FAO. 104 pp. License: CC BY-NC-SA 3.0 IGO; 2019.

24. Gebremedhin B, Jaleta M. Commercialization of smallholders: does market orientation translate into market participation? Improving productivity and market success (IPMS) of Ethiopian farmers project Working Paper 22. Nairobi, Kenya, ILRI; 2010.
25. Cunningham LT, Brorsen BW, Anderson KB, Tostão E. Gender differences in marketing styles. *Agric Econ*. 2008;38(1):1–7.
26. Dawana DD. Determinants of smallholder teff farmers' market participation; a case study in Gena-Bossa District, Dawro Zone, Ethiopia. MSc Thesis Submitted to The School of Graduate Studies of Jimma University, Jimma; 2018.
27. de Janvry A, Fafchamps M, Sadoulet E. Peasant household behavior with missing markets: some paradoxes explained. *Econ J*. 1991;101(409):1400–17.
28. Sadoulet E, de Janvry A. Quantitative development policy analysis. Baltimore and London: The Johns Hopkins University Press; 1995.
29. Key N, Sadoulet E, de Janvry A. Transaction costs and agricultural household supply response. *Am J Agr Econ*. 2000;82(2):245–59.
30. Gabre-Madhin EZ. Market institutions, transaction costs, and social capital in the Ethiopian Grain Market. Research Report 124. International Food Policy Research Institute, Washington D.C.; 2001.
31. Barrett C. Smallholder market participation: concepts and evidence from Eastern and Southern Africa. *Food Policy*. 2007;33(4):299–317.
32. Pender J, Alemu D. Determinants of smallholder commercialization of food crops: theory and evidence from Ethiopia. Discussion Paper No. 75, IFPRI, Washington D.C.; 2007.
33. Alene AD, Manyong VM, Omany G, Mignouna HD, Bokanga M, Odhiambo G. Smallholder market participation under transaction costs: maize supply and fertilizer demand in Kenya. *Food Policy*. 2008;2008(33):318–28.
34. Asfaw DM, Shifaw SM, Belete AA. Determinants of market participation decision and intensity among date producers in Afar Region, Ethiopia: a double hurdle approach. *Int J Fruit Sci*. 2022;22(1):741–58. <https://doi.org/10.1080/15538362.2022.2119189>.
35. Anteneh A, Endalew B. Determinants of teff commercialization among smallholder farmers: beta regression approach. *Cogent Soc Sci*. 2023;9(1):2209987. <https://doi.org/10.1080/23311886.2023.2209987>.
36. Gidelew GE, Tefera TL, Aweke CS. From staple food to market-oriented crop: commercialization level of smallholder teff (*Eragrostis teff*) growers in Jamma District Ethiopia. *CABI Agric Biosci*. 2022;3:53.
37. Senbeta AN. Factors affecting level of potato commercialization in Kofale District, West Arsi Zone, Oromia Regional State, Ethiopia. *J Invest Manag*. 2020;9(2):56–62. <https://doi.org/10.11648/jjim.20200902.13>.
38. Bezabeh A, Beyene F, Haji J, Lemma T. Evaluating the commercialization of smallholder malt barley farmers via vertical coordination in Arsi highlands, Oromia region, Ethiopia. *Cogent Econ Fin*. 2022;10(1):2125660. <https://doi.org/10.1080/23322039.2022.2125660>.
39. Mamo T, Getahun W, Tesfaye A, Chebil A, Solomon T, Aw-Hassan A, Debele T, Assefa S. Analysis of wheat commercialization in Ethiopia: The case of SARD-SC wheat project innovation platform sites. *Afr J Agric Res*. 2017;12(10):841–9. <https://doi.org/10.5897/AJAR2016.11889>.
40. Worku C, Adugna M, Mussa EC. Determinants of market participation and intensity of marketed surplus of smallholder chickpea producers in Este woreda. *Wiley Legume Science; Legume Science*. 2022;4: e132. *Legume Science*. 2022;4:e132; 2021.
41. Kim CS, Abafita J, Atkinson J. Smallholder commercialization in Ethiopia: market orientation and participation. *J Admin Bus Stud*. 2016;2(1):19–28.
42. Sale A, Debebe S. Analysis of smallholder farmer's participation in sesame production and commercialization in southern Ethiopia. *J Agric Dev*. 2021;11(1):26–44.
43. Ayele T, Goshme D, Tamiru H. Determinants of cereal crops commercialization among smallholder farmers in Guji Zone, Ethiopia. *Cogent Food Agric*. 2021;7(1):1948249.
44. Minot N, Warner J, Aredo SD, Zewdie T. Role of agricultural commercialization in the agricultural transformation of Ethiopia: trends, drivers, and impact on well-being, vol. 2156. *Intl Food Policy Res Inst*; 2023.
45. OBOFED (Oromia Bureau of Finance and Economic Development). Physical and socio-economic profile of Arsi Zone and Districts. The National Regional Government of Oromia, Bureau of Finance and d Economic Development, Regional Data and Information Core Process; 2011.
46. Stahl M. Contradictions in agricultural development: A study of three minimum package projects in southern Ethiopia. In: Research report No. 14, The Scandinavian Institute of African Studies, Uppsala; 1973.
47. Cohen JM. Integrated rural development: the Ethiopian experience and the debate. Uppsala: The Scandinavian Institute of African Studies; 1987.
48. Hassena M, Ensermu R, Mwangi W, Verkuijl H. A comparative assessment of combine harvesting vis-à-vis conventional harvesting and threshing in Arsi Region, Ethiopia. In: International Maize and Wheat Improvement Center (CIMMYT) and Ethiopia Agricultural Research Organization (EARO), Mexico, D. F.; 2000.
49. Peter A, Theodore C. Encyclopedia of biostatistics|systematic sampling methods. <https://doi.org/10.1002/0470011815.b2a16077>. 2005. <https://doi.org/10.1002/0470011815.b2a16077>.
50. Kothari CR. Research methodology: methods and techniques. 2nd ed. New Delhi: New Age International; 2004.
51. Israel GD. Sampling the evidence of extension program impact. Program evaluation and organizational development, IFAS, University of Florida, PEOD-5; 1992.
52. von Braun J, Kennedy E. Agricultural commercialization, economic development and nutrition. Baltimore and London: The Johns Hopkins University Press; 1994.
53. Gebreselassie S, Ludi E. Commercialization of smallholder agriculture in selected Tef-growing areas of Ethiopia. *Ethiop J Econ*. 2007;16(1):57–88.
54. Gebreselassie S, Sharp K. Agricultural commercialization in coffee growing areas of Ethiopia. *Ethiop J Econ*. 2007;16(1):89–118.
55. Taye B, Tsegaye W, Ketema M. Commercialization of Ethiopian smallholder farmer's production: factors and Challenges behind. In: Paper presented on the tenth international conference on the Ethiopian Economy, Ethiopian Economics Association, July 19–21, 2012, Addis Ababa, Ethiopia; 2012.
56. Tura EG, Goshub D, Demisie T, Kenead T. Determinants of market participation and intensity of marketed surplus of Teff producers in Bacho and Dawo Districts of Oromia State, Ethiopia. *J Econ Sustain Dev*. 2016;7(1):13–24.
57. Geoffrey KS. Determinants of market participation among small-scale pineapple farmers in Kericho County, Kenya; 2014.
58. Tobin J. Estimation of relationships for limited dependent variables. *Econometrica*. 1958;26:24–36.

59. Winship C, Mare R. Models for sample selection bias. *Ann Rev Sociol.* 1992;19:327–50.
60. Rufino C. Microeconometric analysis of the eating-out behavior of modern Filipino households: the Tobit, the Craggit and the Heckit models. *DLSU Bus Econ Rev.* 2016;26(1):50–69.
61. Humpheys RB. Dealing with zeros in economic data, December 14, 2010. [http://www.ualberta.ca/bhumphre/class/zeros\\_v1.pdf](http://www.ualberta.ca/bhumphre/class/zeros_v1.pdf).
62. Lefebo N, Haji J, Geta E, Zemedu L. Determinants of status and extent of market participation among bulla producers in Hadiya Zone, Southern Ethiopia. *J Biol Agric Healthc.* 2016;6(7):84–92.
63. Sigei G, Bett H, Kibet L. Determinants of market participation among small-scale pineapple farmers in Kericho County, Kenya; 2014.
64. Chalwe, S.2011. Factors Influencing Bean Producers' Choice of Marketing Channels in Zambia. An Msc. Thesis Presented to the School of Graduate Studies of Zambia University.
65. Haile K, Gebre E, Workye A. Determinants of market participation among smallholder farmers in Southwest Ethiopia: double-hurdle model approach. *Agric Food Secur.* 2022;11:18.
66. Gebremedhin B, Jaleta M, Hoekstra D. Smallholders, institutional services, and commercial transformation in Ethiopia. *Agric Econ.* 2009;40(s1):773–87. <https://doi.org/10.1111/j.15740862.2009.00414.x>.
67. Rehima M, Dawit A. Red pepper marketing in Siltie and Alaba in SNNPRS of Ethiopia: factors affecting households' marketed pepper. *Int Res J Agric Sci Soil Sci.* 2012;2(6):261–6.
68. Tarekegn K, Yosefe K. 2017 determinants of poultry market participation decisions: the case of producers in kaffa and bench Majji Zones, Southern Ethiopia. *J Econ Sustain.* 2017;8(3):23–9.
69. Holloway G, Ehui S. Expanding market participation among smallholder livestock producers: a collection of studies employing Gibbs sampling and data from the Ethiopian highlands, 1998–2001. In: *Socio-economic and policy research working paper no. 48.* Nairobi: International Livestock Research Institute; 2002. p. 1–88.
70. Admassu B, Shiferaw Y. Donkeys, horses and mules - their contribution to people's livelihoods in Ethiopia. The Brooke, Addis Ababa, Ethiopia; 2011. <https://www.thebrooke.org/sites/default/files/Ethiopia-livelihoods-2020-01.pdf>.
71. Usman S. Analysis of wheat value chain: the case of Sinana District, Bale Zone, Oromia region, Ethiopia. MSc thesis presented to Haramaya University. Harar, Ethiopia; 2016.
72. Peng J, Zhao Z, Liu D Impact of agricultural mechanization on agricultural production, income, and mechanism: evidence from Hubei Province. *China Front Environ Sci.* 2022;10:838686. <https://doi.org/10.3389/fenvs.2022.838686>.
73. Asfaw S, Shiferaw B, Simtowe F. Does technology adoption promote commercialization? Evidence from chickpea technologies in Ethiopia. In: *CSAE 2010 conference on Economic Development in Africa*, University of Oxford, UK; 2010.
74. Kassa G, Yigezu E, Alemayehu D. Determinants of smallholder market participation among banana growers in Bench Maji Zone, Southwest Ethiopia. *Int J Agric Policy Res.* 2017;5:169–77. <https://doi.org/10.15739/IJAPR.17.020>.
- 75.