Determinants of Crop Commercialization in Irrigation Areas of Ethiopia: The Case of North Wollo and West Gojjam Zones of Amhara Region

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Abstract

The study was carried out to identify factors affecting crop input and output commercialization among smallholder crop-producing farmers in irrigated areas of Amhara region, Ethiopia. primary data was collected from 544 randomly selected households Using three-stage sampling procedures. The data were analyzed using descriptive and inferential statistics to describe the input and output market participation and difference. Input and output commercialization indices were derived for all the participating farmers. two-limit Tobit model was employed to find determinants of agricultural market participation and commercialization of smallholder farms. The study found that the farmers were semi-commercialized for output side but poorly commercialized for input side. In addition, factors which found significantly determining output market participation and commercialization were age of the household head, distance to the nearest market, distance to the nearest town, irrigation experience, share of crop income, livestock ownership measured in TLU, membership in Water Users Association (WUA) and cooperative, proportion of irrigated land and agroecology being in lowland. Similarily, factors which found significantly determining input market participation and commercialization were distance to nearest seed and agrochemical market, irrigation experience, membership in cooperative, share of crop income, TLU and agroecology. The study suggests that the public and private sectors contribute more to commercialization through providing training, improving institutional service, skill and expertise, and infrastructure facilities. Thus, if policies to address these problems such as outgrower schemes, contract farming and Agricultural One Stop Shoping (AOSS) for input supply are implemented in irrigation scheme users. Specifically, improve the inclusiveness of these type of interventions for smallholder farmers like female headed or small land size farmers in irrigated agriculture have a high potential for commercialization.

Keywords: Crop market participation, Commercialization, Irrigation, two-limit Tobit, Ethiopia

Introduction

According to the FAO (2019), 22.8% of the world's undernourished people live in Sub-Saharan Africa, where 1.3 billion people lack enough food to consume. Despite agriculture being the main source of income in Africa, it is unable to feed the continent's expanding population (AU, 2013). Smallholder agriculture has long dominated the sub-Saharan region's economy and will continue to play a crucial role for the foreseeable future (Gollin, 2014).

Ethiopia is the second most populous nation in Africa after Nigeria. In 2010, its population was 87.6 million, and by 2020, the country's population had reached about 115 million, with a large majority over 80 percent of Ethiopia's inhabitants located in rural areas (FAO, 2020). Agriculture is the dominant economic sector in Ethiopia that accounts for about 32.7% of the GDP, and 81.5% of the foreign exchange earnings and supports about 67.3% of the employment (NBE, 2021). Mixed crop-livestock farming system is dominant in Ethiopia. Crop production accounts for 72 % of agriculture. According to the annual report of the Central Statistics Agency (CSA, 2021), in 2020/21, over 34.1 million tons of grain crops, including cereals (88.36%), pulses (9.36%) and oil seeds (2.27%) were produced across 12.98 million hectares of cultivated land. The production of vegetables was 0.91 million tons, contributing about 2.04% of the total crop production.

The growth of the agricultural sector in Ethiopia is essential to the country's overall economic health, and the smallholder sub-sector's progress is a key indicator of this (Gebre-selassie and Bekele, 2012). This suggests that improvements in agriculture may have broad-reaching direct benefits on improving the lot of the underprivileged (smallholder farmers, female, youth and landless) people through employment opportunity, source of income, and improving food security. However, a lot of developing nations have not completely tapped into stated agriculture's various benefits (Pingali, 2010). Since smallholder farmers, who make up a large portion of the rural poor, primarily engage in consumption-oriented subsistence farming, which excludes them from the formal market system and the associated income-mediated benefits, they have also not fully benefited from agriculture's multiple functions (WB, 2008).

Smallholder farmer commercialization, particularly in developing nations, may have a positive effect on livelihood creation in addition to performance (Muriithi & Matz, 2015). The Ethiopian government has placed a lot of focus on agricultural commercialization in its two consecutive five-year Growth

and Transformation Plans (GTP-I and GTP-II), of which the second pillar aims to achieve growth and consequently enhance people's livelihoods and eliminate poverty (MoFED, 2015). In order to provide a strategic entry point for private sector engagement, the government of Ethiopia created agricultural commercialization clusters with the primary objective of commercializing smallholders' agriculture and agro-industrial development (Pauw, 2017). The government has also identified smallholder farmers' commercialization as the primary driver of Ethiopia's agricultural progress in the newly enacted 10-years perspective plans and the home-grown economic reform (FDRE PDC, 2021).

Some of the factors that determine commercialization have been identified by studies done in many parts of the world (Gebiso et al., 2023; Fikadu et al., 2023; Falola et al., 2017; Kabiti et al., 2016). Due to the diverse circumstances faced by smallholder farmers, these drivers vary both within and between nations and across time period as well. To determine the most effective strategy to increase the capacity of the smallholder farmers in the study areas, this call for area-based analysis of commercialization's determinants is being made. Although there are several empirical studies on productivity-related topics (Bachewe et al., 2015; Geta et al., 2013;Wake et al., 2019; Tenaye, 2020; Ademe et al., 2016; Makombe et al., 2017) as well as the factors that influence smallholder commercialization from the output side (Edosa, 2018; Ayele et al., 2021; Minot et al., 2022; Gebiso et al., 2023; Fikadu et al., 2023), the input side of Ethiopia's agricultural markets has received very less attention. Without giving the inputs market the proper consideration, subsistence agriculture could not be transformed into a commercial enterprise.

According to Katerega et al. (2018); Pingali et al. (2019) and Ogutu & Qaim (2018), commercialization happens from the output side with an intensified market excess, which can only be attained through increased input market participation. To increase farm productivity, the input market should expand in size and quality (Gebremedhin et al., 2006; Shikur, 2023). These could improve the access of farmers to input markets or presents new challenge that calls for updated rigorous analysis. There is ongoing intervention with regard to establishing of Agricultural One- Stop Services (AOSS) centers project such as farmers input service centers to improve accessibility of agricultural inputs (seed, and agrochemicals) in most part of Ethiopia. These innovative approaches have not only improved the access but also improves the quality of availability of credible and genuine farm inputs especially

agrochemicals by blinding with support and advisory services (ATA, 2019). AOSS supplies quality pesticides, herbicides, improved seed varieties, and other agricultural inputs on time and at fair price. Moreover, the choice and supply of improved seeds, pesticides, and herbicides increased after the AOSS project (Shikur, 2023). It also incorporates pertinent technologies. Thus, there is a need to emphasize the input side of smallholder commercialization if the mission for commercial transformation of subsistence agriculture has to come true.

Farmers in irrigated areas use more inputs and produce in cluster farming experiences through the year and hence reliable market linkages both to the input and output markets is an interesting case to explore. Therefore, this study aimed toward analyzing current scale of commercialization and identifying determinants of both input and output crop market participation and commercialization of rural households in major irrigated districts of Amhara region.

The rest of the paper is organized as follows: Section two describes the methodology which includes description of the study area, selection of respondents, methods used for measuring market participation, commercialization and model specifications. Descriptive and econometric results are presented, compared and discussed in section three. Finally, concluding remarks and recommendations are offered in section four.

Research Methodology

Study area

The study was conducted in the selected zone of Amahra National Regional State (ANRS), Ethiopia namely: north wollo and west Gojjam. Four woredas in ANRS each with a distinct level of irrigation potential were used for the study. ANRS has a total area of about 153,000 km2 and is estimated to have a population of around 27,618,552 in 2021, according to the Central Statistical Agency of Ethiopia (CSA) (CSA, 2013). The study locations were north Mecha and south Achefer woredas from west Gojjam, where the Koga river dam and other small-scale irrigation schemes are located, and the Raya Kobo and Habru woredas from north Wollo, where the irrigation schemes of the Kobo-Girana valley development program (KGVDP) are located. Location of the study area is given in the map below.

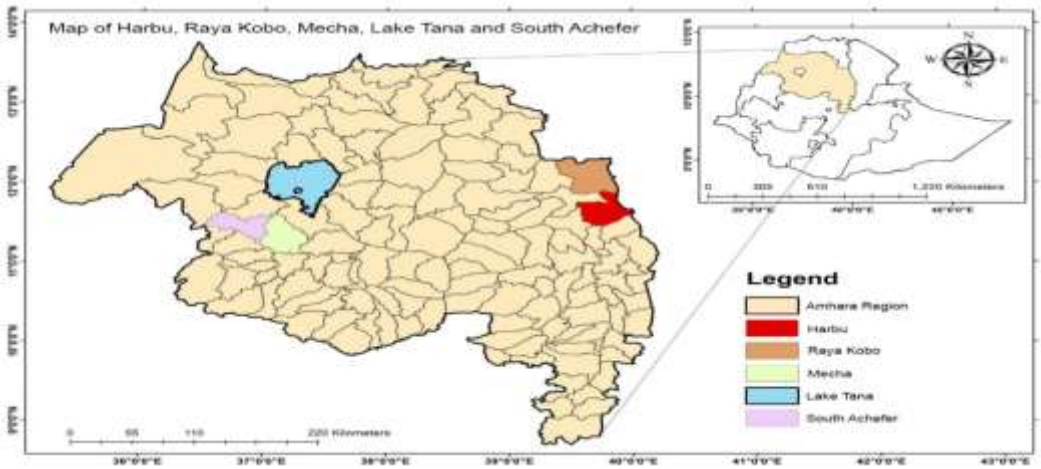

Figure 1. Map of the study area

Sampling technique and sample size

Multi-stage random sampling technique was adopted for this study. First, two zones of the Amhara region were selected purposively based on the availability of irrigation schemes and their representativeness of the western high rain fall and eastern low rain fall areas of the region. The selected zones were West *Gojjam* from western part and North *Wollo* from eastern part of the region. In the second stage, two woredas (districts) from each zone were selected randomly based on their access to irrigation schemes. *Habru* and *Raya Kobo* were selected from North *Wollo* zone whereas, North *Mecha* and South *Achefer* were selected from West *Gojjam* zone of the region. In the third stage, representative kebeles (irrigation schemes) were randomly selected from each district. Finally, 544 respondent households were randomly selected based on the proportionate probability sampling techniques.

Methods of Data Collection

The study was conducted based on data obtained from primary and secondary sources. The data collection was done through face-to-face interviews using a paper-based questionnaire. The first section of the questionnaire introduced the key features of the study and inquired for the consent of the respondents to participate after discussing the anonymity and confidentiality of the interviews. Either of the household heads (male or female) were interviewed after they provided their oral approval to participate in the survey. The interviews were conducted at farmers' residences and no minors were involved in the survey. Personal interviews using a semi-structured questionnaire were

employed to collect primary data. Both open and close-ended types of questions were included in the questionnaire to collect information pertinent to the purpose of the study.

Method of data analysis

The analytical methodologies adopted in past empirical literature are varied. Though a majority of the studies used two-step selectivity models to analyze the discrete decision of market participation and the continuous decision of market participation intensity conditional on having decided to participate (Bellemare and Barrett, 2006; Mather et al., 2011), other studies just analyzed the continuous decision of market participation intensity (Bernard et al., 2007). Pender and Alemu (2007) and (Gabre-Madhin., 2007) analyzed factors that condition households to participate in either net sellers, autarkic or net buyers. A truncated regression model was applied with households that did not participate in the market being excluded from the analysis i.e., the lower bound of the truncation. Applying the Double Hurdle model developed by (Cragg, 1971), Mather et al. (2011) analyzed the determinants of maize market participation in selected eastern and southern African countries by fitting a double hurdle model on panel data in a random effects framework. Moreover, Mamo et al. (2017) analyzed wheat market commercialization in Ethiopia using Tobit model and Addisu et al. (2019) used the censored Tobit model to analyze the commercialization of teff in Dendi district of Oromiya region, Ethiopia.

Unlike several previous studies, our dependent variable is constructed based on the aggregate values of all the ten crops considered in our study. Moreover, crops were categorized as cereal, horticulture and pulse for easiness of analysis. According to Heltberg & Tarp (2002), such an approach maximizes the use of available information. Moreover, it facilitates substitution among crops due to some exogenous variables that may increase participation in the sale of an individual crop at the expense of another. Hence, this study employed two-limit Tobit model to identify factors that affect smallholder crop market participation and commercialization (both outputs and inputs).

Following (Braun. & Kennedy, 1994), we computed household crop output market participation in annual crops as the proportion of the value of crop sales to total value of crop production, which we refer to in this paper as crop-output market participation (COMP) index, computed as depicted in equation 1:

$$COMP_i = \frac{\sum \bar{P}_k S_{ik}}{\sum \bar{P}_k Q_{ik}} \quad (1)$$

Where: S_{ik} is quantity of output k sold by household i evaluated at an average district (community) level price ($\bar{P}_k$),

Q_{ik} is the total quantity of output k produced by household i.

According to commercialization measure adapted from von Braun (1995); Strasberg et al. (1999), Fikadu et al., (2023) farm households involved in greater sales of crop outputs with an index value of 0.5 and above are regarded as commercial-oriented, marketable surplus index ranging between 0.25-0.50 of total production are classified as semi-commercial and less than 0.25 are subsistence oriented.

A conventional approach of measuring household commercialization from the input side is to take the ratio of the value of crop inputs purchased to the total value of crops produced in a particular production period (Katerega et al., 2018; Jaleta et al., 2009). We, however, argue that such indexing is inappropriate from the conceptual point of view. We then considered two aggregate values to index the farmer's intensity of commercialization from the input side: the value of crop inputs purchased and used. Our exposition here follows; households obtain inputs from two sources; partly from their own source or left over inputs and the rest from market. Only the part of inputs which was obtained from input market explains the degree of market participation of the householders. Following this conceptualization, we index the crop input market participation as the proportion of the gross value of purchased inputs from the total value of crop inputs used in annual production. Therefore, we trusted our measuring method best indexes the extent to crop input commercialization by smallholder households in the study areas. Hence, the crop input commercialization index (CIMP) was computed by using the formula as follows:

$$CIMP_i = \frac{\sum \bar{P}_{if} F_{if}}{\sum \bar{P}_{ki} Q_{ik}} = \left(\frac{gross\ value\ of\ crop\ inputs\ acquired\ from\ markets\ (ETB)}{gross\ value\ of\ crop\ input\ used\ in\ the\ production\ (ETB)}\right) \quad (2)$$

Where: F_{if} is quantity of input F bought by household i evaluated at an average district (community) level price ($\bar{P}_{fi}$) represent by gross value of crop inputs acquired from markets (in ETB). Q_{ik} is total quantity of input used /output k produced by household i evaluated at an average district (community) level price gives gross value of input used in crop production (in ETB).

For the analysis of household market participation and commercialization (both in the output and input market) we employed probit and two-limit Tobit models, respectively. Since these variables are lower censored at zero and upper censored at one. Consequently, fractional outcome regression models are applicable if the dependent variable is explained in the form of fractions, rates, indices, and proportions (Gallani et al., 2015).

The probit and filtered Tobit models are suitable for this investigation to address the aforementioned issue. The

model specification of (probit model) on farmers' decisions whether to participate or not and the volume of supply of crop can be estimated as follows:

$$Y^* = X_{1i}\beta_1 + U_{1i};\ U_{1i} \approx N(0, 1) \quad (3)$$

$Y = 1$ if $Y^* > 0$.

$Y = 0$ if $Y^* \leq 0$

Where:

Y^* = is a dependent variable that has a value of 1 if a household participates in the crop market and 0 otherwise.

X_i: are sets of variables that are presumptively related to the likelihood of sampled households participating in the crop market.

B_1: is a vector that represents an unknown parameter in the participation equation.

U_1: are residuals with a zero mean and constant variance that are distributed normally and independently.

Among fractional outcome models, the fractional probit regression model which is inbeded in tobit model is appropriate when the outcome variable commercialization index (C_i) includes values between zero and one and including both zero and one i.e. $0 \leq C_i \leq 1$ (Gallani et al., 2015; Semykina & Wooldridge, 2018). Such a problem of households including both non participant and fully participant in the market is overcome by following a two-stage procedure as suggested by (Heckman, 1979) or Tobit procedures. These procedures has been discussed broadly in (Tobin, 1958) and (Greene, 1997).

The Tobit regression model is a limited dependent variable model that helps to realize the probability of crop commercialization decisions and the extent of crop commercialization in the study areas. The model is used when the dependent variable assumes the same value for a considerable number of observations and a continuous value for others. The model in the context of this study assumes that both the decision to commercialize and the extent of commercialization are determined by the same variables with the same sign, i.e., the variables that increase the probability of commercialization also increase the extent of commercialization. This model suits such kinds of analysis as it enables one to examine the effect of different explanatory variables on a limited dependent variable. The Tobit model is estimated by assuming a correlation between the unobservables affecting households' decisions to sell and their decisions on how much to sell. The Tobit model uses the maximum likelihood method to execute the estimation.

The general specification defining the Tobit model is specified in matrix notation as follows (eq.4):

$$y_i = \beta' x_i + \varepsilon_i \quad (4)$$

Where: y_i* = is a latent variable, which is unobserved for values less than 0 and greater than 1 that represent subsistence or fully commercial index;

x_i = is vector of independent variables, which includes factors affecting market participation and level of commercialization;

β = is vector of unknown parameters to be estimated;

ε_i = is a disturbance term assumed to be normally distributed with zero mean and constant variance σ^2; and i = 1, 2, 3... n (n = the number of observations)

$$y_i = \begin{cases} y^* \; if \;\; 0 < y^* < 1 \\ 0 \;\; if \;\; y_i{}^* \leq 0 \end{cases} \quad (5)$$

The advantage of the Tobit model as in Equation (5) is that it captures the decision to participate as well as the resulting outcome extent of commercialization, whereas a probit model provides information on the decision to participate only. The Tobit model is estimated using maximum likelihood estimations. The log likelihood (LL) of the model is specified in equation 6 as:

$$ln\, L = ln\left(\coprod_{y_i>0} f(y_i) \coprod_{y_i=0} F(0)\right) = \left(\sum_{y_i>0} ln\, f(y_i) \sum_{y_i=0} ln\, F(0)\right) \quad (6)$$

Since y* is assumed to be normally distributed as error terms are assumed to be normally distributed, f(.), F(.) and hence the log likelihood functions can be written in the form of the density function and cumulative density function of the standard normal distribution as: ∅ (.) and Φ(.) and the log likelihood function is rewritten as follows (eq.7):

$$ln\, L = \sum_{y_i>0} \left(\left(-ln\, \sigma + ln\, \emptyset \left(\frac{y_i - x_i\beta}{\sigma} \right) \right) + \sum_{y_i} ln\, \left(1 - \emptyset \left(\frac{x_i\beta}{\sigma} \right) \right) \right) \quad (7)$$

There are three main conditional expectations of interest in the Tobit model. These are: the conditional expectation of the underlying latent variable (y^*); the conditional expectation of the observed dependent variable (y); and the conditional expectations of the uncensored observed dependent variable ($y/y > 0$). Following (McDonald and Moffitt, 1980;Heckman, 1979; (Johnston & Dinardo, 1997) the marginal effects of these conditional expectations, respectively, are given as follow in equations:

$$\frac{\partial E\left(\frac{y^*}{x}\right)}{\partial x} = \beta \quad (8)$$

$$\frac{\partial E\left(\frac{y}{x}\right)}{\partial x} = \beta \emptyset \left(\frac{x\beta}{\sigma} \right) \quad (9)$$

$$\frac{\partial\, Pr\left(y > \frac{0}{x}\right)}{\partial x} = \emptyset \left(\frac{x\beta}{\sigma} \right) \frac{\beta}{\sigma} \quad (10)$$

The interpretations of these marginal effects depend on the point of interest based on the focus of the study (Greene, 2012).

Result and Discussion

Descriptive statistics

This section presents the household demographic and socioeconomic characteristics, farm characteristics, input and output market participation, commercialization index of the farm households and access to institutional services.

Household demographic and socioeconomic characteristics

About 15.44% of households in the sample are female-headed. About 55% of household heads were literate. Water user association members and non-members have significant differences in both output and input market participation. The output market participation of rate of WUA members was higher than non-members by 4%. The average household size is about 6, with an average family labor supply of 3.3 persons per household. The mean age and education level of the sample households is about 43.25 years and grade 2.89, respectively. The average livestock owned is about 4.87 TLU. Most of the sample households (92.65%) had access to extension services while about 31.3% of them had access to credit service in 2019 cropping season. On average, the sample households walk about 58.6 min (nearly one hour) to reach the market of input and output in the study area (Table 1).

Table 1. Descriptive statistics of variables used in the regression analysis

Variable description	WUA Member		WUA Non-member		Pooled		t-value
	Mean	SD	Mean	SD	Mean	SD	
Output commercialization index	68.33	21.31	60.91	23.29	64.83	22.56	-3.88***
Value of crop produced in ETB	102932	74091	90686	68807	97146	71839	-1.99**
Value of crop sold in ETB	67891	51923	57594	57428	63561	54834	-2.41***
Input commercialization index	13.88	15.53	11.01	11.19	12.52	13.71	-2.44***
Education level of the head	3.13	3.39	2.61	3.14	2.88	3.29	-1.85**
Dist. of fertilizer in min. of walk	31.55	31.89	37.63	39.92	34.42	36.00	1.97**
Dist. to the nearest market in min.	84.70	55.85	80.56	53.35	82.75	54.67	-0.88
Distance to the nearest town in min...	82.22	56.31	70.36	50.30	76.62	53.83	-2.58***
Total income in ETB	95741	55228	79351	51850	87998	54232	-3.56***
Total income in ETB per AE	22702	13610	19146	12656	21022	13258	-3.14***
Family size in number	5.67	1.95	5.40	1.83	5.54	1.90	-1.62
Share of crop income	76.28	20.47	75.27	20.77	75.80	20.59	-0.57
Share of off-farm income	6.44	12.06	8.612	13.65	7.464	12.87	1.97**
Land fragmentation (Simpson)[1]	0.35	0.18	0.33	0.15	0.34	0.17	-1.48
Land size in hectare	1.51	0.70	1.60	0.79	1.55	0.74	1.38
	Response	WUA Member		Non-member		Total	x^2-value
		No	Percent	No	Percent		
Sex of household head	Female	30	10.4	54	21	84	11.6***
	Male	257	89.6	203	79	460	
Cooperative member	No	81	28	91	35	172	3.24*
	Yes	206	72	166	65	372	
Animal scotch cart	No	116	40.42	183	71.21	299	51.9***
	Yes	171	59.58	74	28.79	245	
Pack animals ownership	No	199	69.34	204	79.38	403	7.12***
	Yes	88	30.66	53	20.62	141	
Number of observations		287		257		544	

Note: ***, **, and * indicates significant at the probability level of 1%, 5% and 10% respectively.

Source: Authors' computation from sample survey data (2019).

[1] Simpson index = $1 - \frac{\sum_1^n {a_i}^2}{A^2}$ where: a_i is plot size; A is total farm size; n is number of plots

Commercialization index

Output commercialization index of WUA members was significantly higher than that of non-members. The output commercialization index of WUA members' was 8 percent higher than non-members. Input market participation index was also higher for WUA members as compared to non-members. Moreover, there was significant difference in the value of crop sold and value of crop produced among groups of members and non-members. There was also significant difference in total income and share of off-farm income among the two groups.

The result revaled that 97% of the sample households have participated in food crop sales. However, on average, 65% of the annual crop produced was marketed as measured by the crop market participation index, indicating high (sufficient) market participation. The average value of annual crop produced and sold per household was ETB[2] 97148 and 63562, respectively. On average, a household cultivated 1.55 ha of land being a minimum of 0.4 ha and a maximum of 4.8 ha.

The result in table 2 also depicted that the average value of the overall sample household output commercialization index of crop producers was 0.65 (65%), with the highest and lowest in north Mecha (0.75) and Habru (0.56) districts, respectively. This level of market participation is higher than the national average of 52% which was reported by Agricultural Transformation Agency (ATA, 2016). Recent research in Ethiopia and Amhara region estimated that crop commercialization was about 48.9% and 33.8%, respectively (Minot et al., 2021). Hence, the higher value of commercialization in this study areas was due to the fact that most of the products produced in the irrigation season were targeted to market and high value crops that have more demend in the market. More importantly, vegetables are relatively less prevalent in the food basket consumed and primarily produced for cash to meet extra cash needs for children's school fee, medical expenses, and other household social obligations. Moreover, cereal and pulse crops produced in the irrigation season target for the market as a source of cash.

[2] Birr the official currency of Ethiopia and 1 US$ was equivalent to 29.32 ETB (1 ETB = 0.033 USD) during the time of the survey [in March, 2019].

Table 2. Commercialization index of households by district and crop type

District	Output comm. index in %	Horticulture comm. Index in %	Cereal comm. index in %	Pulse comm. index in %	Input comm. index in %
Habru	56.43 (27.4)	94.28 (19.85)	24.84 (22.96)	65.31(40.25)	7.89 (13.14)
Raya Kobo	61.7 (22.42)	99.26 (3.06)	32.09 (20.77)	57.56 (32.61)	3.54 (3.65)
North Mecha	75.01 (15.31)	93.26 (18.36)	68.05 (14.85)	-	30.12 (16.55)
South Achefer	71.07 (13.73)	88.99 (11.95)	59.18 (19.73)	-	18.18 (11.52)
Average	64.83 (22.56)	95.09 (14.32)	42.73 (26.68)	59.33(34.49)	12.52 (13.71)
Status of commercialization in number (%)					
Subsistence level	37 (6.8)	5 (1.29)	145 (27.51)	24 (18.9)	444 (81.62)
Semi- commercial	84 (15.44)	6 (1.55)	163 (30.93)	29 (22.83)	87 (15.99)
Commercial	423 (74.76)	377 (97.16)	219 (41.56)	74 (58.27)	13 (2.38)
N	544	388	527	127	544

Note: Standard errors in parenthesis; Source: Authors' computation from sample survey data (2019).

The survey result also showed that the farm households' crop output commercialization index falls in commercial level. The result also indicates that 3.31% of the overall sample households have a commercialization index of zero value, indicating that they are fully subsistent in terms of crop production and marketing. However, there is a great variation in the proportion of subsistent farmers in terms of specific crops among districts, with the highest and lowest in Habru (34.56%) and north Mecha (2.26%), respectively. The result also revealed that most of the commercialization index (74.45%) falls above 50% while the least (6.8%) falls below 25%. The majority (77.8%) of farmers were categorized as commercial farmers, whereas semi-commercialized and subsistence (non-commercialized) farmers constituted 15.4% and 6.8% of the total farm households, respectively. These result indicated that there exist heterogeneity in terms of commercialization rate by commodity and district level.

Econometric analysis

Before the econometric analysis, essential tests (like linearity, outlier, multicollinarity, heteroscedasticity, omitted variable) that verify the model to employ for the analysis were undertaken on hypothesized variables. Out of the total of 544 sample households 18 (3.3%) of them did not sell their product even if they produced in 2019 production year and 26 (4.78%) of the sample households did not buy input from the market. Since the commercialization index, which is the dependent variable of this study, is censored, the maximum likelihood estimation Tobit regression model was used.

Determinants of crop output market participation and commercialization

Household output commercialization indicates the degree of participation of a household in output markets as a seller. We employed two limit tobit

model to estimate the likelihood of crop output market participation and factors affecting market participation of smallholder farm households in the study area. The results of the econometric analysis depicted in table 4. The results from the tobit model regression depicted that the likelihood of farm households' output market participation was positively influenced by distance to the nearest town, share of crop income, total livestock number, member of WUA, agricultural cooperative membership and proportion of irrigated land. In contrast, it was negatively influenced by age of the head, distance to the nearest market, irrigation farming experience and location. Econometric analysis of factors affecting commercialization (the extent of crop market participation) is also modeled using two-limit Tobit model and the results from this estimation are depicted in Table 3. Ten variables among nineteen tested found to affect commercialization. These are age of the household head, distance to the nearest main market in minutes of walk, distance to the nearest town in minutes of walk, experience in irrigation farming, agricultural marketing cooperative membership, member of water users' association, share of crop income, total tropical livestock units, the proportion of irrigated area and location.

We try to elaborate on major significant variables affecting output commercialization. Distance to the nearest main market in minutes of walk was found to significantly and negatively affect both the likelihood and extent of market participation at 1 percent significance level. The marginal effect result revealed that as the distance to the market increases by one minute of walking, the likelihood of selling their output to the market and the extent of participation decrease by 0.6% and 0.7%, respectively. The closer the smallholder farmers are to the output market, the higher the crop commercialization level due to better information access on the dynamics of market forces and reduced transportation costs. Moreover, distance can separate farmers from accurate and recent price information which exposes farmers to for cheaters resulted in sale of their produce by low price. Ademe et al. (2017); Mamo et al. (2017) and Fikadu et al., (2023) also found similar results that confirm the negative relationship between market distance and crop commercialization.

Experience in irrigation farming was found to significantly and negatively affect both the probability and extent of market participation. The probable reason for the negative relationship is due to the fact that older farmers (more experienced household heads) might be more concerned about being food secured and would not want to take the risk of new crop selection that have higher demend in the market. On the contrary, younger household heads would engage in the markets probably,

they are more dynamic to adopt new technologies that enhance productivity, that in turn would have a positive impact on market participation of the young. This result is in line with the finding reported by Ademe et al. (2017) and Minot et al., (2021) but disagrees with the findings by Kabiti et al. (2016) and Mazengia (2016).

Membership in water users' associations influenced both the probability and extent of crop output market participation positively. The marginal effect result revealed that membership in WUA had a 3.2% more chance of both participating and the extent of market participation. The result suggests that WUA membership contributed to the practice of more productive technologies, training related to irrigation water management and choice of profitable crops. This result is similar to the findings of Stephen et al. (2017) and Tilahun et al. (2019).

Agricultural marketing cooperative membership influenced both the probability and extent of crop output market participation positively. The result suggests that cooperative marketing membership contributed to the practice of crop output market participation via its advantage of obtaining better information access and credit services. The finding is consistent with that of Stephen et al. (2017); Tilahun et al. (2019) and Assefa & Getachew (2023).

The proportion of irrigated land holding increases both the probability and extent of household participation in crop output market as a seller. This may reflect the fact that farm households with sufficiently large irrigated land holdings give priority to market-oriented crop production that could produce a more marketable surplus. This result is in agreement with the finding reported by Tafesse et al. (2020) and Taye et al. (2018) who found that proportion of irrigated land allocated for specific crop production positively affected the marketable surplus of outputs.

Livestock ownership measured in TLU affected both the probability of market participation and commercialization (intensity of participation) positively and significantly at 5 percent significance level. This could be because livestock and crop production is usually considered as complementary enterprises in that livestock can positively contribute to crop production by providing natural fertilizer, oxen used for traction power and a source of cash to finance purchased inputs such as seed, fertilizer and agrochemicals. Therefore, livestock ownership has a positive effect on crop production explicitly and on commercialization implicitly. The result was inline with the findings of Minot et al. (2021) and

Taye et al. (2018), confirming that the number of livestock influences market participation and commercialization level positively.

Determinants of crop input market participation and commercialization

Agricultural commercialization is expected to alter input use and labor demand in farming systems (Strasberg et al., 1999). Commercialization is often associated with increases in the degree of participation in input markets, as farmers increasingly rely on the market for the supply of their inputs such as fertilizers, improved seeds, agro-chemicals, and mechanization services (Leavy and Poulton, 2007) It is therefore imperative to explore the extent to which agricultural commercialization affects input use, labor demand, and farmers' general engagement with factor markets.

Household input commercialization indicates the extent to which a household participates in input markets as a buyer. Major crop inputs considered include improved seed, labor (family and hired), chemical fertilizers (Urea and NPS) and pesticides (insecticide, fungicide and herbicide). The study employed probit regression model to estimate the likelihood of crop input market participation and Tobit model for identifying factors affecting crop input purchase commercialization of smallholder farm households in the study area. The econometric model result depicted in table 4.

To explain some of the significant variables, distance to the nearest place of the improved seed market center was found to affect the likelihood of input market participation positively and significantly. This could be attributed to the fact that farmers who stay far from the town, where markets are located, are more likely to go there less than those who stay closer. The farmers who stay a distant from the input market are prone to buy their inputs earlier than those who are in the proximity of the market. The result is in line with the findings of Kabiti et al. (2016) who found that distance to input markets have a positive influence on the level of input commercialization in Zimbabwe. On the other hand, distance to nearest agrochemical center was found to affect the likelihood of input purchase negatively and significantly. The farther distance from the nearest agrochemical marketplace is more likely associated with higher transactions costs. The finding is in line with the results of Chala and Chalchisa (2017) and Ademe et al. (2017).

Table 3. Determinants of crop output market participation and commercialization

Crop market participation/ Commercialization	Two-limit Tobit			
	Coef. (S.E)	$\frac{\partial E(y*/y_i>0)}{\partial(x_i)}$	$\frac{\partial E(y/y_i>0)}{\partial(x_i)}$	$\frac{\partial P(y>0/x)}{\partial(x_i)}$
Sex of household head	0.013	0.013	0.013	0.002
	(0.024)	(0.024)	(0.024)	(0.003)
Age of household head	-0.002**	-0.002**	-0.002**	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Literacy status	-0.016	-0.016	-0.016	-0.002
	(0.019)	(0.019)	(0.019)	(0.002)
Family size in AE	-0.004	-0.004	-0.004	-0.004
	(0.006)	(0.006)	(0.006)	(0.006)
Distance nearest market in minutes of walk	-0.006***	-0.006***	-0.006***	-0.007*
	(0.002)	(0.002)	(0.002)	(0.004)
Distance to nearest town in minutes of walk	0.003*	0.003*	0.033*	0.004
	(0.002)	(0.0002)	(0.02)	(0.003)
Irrigation experience	-0.003*	-0.003*	-0.003*	-0.0003
	(0.0015)	(0.0015)	(0.0015)	(0.0002)
Fragmentation index	-0.031	-0.031	-0.030	-0.004
	(0.066)	(0.066)	(0.066)	(0.007)
Share of crop income	0.003***	0.003***	0.003***	0.003*
	(0.001)	(0.001)	(0.001)	(0.002)
Share of off-farm income	0.006	0.006	0.006	0.0006
	(0.009)	(0.009)	(0.009)	(0.001)
TLU	0.009**	0.009**	0.009**	0.009
	(0.004)	(0.004)	(0.004)	(0.006)
WUA member (Yes=1)	0.032*	0.032*	0.032* (0.018)	0.003
	(0.018)	(0.018)		(0.003)
Coop. member (Yes=1)	0.045*	0.045*	0.045* (0.025)	0.004
	(0.025)	(0.025)		(0.003)
log (off-farm income)	-0.002	-0.002	-0.002 (0.002)	-0.002
	(0.002)	(0.002)		(0.002)
Prop. irrigated land in ha	0.002***	0.002***	0.002***	0.0002**
	(0.0004)	(0.0004)	(0.0004	(0.0001)
Agro-ecology (lowland=1)	-0.196***	-0.196***	-0.195***	-0.002*
	(0.050)	(0.050)	(0.049)	(0.001)
constant	0.499***	-	-	-
	(0.089)			
/sigma	0.1999***	-	-	-
	(0.008)			

Note: Standard errors in parentheses. ***= p<0.01; ** =p<0.05; *=p<0.1; Pseudo R^2 = 9.77%
Source: Model result from sample survey data (2019).

In similar way, the significant variables explaining the input market participation and commercialization interpreted as follow based on the sign and magnitude of the marginal effect as depicted in table 4.

Membership in agricultural marketing cooperatives positively influenced both the probability and extent of crop input market participation, respectively. The marginal effect result

revealed that for households who are members of the marketing cooperative, the likelihood to buy input from the market and the extent of input purchase increased by 5.3% and 3.4%, respectively. The result suggest that marketing cooperative membership contributed to the practice of crop input market participation via its advantage of obtaining better information access and credit services. The finding is consistent with the result of Chala and Chalchisa (2017) who found membership in cooperative increase the intensity of input purchase in Ethiopia.

Experience in irrigation farming was found to be statistically significant and negatively affect the probability of input market participation at 1 percent significance level. The marginal effect depicted that as experience in irrigation farming increase by one year, the probability of input market participation decreases by 3.3%. This result is in line with the finding reported by Kabiti et al., (2016).

Livestock ownership measured in TLU was found to be significantly and positively affect the level input market participation at 1 percent significance level. The marginal effect result showed that an increase in livestock owned by one TLU, the probability of crop input market participation increases by 1.1%. Generally, the importance of owning considerable number of livestock helps households to generate income from sale live animals and their products that used to purchase agricultural inputs. The result is in line with the findings of Chala and Chalchisa (2017) in their study on determinates of input commercialization in Ethiopia.

Share of crop income is an important variable that was found to affect the likelihood and extent of input market participation negatively and significantly at 1 percent significance level. The marginal effect result showed that an increase in share of crop income by one percent, the likelihood and extent of crop input market participation decrease by 1.7% and 0.7% respectively. The result is in line with the findings reported by Kabiti et al. (2016).

Agro-ecology was found to affect the level of crop input market participation negatively and significantly at less than 1% significance level. The household being in the lowland (eastern part of Amhara), the extent of input market participation decreased by 17.4%. This finding is in line with the study by Kongai et al. (2020).

Table 4. Determinants crop input market participation and commercialization

Crop input market participation/ Commercialization	Two-limit Tobit model estimation			
	Coef. (S.E)	$\frac{\partial P(y>0/x)}{\partial(x_i)}$	$\frac{\partial E(y/y_i>0)}{\partial(x_i)}$	$\frac{\partial E(y^*/y_i>0)}{\partial(x_i)}$
Sex of head	0.014	-0.003	0.009	0.013
	(0.012)	(0.013)	(0.008)	(0.010)
Distance nearest main market in min.	0.001	0.002	0.009	0.001
	(0.009)	(0.001)	(0.007)	(0.009)
Dist. to nearest town	-0.003	-0.007	-0.002 (0.006)	-0.003
	(0.001)	(0.001)		(0.008)
Dist. to nearest market place of improv. seed	0.002	0.005***	0.0001 (0.008)	0.02
	(0.001)	(0.001)		(0.01)
Distance to nearest agrochemical market	0.002	-0.004***	0.001	0.002
	(0.01)	(0.001)	(0.007)	(0.009)
Irrigation experience	-0.001	-0.033***	-0.007 (0.005)	-0.008
	(0.0008)	(0.001)		(0.006)
Agri. Market cooper. membership	0.037**	0.053**	0.027**	0.034**
	(0.015)	(0.021)	(0.012)	(0.014)
Cultivated land in ha	0.004	0.005	0.003	0.003
	(0.007)	(0.009)	(0.006)	(0.006)
Amount of manure used in kg/ha	0.002	-0.001	0.001	0.001
	(0.003)	(0.002)	(0.002)	(0.002)
Share of crop income	-0.007***	-0.017***	-0.005***	-0.007***
	(0.002)	(0.003)	(0.002)	(0.002)
Dist. nearest coop. in min. walk	-0.002	-0.002	-0.001 (0.001)	-0.002
	(0.001)	(0.001)		(0.001)
TLU	-0.001	0.011***	-0.001 (0.001)	-0.001
	(0.002)	(0.002)		(0.002)
WUA member	-0.005	-0.017	-0.004 (0.007)	-0.005
	(0.010)	(0.013)		(0.009)
Extension services	0.001	0.018	0.006	0.001
	(0.017)	(0.017)	(0.012)	(0.015)
Agro-ecology	-0.193***	-	-0.145*** (0.009)	-0.174***
	(0.011)			(0.009)
Constant	0.304***	-	-	-
	(0.031)			
/sigma	0.098***	-	-	-
	(0.003)			

Note: Standard error in parenthesis. ***, **, * significant at p < 0.01, p < 0.05 and p<0.1, respectively.
Source: Authors'computation based on model output

Conclusion and Recommendations

The study identified the factors that play significant roles in determining the level of farming enterprises commercialization, both on the input and output side. In the study areas, internal and external factors contribute to the likelihood of output market participation and commercialization. Output commercialization was found to be highly commercialized. Hence, among the factors age of household head, distance from the market place,

distance from the nearest town, experience in irrigation farming, share of crop income, livestock ownership measured in TLU, membership in water users' association, membership in marketing cooperative, proportion of irrigated land, and location were significantly influencing crop output market participation and commercialization among smallholder crop producers. Smallholder farmers in the study area were found to be low input commercialized, among the factors that affect input commercialization distance to input market, irrigation experience, and membership in marketing cooperative, share of crop, TLU and agro-ecology.

The results suggest the importance of institutional characteristics of collective action via membership in water users' association and marketing cooperative in promoting agricultural commercialization through its advantage of obtaining better information access and credit services. Consequently, an effort has to be done to organize farmers in the stated institutions in order to get the advantage accordingly. Therefore, national and local governments and development partners promoting crop farming should seek to increase access to extension and promote group memberships among smallholder farmers.

Distance from the nearest market negatively affects smallholder farmers' crop output commercialization. Thus, organizations supporting smallholder commercialization should seek to support efforts that lower the variable transaction costs. Such measures could include improving rural feeder roads leading to farms, scale up market linkages, and supporting the development of product aggregation centers is vital to enhance agricultural commercialization. Land size allocated to irrigated crop production had a positive effect on crop output market commercialization. As a result, land productivity-enhancing technologies should be designed and implemented. Since land resources are limited in the study area, output-output production-based education, training, and extension service should be executed to increase land productivity to rise smallholder farmers' participation in the output market. The study also suggests that the public and private sectors contribute more to commercialization through providing training, improving institutional service, skill and expertise, infrastructure facilities and financial support for smallholders Since credit supply in Ethiopia is closely related with the use of improved agricultural inputs, owning to the poverty level and liquidity constraints farmers are facing. Thus, if policies to address these problems such as outgrower schemes and contract farming are implemented, smallholder farmers in irrigated agriculture have a high potential for commercialization.

While several tests confirmed the robustness of our findings, a few limitations remain. First, the analysis relies on cross-sectional data, which limits the strength of our estimation of commercialization levels and their determinants. Follow-up studies with panel data and observed changes in the level of commercialization over time would be very useful in the context of seasonality in agricultural production and marketing. Finally, while the results are context-specific and should not be generalized, they indicate the factors that could support or depress smallholder farmers from engaging in crop commercialization. Commercialization is also promoted as a mechanism for improving household welfare and local economies. Therefore, future research should assess the effect of commercialization on farmers' welfare such as income, poverty, food security, and nutrition.

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