Determinants of Commercializing Crop Outputs of Smallholder Farmers in West Gojjam Zone, North-western Ethiopia

Lijalem Abebaw [1,2*], Worku Tuffa Birru [1] and Dawit Alemu [3]

[1]College of Development Studies, Addis Ababa University, Addis Ababa, Ethiopia
[2]Amhara Agricultural Research Institute, Bahir Dar, Ethiopia
[3]Stichting Wageningen Research (SWR) Ethiopia, Wageningen University and Research (WUR), The Netherlands

Abstract

Background: Commercializing crop production is the pathway for economic development. Previous studies revealed that crop commercialization is affected by resource endowments, and access to institutions and markets. However, the studies have failed to consider landholding size, farmland fragmentation, and crop diversity.

Objective: This study was aimed at investigating factors affecting crop outputs commercialization

Method and Materials: the study addresses quantitative and qualitative research questions used to understand the determining factors of crop output commercialization in west Gojjam Zone of the Amhara Regional State of Ethiopia. Multistage random sampling method was used to sample 385 respondents and a structured interview was conducted. The quantitative data was analysed using descriptive statistics and zero-inflated beta regression. Qualitative data were collected using a focus group discussion and individual interviews, which were then analysed using narration.

Results: The results of the analysis of the data revealed that the average smallholders' crop output commercialization was estimated at 22.7%. Results from the zero-inflated beta regression model revealed that ownership of cell phones, farmland rental contract, and market orientation increased the probability of output commercialization. However, distance of all-weather roads from residence limited the probability of output commercialization. Household head age, household head educational status, farmland fragmentation, crop diversification and market orientation increased the proportion of output commercialization whereas landholding size reduced the extent of output commercialization.

Conclusion: Land holding size reduces proportion of output commercialization; farmland fragmentation and crop diversification increases proportion of output commercialization. The results imply that increasing the size of landholding reduces intensified crop production. Farmland fragmentation allows farmers to access favourable agro-ecological functions for growing marketable crops. The results also imply that crop diversification is a strategy to reduce market risks and promotes output commercialization, thereby improving access to technologies, lowering input purchase costs, reducing output market price seasonal volatility, and enhancing crop output commercialization.

Keywords: Crop diversification; Farmland fragmentation; Landholding; Zero-inflated beta regression

1. Introduction

Commercializing smallholder farmers is the pathway for rural economic development in sub-Saharan Africa (Olwande *et al.*, 2015). Cognizant of this fact, boosting crop production and enhancing commercialization has received greater attention as part of agricultural transformation process in Ethiopian Agricultural Development Led Industrialization (ADLI) economic development policy, which trickles down in consecutive strategic plans such as Sustainable Development and Poverty Reduction, Plan for Accelerated and Sustained Development to End Poverty, Growth and Transformation Plan I and Growth and Transformation Plan II.

Output commercialization is a process that involves producing and marketing commodities demanded by the market. Thus, production of diversified commodities gradually declines while production of specialized commodity increases (Pingali and Rosegrant, 1995; Pingali, 1997). In the context of smallholder farmers, output commercialization indicates the extent to which crop production by smallholder farmers is market-oriented (Strasberg *et al.*, 1999). In other words, output commercialization differs by the level of cultivation of diversified crop species. In relative terms, cultivation of low mix of crop species is a market-oriented production whereas cultivation of multiple crop mixes is a consumption-oriented production (Pingali and Rosegrant, 1995; Pingali, 1997).

*Corresponding Author: lijalem99@yahoo.com

ISSN 1993-8195 (Online), ISSN 1992-0407(Print)

Output commercialization is often considered to be influenced by resource endowments, access to institutional services, and access to input and output markets (Pingali and Rosegrant, 1995; Key *et al.*, 2000; Pingali *et al.*, 2005; Adam Bekele and Dawit Alemu, 2015; Olwande *et al.*, 2015; Barrett *et al.*, 2017). Resource endowments are household's ownership and access to resources used for agricultural production. It comprises socio-demographic characteristics such as household head, age, education, family size, and labour. Physical resource endowments contain cultivated landholding size, livestock and access to irrigation. It has been argued that the ownership and size of the aforementioned resources influence the commercialization of the crop output (Pender and Dawit Alemu, 2007; Adam Bekele and Dawit Alemu, 2015;). Access to institutional services comprises access to credit and agricultural technology. Access to markets includes access to input and output markets, and transaction costs. The empirical evidence states that the factor and output markets situation and transaction cost affect crop output commercialization (Boughton *et al.*, 2007; Argea Alene *et al.*, 2008; Adam Bekele and Dawit Alemu, 2015).

The contribution of understanding the determinants of smallholders' crop output commercialization is three-fold. First, previous studies examined the factors affecting output commercialization on a specific commodity. Arega Alene *et al.* (2008), Mmbando *et al.* (2015), and Adem Kelifa *et al.* (2021) analyzed commercialization of smallholder farmers on maize and pigeon pea commodities. The exception is the work by Berhanu Gebremedhin and Moti Jaleta (2010); and Adam Bekele and Dawit Alemu (2015) who analyzed the determinants of crop commercialization, which comprises all crop types produced and marketed. However, the effects of landholding size, farmland fragmentation and crop diversification remain unexplored. As a result, this study focused on investigating the determinants of crop output commercialization incorporating landholding size, farmland fragmentation and crop diversity. Second, when analyzing the decision to commercialize the output, the previous studies used Tobit regression, which assumes normal distribution and corner zero observations. In this study, it was argued that output commercialization is an index with beta (0, 1) observations and Bernoulli distributions (zero observations). Therefore, zero-inflated beta regression is more appropriate to adequately address the beta and Bernoulli distributions. Third, smallholder farmers, in the study area, cultivate diversified crop types on fragmented farmlands to meet household food consumption and market demand. Cognizant of this fact, from a practical perspective, understanding smallholder farmers output commercialization can serve as the basis for policy making to transform subsistence farming system into market-oriented production system. Therefore, this study investigating determinants of crop output commercialization to fill knowledge gaps and guide appropriate polices for enhancing smallholder farmers outputs commercialization.

2. Methodology

2.1. Description of the Study Area

West Gojjam Zone in north western Ethiopia has been deliberately chosen. In the area, crop cultivation is overwhelmingly done by smallholder farmers who totally plough 682893 hectares of farmland, which produces 1988044.245 tons of grain (CSA, 2021). Crop production is the major livelihood strategy of smallholder farmers in this area. The smallholder farmers' individual landholding size, in the study area, ranges from 0.1 to 10 hectares and averages 0.928 hectares (CSA, 2014, 2021). The same source revealed that farmland fragmentation is high in the area. Smallholder farmers in the study area cultivate a variety of cereal crops including maize, teff (*Eragrostis teff*), wheat, barley, and finger millet; pulse and oil crops such as faba bean, field pea, lentil crops and a variety of vegetables and root crops (CSA, 2021).

Burie zuria woreda is located with an altitude range from 700 to 2350 masl. The population is 133307 of which, 66282 and 67025 are male and female, respectively (west Gojjam Zone plan commission). The population density is 138 persons per square kilometer. Temperature ranges from 17-25 degree Celsius and rainfall from 1000 to 1500 millimeter. Topography is 76% plain, 10% mountainous, 7% undulated topography and 7% valley. Land use 47% crop cultivation, 20.38% grazing land, 24.07% shrubs and forest land, 8.25% construction and 0.316% water bodies. Dembecha zuria woreda is located with an altitude range from 1,500 to 2,995 meters above sea level. The total population is 144993 of which 70748 and 74245 are male and female, respectively (west Gojjam zone plan commission). The population density is 133.08 persons per square kilometer. Topography 60% plain, 30% mountainous and 10% undulated topography.

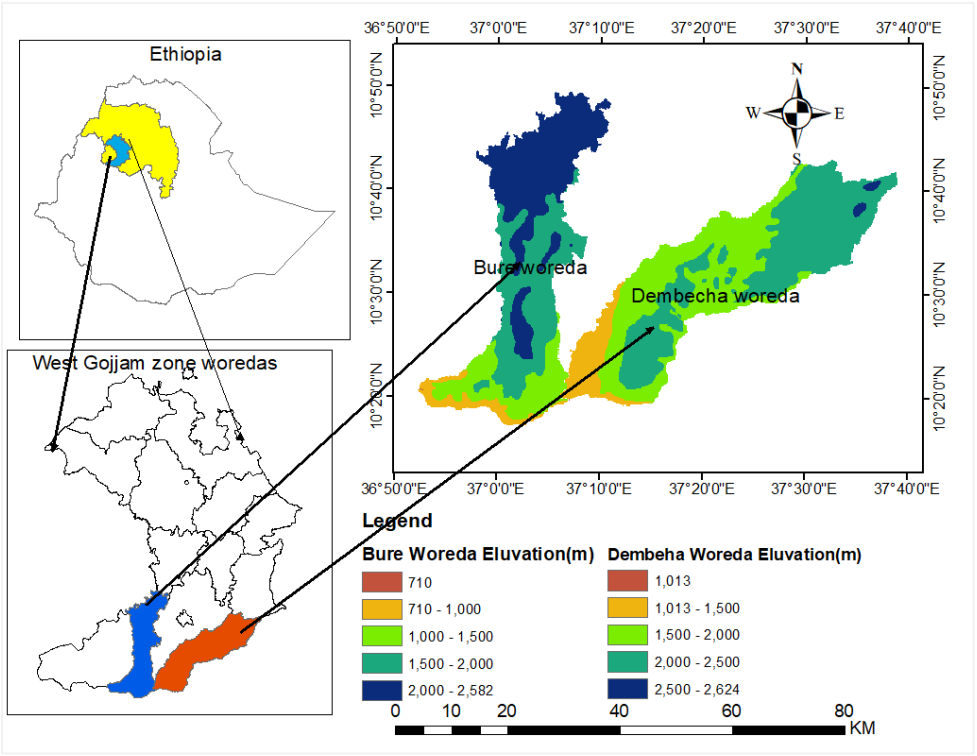

Figure 1. Geographical map of the study area (Source: Ethio-GIS, 2021).

2.2. Sampling Procedure and Data Collection Method

Quantitative and qualitative data were collected through a structured questionnaire interview, focus group discussions, and in-depth personal interviews. Proportion to size multi-stage probability sampling method was used to select sample respondents. In the first stage, Dembecha Zuria and Burie Zuria woredas were randomly selected by lottery method among the 14 woredas administered in west Gojjam Zone. In the second stage, kebeles in each woreda were clustered in to lowland, midland and highland based on agro-ecology and agriculture production capacity. A *kebele* is the smallest local administrative unit in Ethiopia. Then, four kebeles from Dembecha Zuria (such as Astevoch, Egziabhierab, Yesheboch and Gelila) and three kebeles (namely Zeyushewen, Wadera and Ambaye) from Burie Zuria woreda were randomly selected from the three agro-ecological zones. Finally, probability proportion to size sampling method was used to sample 385 respondents.

The total sample size was determined using Cochran sample size determination formula that provides the maximum size to ensure the desired precision, in the case of large population and unknown variability of smallholder farmers crop ouput market participation, in the study area.

$$n_0 = \frac{z^2 pq}{e^2} \quad (1)$$

Where, z is 1.96, p is the estimated proportion of the population who is commercialized (0.5) q= (1– p) = 0.5 and e is the precision level (0.05).

Qualitative data collection methods such as focus group discussion and individual in-depth interviews were used to understand output commercialization. In both cases, participants were purposively selected through discussions with agriculture experts and development agents. A checklist was prepared to guide the discussion. Totally, two focus group discussions and four in-depth interviews were conducted with eighteen and four farmers, respectively in each of the two woredas.

2.3. Methods of Data Analysis

Quantitative and qualitative methods of data analysis were used to analyse the data. For analysing the quantitative data, descriptive statistics and zero-inflated beta regression were used. For analysing the qualitative data, narrations were used.

2.3.1. Measuring commercialization of crop output

A large body of literature defines and measures smallholder output commercialization differently. First, commercialisation represents the ratio of the gross value of cash crops to the gross value of all crops (Govereh and Jayne, 1999; Dawit Alemu *et al.*, 2006). However, smallholder farmers do not have dichotomous decisions. They produce a mix of food and cash crops, and thus commodities traditionally considered as food crops are marketed (von Braun and Kennedy, 1994; Pender and Dawit Alemu, 2007). Second, net and absolute market positions (net seller, autarky and net buyer) are commonly computed as the difference between percentage of the volume of marketed crop outputs to the summation of the quantity of crop produced, and the percentage volume of crop purchased to the total volume of crop produced (Bellemare and Barrett, 2006; Dawit Alemu *et al.*, 2006). However, in the subsistence smallholder production system, purchasing crops for household consumption is non-existent (Pender and Dawit Alemu, 2007). Moreover, net and absolute market positions are ordered in nature (Bellemare and Barrett, 2006), and thus, clusters net sellers as one group while there are variations in their extent of output market participation. Also, net buyers as they sell cash crops and buy food crops for household consumption through the farmers are too subsistent in nature. Subsistent farmers may be unable to meet their annual food demand by their own production and are hence assisted by other entities. Third, smallholder farmers' decisions to market their produce involves selling of diversified agricultural outputs to meet household cash income demand to purchase non-produce commodities and improve household well-being (Carletto *et al.*, 2017). This conceptualization of output commercialization considers smallholder farmers diversified production system, which aims at meeting both food for household consumption and marketable surplus for cash income generation to buy non-produce commodities. Thus, the ratio of the value of crop marketed over the value of crop produced in a production year is a better proxy to measure the smallholder farmers output commercialization (von Braun and Kennedy, 1994; Strasberg *et al.*, 1999; Adam Bekele and Dawit Alemu, 2015). The annual crops produced by the farmers, in the study area and used for analysis were pepper, maize, teff, wheat, millet, barely, faba bean, chickpea, field pea, niger seed, potato, and onion. The index measures the extent to which a smallholder farmer's crop production is market oriented; and the value zero (0) means a household is purely subsistence and the value one (1) means highly commercialized.

$$\text{Output commercialization} = \frac{\text{Value of crop sales}}{\text{Value of crops produced}}$$

$$\text{Outputcomm}_i = \frac{\sum_{j=1}^{k} P_j S_{ij}}{\sum_{j}^{k} P_j C_{ij}} \quad (2)$$

Where, Outputcomm_i is the level of output commercialization of household 'i'; P_j is the average price of crop 'j'; S_{ij} is the amount sold by the household 'i' of crop 'j', where j ranges from 1 to k; and C_{ij} is the total volume of crop 'j' produced by household 'i'.

2.3.2. Application of zero-inflated beta regression

Smallholder farmers produce diverse crops, and market crops when they face liquidity constraints to purchase commodities for household consumption and inputs for agricultural production. Thus, output commercialization is an index which contains a continuous proportion of values between 0 and 1 with a probability at zero, which is continuous-discrete distribution (Pereira and Cribari-Neto, 2010). The continuous distribution is described by beta distribution while the discrete is defined by the Bernoulli distribution (Ospina and Ferrari, 2012). In view of this, the zero-inflated beta regression econometric model was employed. Zero-inflated beta regression is the probability and conditional mean density functions of the farmers' commercialization with respect to the measure generated by the mixture of beta and Bernoulli distribution (Pereira and Cribari-Neto, 2010; Ospina and Ferrari, 2012).

$$\text{bic}(y;\ \alpha, \mu, \phi) = \begin{cases} \alpha & \text{if } y = 0 \\ (1-\alpha)f(y;\mu,\phi) & \text{if } y\varepsilon(0,1) \end{cases} \quad (3)$$

Where, bic is zero inflated beta regression, y is farmers' output commercialization index: as the index is zero ($y = 0$), α is the probability of farmers' output commercialization index at zero. Otherwise, the household output commercialization index is between one and zero $y\varepsilon(0,1)$; the beta density of farmers output commercialization conditional mean (μ) and precision parameter ϕ are ($0< \mu < 1\ and\ \phi > 0$).

The mean of output commercialization and its variance are computed as:

$$E(y) = \alpha c + (1-\alpha)\mu \quad (4)$$

$$\text{var}(y) = (1-\alpha)\frac{\mu(1-\mu)}{\phi+1} + \alpha(1-\alpha)(c-\mu)^2 \quad (5)$$

$E(y)$ is the weighted average of the mean of the Bernoulli distribution at y =0 and beta distribution $B(\mu, \phi)$ with weights α and $(1-\alpha)$ and also $E(y/y\ \varepsilon\ (0,1)) = \mu$; $var\ (y/y\ \ \varepsilon\ (0,1) = \frac{\mu(1-\mu)}{\phi+1}\ \mu$ and ϕ are parameters of beta distribution

Zero-inflated beta regression functional form is the output commercialization index as conditional mean, the probability at zero and the precision parameter can be given as follows (Pereira and Cribari-Neto, 2010).

The probability of household output commercialization at zero function is:

$$h(\alpha) = \gamma_0 + \gamma_1 z_1 + \varepsilon \quad (6)$$

output commercialization conditional mean function

$$g(\mu) = \beta_0 + \beta_1 x_1 + \varepsilon \quad (7)$$

The precision parameter function is

$$b(\phi) = \lambda_0 + \lambda_1 s_1 + \varepsilon \quad (8)$$

Where, $h(\alpha)$ is the probability of household output commercialization at zero function; $g(\mu)$ is the smallholder farmers output commercialization conditional mean function; $b(\phi)$ is the households output commercialization precision parameter function. $\gamma_1, \beta_1\ \lambda_1$ are Vector of parameters to be estimated. $z_1\ x_1$, s_1 are Vector of covariate variables.

Equation (3) to equation (5) provides interesting features. The variance of output commercialization is a function of (α, μ, ϕ) and the consequence of the covariate values; hence non-constant response variances are naturally accommodated by the model (Ospina and Ferrari, 2012). The parameters and covariates play important role in the model. For example, while output commercialization index is zero $y = \alpha = 0$; $\gamma_1\ and\ z_1$ affect the Pr ($y = 0$), $\beta_1\ and\ x_1$ control $E(y/y\ \varepsilon\ (0,1))$ and $\lambda_1\ and\ s_1$ influence precision of the conditional distribution of output commercialization index, given that $y\ \varepsilon\ (0,1)$. Therefore, zero-inflated beta regression offers the effect of the heterogeneity among farmers who don't commercialize their output and those farmers who commercialize their output on probability and extent of output commercialization, respectively.

2.3.3. Hypothesized determinants of crop output commercialization

The review of previous studies uncovers variables hypothesized to affect smallholder farmers' output commercialization. Age of the household head, measuring the farmers' experience in farming, helps the farmer to understand and practice crop management practices and enhance production and productivity (Pender and Dawit Alemu, 2007), thereby increasing output commercialization. The educational status of the household head enhances decision-making ability in allocating resources for marketable commodities through analysing the cons and pros of adopting improved technologies and participating in the output market (Yigezu Atnafe *et al.*, 2018). The real-dependency ratio measures the non-working household members who are dependent on the productive household members' effort (Sharp, 2005). As the real-dependency ratio increases, the demand for domestic consumption increases, hence the farm households are expected to reduce output commercialization.

Smallholder farmers who have larger landholdings have the opportunity to increase crop production through adopting improved technologies and then, enhancing output commercialization (Adam Bekele and Dawit Alemu, 2015; Pender and Dawit Alemu, 2007). Farmland fragmentation is the parcel of spatially separated farmlands a household owns (Ntihinyurwa *et al.*, 2019). The physical fragmentation of farmland is the state of non-contiguous farmland parcels that are owned and tilled by the household. The fragmented farmlands and increased production costs may hinder smallholder farmers' output commercialization. In order to calculate smallholder farmers' per-capita farmland fragmentation, we used Simpson index. Simpson index takes in to account the number of parcels and the size of the parcel (Wu *et al.*, 2005).

Farmland rental contract is a practice of contracting other farmers' farmland either for sharecropping or/and by cash-rent agreement between the renter and the owner for a limited crop production season (Zeng *et al.*, 2018). The farmland rental may increase crop production and thereby enhance the commercialization of outputs. Livestock is a source of cash income to purchase inputs for crop production (Barrett *et al.*, 2001) and source of traction power to cultivate crops. Thus, livestock ownership is expected to increase farmers' output commercialization. Irrigation increases production of high value crops by enabling smallholder farmers to

practice double cropping. Thus, access to irrigation is expected to increase output commercialization. Moreover, cell phone ownership is used to market outputs thereby reducing transaction costs. Cell phones enable farmers to access market price information either from the broker or the trader. Thus, owning a cell phone may enhance output commercialization.

Transaction cost is a cost incurred in the process of commodity exchange taking place between the seller and the buyer. It reduces profit gains from the transaction (de Janvry *et al.*, 1991). Thus, it affects smallholder farmers' output market participation and quantity of output marketed (Arega Alene *et al.*, 2008; Key *et al.*, 2000). The cause for high transaction costs is the lack of physical and information communication infrastructure (Dillon and Barrett, 2017) and market information asymmetry (Arega Alene *et al.*, 2008). Transaction cost is measured using proxies like measuring the time taken to reach the nearest all-weather roads and market places, and ownership of communication apparatus. The lower the time taken to reach an all-weather road and a market place, the lower the transaction costs. This is expected to increase smallholder farmers' output commercialization.

A farmers' cooperative is a collective action for reducing transaction costs and increasing market access (Holloway *et al.*, 2000). A farmers' cooperative has strong internal institutions, functioning group activities, endowed with a good asset base and members' motivations to enhance access to output markets (Gyau *et al.*, 2014; Latynskiy and Berger, 2016). Though the degree of performances of cooperatives varies, farmers who are members of cooperatives are expected to reduce transaction costs to access input and output markets, thereby increasing their output commercialization. Smallholder farmers have informal contacts and networks with their relatives. The contacts and networks include sharing social and economic costs and benefits with each other and providing gifts and loans for crop production. Remittances affect farmers investment decisions (Rapoport and Docquier, 2005); thus, we expect that remittances are used for increasing purchase of agricultural inputs and enhancing marketing of agricultural outputs. Thus, remittances are likely to increase smallholder farmers' output commercialization.

Agro-ecology is the application of ecology in agriculture (Wezel *et al.*, 2009). Smallholder farmers cultivate diverse crop species is due to accessibility to diversified micro-climates and to cope with agro-climatic and market related risks (Ciaian *et al.*, 2018; Leavy and Poulton, 2007). Subsistence-oriented smallholder farmers diversify crop production for their subsistence needs and cope with production and market related risks while market-oriented smallholder farmers cultivate less diversified crop species for household consumption and market. Cognizant of this fact, crop diversification is a strategy to increase production of food crops and/or marketable crops. Thus, we expect that crop diversification might be for the purpose of either market or household consumption. Herfindahl-Hirschman Index (HHI) is used to calculate the diversity of crops cultivated by smallholder farmers by considering the number of crop species cultivated and the relative share of farmland size (Malik and Singh, 2002). When the value of the index is one (unity), it is considered a specialized crop production system but when the value approaches zero, it is considered a diversified crop production system.

Market orientation is the relative allocation of resources (land, labour and capital) for cultivation of agricultural produces for market (Berhanu Gebremedhin and Moti Jaleta, 2010). Market orientation is calculated as the smallholder farmland allocation to each type of crop cultivated, weighted by the marketability of each crop at a farm level, divided by the total area cultivated (Berhanu Gebremedhin and Moti Jaleta, 2010; Lijalem Abebaw *et al.*, 2021). When the value of the index approaches one the market orientation increases, and vice versa. The smallholder farmers' market orientation decision is based on analysing the cons and pros of output market. Thus, it would have a positive effect on output commercialization.

3. Results and Discussion

3.1. Smallholder Farmers' Characteristics

The analysis of output commercialization included annual crops, namely, pepper, maize, teff, wheat, millet, barely, faba bean, chickpea, field pea, niger seed, potato, and onion (Table 1). The Output Commercialization Index of farmers averaged 0.227, with a minimum of no participation at all and a maximum proportion value of marketed output of 0.987, showing that a significant number of smallholder farmers were entering a commercialized crop production system. Supporting this postulation, Neway Gebre-ab (2006) explains that, if the smallholder farmers output commercialization index is greater than 15%, they are getting in to a commercialized farming system. Among the sampled households, 90.3% were male-headed households. The average household head age was 47.5, the youngest household head age being 25 years and the oldest age being 83 years. On average,

heads of households completed grade 1.234 with a maximum of completing grade 12. The household real-dependency ratio was 0.449 with the maximum dependency ratio being 0.567. The sampled farmers' average livestock ownership was 4.004 TLU (Tropical Livestock Unit), and ranged from a minimum of not having to a maximum of 17.16 TLU. This shows that there is a diverse agricultural production system that includes livestock and crop production in the study area. The average landholding of the farmers included in the sample was 1.238 hectares, and ranged from a minimum of not possessing any land to cultivate to a maximum of possessing four hectares of land. The average fragmentation index was 0.563 with a minimum of having a consolidated farmland to a maximum fragmentation of 0.875. The smallholder farmers' average rented farmland was 0.511 hectares, which ranged from no rented farmland to a rented farmland of 4.5 hectares. About 25.4% of the sampled farmers accessed irrigation. The average distance from all-weather roads to the farmers' residence was 24.501 minutes ranging from zero to 180 minutes. The average residence distance from the main market was 94.707 minutes, with a minimum of zero to a maximum of 360 minutes. The table shows that 67.8% of the sampled farmers were members of farmers' co-operatives. Among the sampled farmers, 7.12% received remittance from their relatives and friends living abroad.

The survey results showed that 51% of the sampled farmers had access to credit. Among the sampled farmers, 86.2% accessed extension advisory services. The average Herfindahl-Hirschman crop diversity index of the sampled farmers was 0.320 with, indicating cultivation of a single crop (specialization). The average market orientation index of the sampled farmers was 0.151, with a maximum of 0.764.

Table1. Descriptive statistics.

Variable	Observation	Mean	SD	Min.	Max.
Output commercialization index	385	0.227	0.220	0	0.987
Socio-demographic					
Household head sex (1 male,0 otherwise)	385	0.903	0.296	0	1
Household head age (years)	385	47.532	12.380	25	83
Household head education (grade)	385	1.234	2.191	0	12
Real-dependency ratio	385	0.449	0.245	0	0.567
Resource endowments					
Livestock in TLU	385	4.004	2.667	0	17.16
Mobile owned (1 owned; 0 = otherwise)	385	0.669	0.471	0	1
Landholding size in hectares	385	1.238	0.815	0	4
Farmland fragmentation index	376	0.563	0.233	0	0.875
Farmland rental contract in hectares	385	0.511	0.709	0	4.5
Access to irrigation (1 if access; 0 otherwise)	385	0.254	0.436	0	1
Market access					
Residence distance from the all-weather road in minutes	385	24.501	26.744	0	180
Residence from distance from main market in minutes	385	94.707	192.420	0	360
Social capital					
Membership to cooperative (1 member; 0 otherwise)	385	0.678	0.468	0	1
Remittance (1 yes; 0 otherwise)	385	0.0712	0.258	0	1
Access to institution services					
Access to credit service (1 accessed; 0 otherwise)	385	0.510	0.5001	0	1
Access to extension service (1 accessed; 0 otherwise)	385	0.862	0.346	0	1
Herfindahl-Hirschman crop diversity index	380	0.320	0.163	0.142	1
Market orientation index	380	0.151	0.149	0	0.764

3.2. Determinants of Output Commercialization: Zero-inflated Beta Regression Estimation

Before estimating the Zero-inflated beta regression, diagnostic tests such as multicollinearity, endogeneity, heteroscedasticity, omitted variable test and model fitness tests were performed. The smallholder farmers' market orientation decision is based on analysing the cons and pros of output market. Accordingly, market orientation and output commercialization might have simultaneous endogeneity that constrains the parameter estimates of zero-inflated beta regression. However, the econometric estimate shows the association between market orientation and output commercialization is significant, which suggests simultaneous endogeneity is not a problem; rather market orientation is highly translated to output commercialization. The Breusch-pagan/Cook-Weisberg test shows that there was heteroscedasticity, which was alleviated through running robust regression. Variable Inflation Factor (VIF) test shows there was no multicollinearity between covariates. The omitted variable test shows that there is no omitted variable (P = 0.214). The link test, *_hatsq* was not statistically significant (P = 0.152), which reveals the model is correctly specified. In addition, the precision parameter estimates show that there is a significant variation in conditional distribution of output commercialization index at 0.01 significance level. From the total 18 hypothesized variables, five variables were found to significantly affect the extent of smallholder commercialization (proportion) and three variables affected the probability of output commercialization (Table 2).

Age of household head increased the proportion of output commercialization, but did not influence the probability of output commercialization. This could be because the age of the household head can help to acquire knowledge and skills about production practices and improved technology, which in turn may increase the marketed surplus. Previous studies have shown that older household heads commercializes their crops more than younger ones (Adam Bekele and Dawit Alemu, 2015; Samuel Gebreselassie and Laudi, 2007). As expected, household head educational status enhanced the proportion of output commercialization. Similarly, Berhanu Gebremedhin and Moti Jaleta (2010) found that the training of heads of households increased participation in output markets.

As expected, cell phone ownership increased farmers' likelihood to engage in output commercialization but not the proportion of output commercialization. This is due to the fact that market information is a quantity marketed invariant transaction cost, it does not affect the volume of marketed surplus (Arega Alene *et al.*, 2008; Key *et al.*, 2000). As hypothesized in this study, residence distance to all-weather road limits the likelihood of output commercialization. This is possibly because smallholder farmers' lack of access to all-weather road increases the transaction cost, which in turn, reduces the benefit gained, thereby discouraging them from participating in crop output marketing. Similarly, Alelign Ademe *et al.* (2017) and Abdu Wudad *et al.* (2021) found that lack of access to all-weather road hindered the supply of crop produces to the market.

Unlike the stated hypothesis formulated, however, landholding size reduced the proportion, but did not affect the probability of smallholder farmers' output commercialization. This is possibly because smallholder farmers are reluctant to purchase labour, chemical fertilizer, and seeds of improved crop varieties that are required for increased productivity and cultivation of their lands. The results generated from the focus group discussions and in-depth individual interviews revealed that households headed by elderly persons had larger landholdings than households headed by younger or junior persons. This is possibly because young households establish families inheriting smaller farm lands from their parents. On the other hand, establishing new families causes reduction in labour in households headed by elderly persons. Consequently, the households headed by elderly persons which have larger landholding are challenged by lack of household labour to cultivate their land. Also, smallholder farmers are reluctant to recruit wage labour (Wiggins *et al.*, 2011). The smallholder farmers do not afford to purchase large quantities of chemical fertilizer and seeds of improved crop varieties. Which implies less intensification of crop production, thereby reducing the quantity of marketed surplus. Similarly, farmers possessing smaller landholdings apply chemical fertilizer and intensive crop management practices than those possessing larger landholdings (Pender and Berhanu Gebremedhin, 2008). On the other hand, due to higher costs of inputs, smallholder farmers holding large farmlands are compelled to rented out and/or share out portions of their farmlands to the landless youths or farmers holding smaller farmlands. This suggests there are input market imperfections (Barrett *et al.*, 2010) that increase production costs, discouraging farmers from intensifying crop production, thereby negatively affecting output commercialization.

Farmland rental contracts increase the probability that smallholder farmers participate in the output market but do not affect the proportion of output commercialization. This is because landless youths or farmers holding less farmlands rent in and/or share in to produce crops to meet the subsistence market demand. The farmland fragmentation increased the household proportion of output commercialization significantly ($P < 0.05$), but did not affect the probability of output commercialization ($P > 0.1$).

The results generated from the focus group discussions and individual interviews indicated that a farmer who owns a large number of farmlands is more likely to access different types of agro-ecosystem functions such as physical environment, microclimate, and variations in soil fertility compared to farmers with less fragmented farmland. For instance, an interviewee stated that "we live on the top of the mountain, where pepper is not produced due to low temperature (cold) and reduced soil fertility; however, in the valleys below the mountain, it is warmer and the soil fertility status is higher, which enhances production of pepper, a warm-season crop. This suggests that farmland fragmentation enables the farmers to produce various types of crops types for markets. Similarly, farmland fragmentation enables the farmers to produce diverse high value crops (Di Falco *et al.*, 2010; Rehima Mussema *et al.*, 2015; Ciaian *et al.*, 2018).

Herfindahl-Hirschman crop diversity index reduces the proportion of output commercialization, suggesting that smallholder farmers cultivate diversified crop species to increase the extent of output commercialization; however, it does not affect the probability of output commercialization. Crop diversification is an important strategy for reducing vulnerability to production and market failure risks (Leavy and Poulton, 2007). For instance, perishable horticultural crops such as onion and potato were considered as marketable crops that are highly affected by market inefficiencies and seasonal market price fluctuations. Moreover, in the study area, the production is predominantly subsistence and traditional. So there is no system of technical, managerial, and structural organization for minimizing the perishability of a particular agricultural produces or to prolong shelf life shelf life (Pingali and Rosegrant, 1995). As a result, smallholder farmers are encouraged from diversifying their marketable outputs (Samuel Gebreselassie and Laudi, 2007). Smallholder farmers' market orientation was found to increase both the probability and proportion of output commercialization significantly ($P < 0.01$). This is because the household's farmland allocation for marketable crops is based on output market signal (Berhanu Gebremedhin and Moti Jaleta, 2010).

Table 2. Zero-inflated beta regression estimates of smallholder farmers' output commercialization.

Categories	Dependent	Output commercialization			
				Marginal effects (case of zero-inflate)	
	Explanatory variables	Proportion	Zero-inflate	Dydx	
Socio-demographic characteristics	Household head sex (1 male,0 otherwise)	–0.0451(0.204)	0.604(1.071)	0. 0111	
	Household head age (years)	0.00875**(0.00436)	–0.0532(0.0442)	–0. 0009	
	Household head education (grade)	0.0526**(0.0248)	–0.164(0.184)	–0. 003	
	Real-dependency ratio	–0.102(0.0793)	0.714(1.570)	0. 0131	
Resource endowment	Livestock in TLU	–0.0293(0.0249)	0.217(0.267)	0. 004	
	Mobile owned (1owned; 0 = otherwise)	0.00934(0.124)	–1.681**(0.837)	–0. 0309	
	Landholding size (hectare)	–0.131*(0.0756)	0.865(1.520)	0. 0159	
	Farmland fragmentation index	0.454**(0.213)	–0.541(2.063)	–0. 01	
	Farmland rental contract (hectare)	0.107(0.0723)	–3.095*(1.640)	–0. 057	
	Access to irrigation (1 if access; 0 otherwise)	0.169(0.106)	–0.530(1.166)	–0. 0098	
Market access	Residence distance from the all-weather road in minutes	0.00130(0.00153)	0.0254*(0.0134)	0. 0005	
	Residence from distance from main market minutes	–0.000347(0.00128)	0.000430(0.000759)	7.92e-06	
Social capital	Membership to cooperative (1member; 0 otherwise)	–0.0806(0.108)	0.171(0.908)	0.0031	
	Remittance (1 yes; 0 otherwise)	–0.241(0.225)	0.0656(1.213)	0.0012	
Access to institutional Services	Access to credit service (1 accessed; 0 otherwise)	0.0189(0.0960)	0.119(1.113)	–0.0022	
	Access to extension service (1 accessed; 0 otherwise)	0.0129(0.150)	-1.410(1.103)	–0.0259	
	Herfindahl-Hirschman crop diversity index	–1.093**(0.534)	1.892(2.334)	0.0348	
	Market orientation index	4.645***(0.478)	-6,762***(893.4)	–-124.41	
	Constant	–1.910***(0.400)	3.509(2.264)		1.811***(0.158)
	Observations	330	330	330	

Note: *Robust standard errors in parentheses, ***,** and * refer to statistical of significance at 1%, 5%, and 10% probability level.*

4. Conclusion and Policy Implications

The results of this study have demonstrated that the average output commercialization is about 22.7%. The results of this study have demonstrated that age of household heads, household head's educational status, farmland fragmentation, crop diversity and market orientation enhance smallholder farmers' proportion of output commercialization. However, the results revealed that landholding size reduces proportion of output commercialization. On the other hand, cell phone ownership and farmland rental contracts and market orientation increase the probability of output commercialization. However, distance of residence from all-weather roads limits the probability of output commercialization.

Our results help to elucidate pathways to enhance smallholder output commercialization. Output commercialization is affected by a number of factors such as socio-demographic, resource endowment and arrangements, transaction cost and access to institutions, and diversity of agro-ecological functions. Specifically, farmland fragmentation encourages smallholder farmers to commercialize their output. This is because it increases the access to different agro-ecological functions suitable to cultivate marketable crops. Crop diversification enhances smallholder farmers output

commercialization. This is because it is used as an important strategy to reduce market risks. Market risks are the outcome of lack post-harvest technologies and management systems that are important for managing seasonality of surplus production and fluctuation of market prices. Landholding size reduces output commercialization. This is because higher costs of inputs such as seeds of improved crop varieties, chemical fertilizer, and labor compel less intensification of crop production and then, reduce marketed surpluses. Therefore, creating access to technologies (seeds of improved crop varieties and post-harvest technologies), reducing costs of inputs, and enable managing the seasonality of crop output market prices could enhance smallholder farmers' output commercialization. Furthermore, future studies are important to broaden the existing knowledge on the commercialization of smallholder farmers crop outputs. Because, smallholder farmers crop types production and marketability vary in accordance with diversity in socioeconomic and agro-ecological factors. Therefore, there is a scope for further studies to understand the factors associated with smallholder farmers output commercialization in different socioeconomic and agro-ecological situations thereby gives full-fledged understanding of smallholder farmers crop output commercialization for policy makers and development practitioners.

5. Acknowledgements

The authors thank the Amhara Region Agricultural Research Institute and Addis Ababa University for funding the research. The authors also thank the smallholder farmers who volunteered to participate in the research as respondents and the enumerators for collecting the data.

6. References

Adam Bekele and Dawit Alemu. 2015. Farm-level determinants of output commercialization: In haricot bean based farming systems. *Ethiopian Journal of Agricultural Sciences*: 61–69.

Abdo Wudad, Sultan Naser and Latamo Lameso. 2021. The impact of improved road networks on marketing of vegetables and households' income in Dedo district, Oromia regional state, Ethiopia. *Heliyon*, https:// DOI: 10.1016/j.heliyon.2021.e08173.

Adem Kelifa, Amsalu Mitiku and Osman Rahmeta. 2021. Commercialization of smallholder farmer's maize producer in Bilo Nopa district of Ilu Aba Bor zone, Oromia region, Ethiopia: market orientation and market participation. *Ethiopian Journal of Applied Sciences and Technology,* 12(1): 18-31.

Aleleign Ademe, Belaineh Legesse, Jemma Haji and Degeye Goshu. 2017. Smallholder Farmers' crop commercilization in the highlands of eastern Ethiopia. *Review of Agricultural and Applied Economics*, 20(2): 30–37.

Arega Alene, Manyong, V.M., Omanya, G., Mignouna, H.D., Bokanga, M., et al. 2008. Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya. *Food Policy*, 33: 318–328.

Barrett, C.B., Bellemare, M.F. and Hou, J.Y. 2010. Reconsidering conventional explanations of the inverse productivity-size relationship. *World Development*, 38(1): 88–97.

Barrett, C.B., Mesfin Bezuneh and Aboud, A. 2001. Income diversification, poverty traps and policy shocks in Côte d'Ivoire and Kenya. *Food Policy*, 26: 367–384.

Barrett, C.B., Christian, P. and Bekele Shiferaw. 2017. The structural transformation of African agriculture and rural spaces: Introduction to a special section. *Agricultural Economics*, 48: 5–10.

Bellemare, F.M. and Barrett, B.C. 2006. An ordered tobit model of market participation: Evidence from Keneya and Ethiopia. *American Journal of Agricultural Economics*, 88(2): 324–337.

Berhanu Gebremedhin and Moti Jaleta. 2010. Commercialization of smallholders: Is market participation enough? *Paper presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th agricultural economists association of South Africa (AEASA) Conference, 19-23 September 2010, Cape Town, South Africa.*

Boughton, D., Mather, D., Barret, C., Benfica, R., Abdula, D., et al. 2007. Market participation by rural households in a low-income country: An asset based approach applied to Mozambique. *Faith and Economics*, 50: 64–101.

Carletto, C., Corral, P. and Guelfi, A. 2017. Agricultural commercialization and nutrition revisited: Empirical evidence from three African countries. *Food Policy*, 67: 106–118.

Ciaian, P., Guri, F., Rajcaniova, M., Drabik, D. and Paloma, S.G. 2018. Land fragmentation and production diversification: A case study from rural Albania. *Land Use Policy*, 76: 589–599.

CSA (Centrl Statistics Agenency). 2014. The Federal Democratic Republic of Ethiopia central statistical agency agricultural sample survey

2013/14. Report on area and production of major crops. Statistical Bulletin 532, Addis Ababa, Ethiopia.

CSA (Centrl Statistics Agenency). 2021. The Federal Democratic Republic of Ethiopia central statistical agency agricultural sample survey 2020/21. Report on area and production of major crops. Statistical Bulletin 590, Addis Ababa, Ethiopia.

Dawit Alemu, Eleni Gebre-Medhin and Samson Dejene. 2006. From farmer to market and market to farmer: Characterizing smallholder commercialization in Ethiopia. *Paper submitted to ESSP policy conference on "Bridging, balancing, and scaling up: Advancing the rural growth agenda in Ethiopia" 6-8 June 2006, Addis Ababa, Ethiopia.*

de Janvry, A., Fafchamps, M. and Sadoulet, E. 1991. Peasant household behaviour with missing markets: Some paradoxes explained. *The Economic Journal*, 101(409): 1400–1417.

Di Falco, S., Penov, I., Aleksiev, A. and van Rensburg, T.M. 2010. Agrobiodiversity, farm profits and land fragmentation: Evidence from Bulgaria. *Land Use Policy*, 27(3): 763–771.

Dillon, B. and Barrett, C.B. 2017. Agricultural factor markets in sub-Saharan Africa : An updated view with formal tests for market failure. *Food Policy*, 67: 64–77.

Govereh, J. and Jayne, T.S. 1999. Effects of cash crop production on food crop productivity in Zimbabwe: Synergies or Trade-offs? *MSU international development working paper No. 74, Department of Agricultural economics and Economics, Michigan State University, Michigan.*

Gyau, A., Franzel, S., Chiatoh, M., Nimino, G. and Owusu, K. 2014. Collective action to improve market access for smallholder producers of agroforestry products: Key lessons learned with insights from Cameroon's experience. *Current Opinion in Environmental Sustainability*, 6: 68–72.

Mmbando, F.E., Edilegnaw Z. Wale and Baiyegunhi, L.J.S. 2015. Determinants of smallholder farmers' participation in maize and pigeonpea markets in Tanzania. *Agrekon*, 54(1): 96–119.

Holloway, G., Nicholson, C., Delgado, C., Staal, S. and Ehui, S. 2000. Agroindustrialization through institutional innovation transaction costs, cooperatives and milk-market development in the east-African highlands. *Agricultural Economics*, 23: 279–288.

Key, N., Sadoulet, E. and de Janvry, A. 2000. Transactions costs and agricultural household supply response. *American Journal of Agricultural Economics*, 82: 245–259.

Latynskiy, E. and Berger, T. 2016. Networks of rural producer organizations in Uganda: What can be done to make them work better? *World Development*, 78: 572–586.

Leavy, J. and Poulton, C. 2007. Commercialisation in agriculture. *Ethiopian Journal of Economics*, XVI(1): 3–41.

Lijalem Abebaw, Worku Tuffa and Dawit Alemu. 2021. Determinants of smallholder farmers' market orientation for small-scale crop commercialization in west Gojjam zone, Amhara region, Ethiopia. *Ethiopian Journal of Economics*, XXX(1): 45–76.

Malik, D.P. and Singh, I.J. 2002. Crop diversification - an economic analysis. *Indian Journal of Agricultural Research*, 36(1):61–64.

Newai Gebre-Ab. 2006. Commercialization of smallholder agriculture in Ethiopia. *EDRI notes and paper Series No. 1, Ethiopian Development Research Institute, Addis Ababa, Ethiopia*

Ntihinyurwa, P.D., de Vries, W.T., Chigbu, U.E. and Dukwiyimpuhwe, P.A. 2019. The positive impacts of farm land fragmaentation in Rwanda. *Land Use Policy*, 81: 565–581.

Olwande, J., Smale, M., Mathenge, M. K., Place, F. and Mithöfer, D. 2015. Agricultural marketing by smallholders in Kenya: A comparison of maize, kale and dairy. *Food Policy*, 52: 22–32.

Ospina, R., and Ferrari, S.L.P. 2012. A general class of zero-or-one inflated beta regression models. *Computational Statistics and Data Analysis*, 56: 1609–1623.

Pender, J. and Dawit Alemu. 2007. Determinants of smallholder commercialization of food crops: Theory and evidence from Ethiopia. *IFPRI discussion papers 00745, International Food Policy Research Institute, Washington, USA.*

Pender, J. and Berhanu Gebremedhin. 2008. Determinants of agricultural and land management practices and impacts on crop production and household income in the highlands of Tigray, Ethiopia. *Journal of African Economies*, 17(3): 395–450.

Pereira, T.L. and Cribari-Neto, F. 2010. A test for correct model specification in inflated betarRegressions. http://www.ime.unicamp.br/sinape/sites/default/files/reset_beoi.pdf accessed on 25 November, 2021.

Pingali, P., Khwaja, Y. and Meijer, M. 2005. Commercializing small farms: Reducing transaction costs. *ESA Working Paper No. 05-08, Agriculture and Development Economics Division, Food and Agriculture Organization of the United Nations.*

Pingali, P.L. 1997. From subsistence to commercial

production systems: The transformation of Asian agriculture. *American Journal of Agricultural Economics*, 79: 628–634.

Pingali, P.L. and Rosegrant, M.W. 1995. Agricultural commercialization and diversification: Processes and policies. *Food Policy*, 20(3): 171–185.

Rapoport, H. and Docquier, F. 2005. The Economics of migrants' remittance. *IZA Discussion Paper Series No. 1531, Forschungsinstitut zur Zukunft der Arbeit Institute for the Study of Labor, Germany*.

Rehima Mussema, Belay Kassa, Dawit Alemu and Shahidur, R. 2015. Determinants of crop diversification in Ethiopia: Evidence from Oromia region. *Ethiopian Journal of Agricultural Sciences,* 25: 65–76.

Samuel Gebreselassie and Laudi, E. 2007. Agricultural commercialization in coffeee growing areas of Ethiopia. *Ethiopian Journal of Economics*, XVI(1): 89–118.

Sharp, K. 2005. *Squaring the 'Q's?* methodological refelections on a study of destitution in Ethiopia. *Q-squared working paper No. 7, Centre for International Studies, University of Toronto, Toronto.*

Strasberg, P.J., Jayne, T.S., Yamano, T., Nyoro, J., Karanja, D., et al. 1999. Effect of agricultural commercialization on food crop input use and productivity in Kenya. *MSU International Development Working Papers No. 71, Department of Agricultural Economics, Michigan State University, Michigan.*

von Braun, J. and Kennedy, E., editors. 1994. *Agricultural commercialization, economic development and nutrition*. The Johns Hopkins University Press, Baltimore and London.Pp.431

Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D., et al. 2009. Agroecology as a science, A movement and a practice: A Review. *Agronomy for Sustainable Development*, 29(4): 503–515.

Wiggins, S., Argwings-kodhek, G., Leavy, J. and Poulton, C. 2011. Small farm commercialisation in Africa: Reviewing the issues. Future Agriculture, Research Paper 023. https://assets.publishing.service.gov.uk/media/57a08ad1e5274a27b20007b3/Research_Paper23.pdf. Accessed on 25 November 2021.

Wu, Z., Liu, M. and Davis, J. 2005. Land consolidation and productivity in Chinese household crop production. *China Economic Review*, 16(1): 28–49.

Yigezu Atnafe, Mugera, A., El-Shater, T., Aw-Hassan, A., Piggin, C., et al. 2018. Enhancing adoption of agricultural technologies requiring high initial investment among smallholders. *Technological Forecasting and Social Change*, 134: 199–206.

Zeng, D., Alwang, J., Norton, G., Moti Jaleta, Bekele Shiferaw, et al. 2018. Land ownership and technology adoption revisited: Improved maize varieties in Ethiopia. *Land Use Policy*, 72: 270–279.