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Analysis of Factors Influencing the Commercialization of Tomato in Southern Ethiopia

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Abstract: This study aimed to identify the factors influencing the commercialization of tomato production among farmers in the Wolayita and Gamo zones of southern Ethiopia. The study utilized both primary and secondary data sources. Primary data were collected through a household survey using a structured questionnaire, employing multistage and purposive sampling techniques to select 160 tomato-producing households. Descriptive statistics and an econometric model were applied for data analysis. The descriptive statistics showed that the average commercialization of smallholder farmers in the study area was 67.7% indicating, that households were mainly producing for commercial purposes. The double hurdle model results indicated that the education level of the household head, family size, farming experience in tomato production, and frequency of extension contact were factors that significantly affected the market participation decision of tomato producers. On the other hand, the education level of the household head, frequency of extension contacts, and distance to the nearest market were factors that significantly affected the level of tomato commercialization. Therefore, policies aimed to improve the educational capacity of smallholder farmers through training, formal adult education programs, aimed at improving their knowledge and skills, improving infrastructural facilities, and providing frequent and effective extension services are recommended to improve the commercialization of tomato production.

Keywords: Commercialization, Double hurdle, Level of commercialization, Market-participation, Tomato.

Research Paper

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INTRODUCTION

Agriculture remains the primary source of employment, livelihood, and income for 50-90% of the people in developing countries. Small-scale farmers account for the vast majority of this percentage, comprising up to 70-95% of the farming population. Small-scale farmers are therefore a significant proportion of the population (IATP, 2024). Agriculture is the major contributor to Ethiopia's national economy. It is crucial to the country's food security, and it is the most significant contributor to overall economic growth and poverty reduction. Smallholder farming accounts for about 95% of agricultural production and 85% of overall employment (FAO, 2024).

Agricultural commercialization refers to the transition from subsistence farming to a market-oriented approach, where production decisions are driven by market signals and a significant portion of output is sold in the market (Abafita *et al*., 2016). Agricultural commercialization is the increase in the proportion of agricultural output sold in the market rather than used for home consumption (Olwade *et al*., 2015; Minot *et al*., 2022). Agricultural commercialization enhances farmers' welfare by providing them with a comparative advantage and boosting total factor productivity growth (Johnston *et al*., 1961). The commercialization of smallholder agriculture significantly enhances productivity, boosts incomes, expands employment opportunities, and reduces poverty (Carletto *et al*., 2017). Tipraqsa and Schreinemachers (2009) found that commercialized farmers have a higher standard of living than subsistence farmers. This is because commercialized smallholder farmers have implemented more advanced production strategies based on comparative advantage. As a result, higher production is attained through economies of scale, regular engagement, exposure to new ideas, increased learning by doing, and better incentives in the form of high income, all of which benefit smallholder farmers (Rabbi *et al*., 2019).

Ethiopia's potential for commercial agriculture is largely untapped like other African countries, and the current state of agriculture is a source of great concern, as the sector is dominated by poor smallholders who are often only engaged in subsistence agriculture, while the agribusiness sector is in its infancy (Bonaglia *et al*., 2007; Afework and Endrias, 2016). Subsistence agriculture is not an ideal approach for ensuring household food security and welfare (Pingali, 1997). Ethiopia should accomplish faster agricultural development through a sustainable commercialization path to alleviate poverty and promote total national development (Afework and Endrias, 2016). In the past 30 years, Ethiopian agricultural policy has shifted from emphasizing increased productivity to promoting the commercialization and diversification of high-value crops to enhance rural households' income and welfare (Minot *et al*., 2022).

Tomato is among the world's most widely consumed vegetable crops. It is a nutritionally balanced diet, making it crucial for food security and nutrition. Tomato is one of the most commonly grown crops in Ethiopia, particularly in its mid and lowland regions. Ethiopians consume a lot of tomato in their traditional cuisine, including soups, sauces, stews, and salads. In addition to being a source of food, it is a major cash crop for a substantial proportion of rural farming households, notably in the Rift Valley regions of the country, playing a vital role in household income creation, human nutrition, and health (Wiersinga and de Jager, 2009; Brasesco *et al*., 2019; FAOSTAT, 2020). Wolayita and Gamo zones are among the potential tomato production zones of the South Ethiopian Regional State. Diguna Fango is one of the districts in the Wolayita zone that produces tomatoes for both household consumption and commercial purposes. Besides, Mirab Abaya is one of the districts in the Gamo zone; that mainly cultivates tomatoes using irrigation, primarily for income generation (Gezahegn *et al*., 2022).

Despite the Ethiopian government's policy efforts to commercialize subsistence agriculture and the significant potential for tomato production, tomato commercialization remains low in Ethiopia, including in the study area. This is due to a lack of information on factors affecting commercialization and other related factors. There is a dearth of studies on the commercialization of tomato in Ethiopia and study areas in particular. To the best of the author's knowledge, no similar studies on the commercialization and level of commercialization of tomato producers have been conducted in the study areas. Besides, other studies on the commercialization of vegetable crops generally lack specific details about the commercialization of individual crop types (Example, studies by Guta *et al*., 2020; Banchamlak and Akalu, 2022; Asfaw *et al*., 2024). Recognizing the marketing behavior, determinants of market participation, and commercialization each party involved aids in designing and implementing appropriate technological, policy, and institutional strategies to ensure that all is well with the process of commercialization. Thus, this study was conducted to identify the factors affecting tomato market participation and the level of commercialization in the study area.

METHODOLOGY

2.1. Description of the Study Area

This study was conducted in the Digna Fango district of the Wolayita zone and the Mirab Abaya district of the Gamo zone, which are major Tomato-producing areas in the Southern Regional State of Ethiopia. Mirab Abaya Wereda is located 463 km south of Addis Ababa and 225 km south of Hawassa. The wereda's elevation ranges from 1,100 to 2,900 meters above sea level. It receives an average annual rainfall ranging between 800 and 1,600 mm, with temperatures typically ranging from 24°C to 30°C (Direslgne *et al*., 2016; Sitota *et al*., 2016). Duguna Fango Woreda is located 42 km east of the zonal city of Wolaita Sodo, 73 km southwest of Hawassa, and 300 km south of Addis Ababa. The woreda's elevation ranges from 1,289 to 2,445 meters above sea level. It receives an average annual rainfall between 1,400 mm and 2,800 mm. Daytime temperatures range from 24°C to 30°C, while nighttime temperatures vary between 16°C and 20°C throughout the year (Barana *et al*., 2020; Lidya *et al*., 2022).

2.2. Sources and Method of Data Collection

The study was conducted in the Gamo and Wolayita zones of the South Ethiopia Regional State. Both primary and secondary data sources were utilized to ensure a comprehensive analysis. Primary data were collected through a structured questionnaire administered to randomly selected tomato-producing households. The questionnaire was pre-tested and refined based on feedback to enhance its validity and reliability. Data collection was carried out by experienced enumerators who underwent training to ensure high-quality data gathering. The survey was conducted from March to June 2019. Secondary data were obtained from diverse sources, including reports from the Office of Agriculture and Rural Development, publications by international research institutions, and various online resources. Together, these data sources provided a robust foundation for the study's findings and recommendations.

2.3. Sampling Procedure and Sample Size

The study employed a multistage random sampling technique to select the study locations of tomato-producing households. In the first stage, the Wolayita and Gamo zones of the southern region were purposively selected based on their potential for tomato production. Second, Mirab Abaya district of the Gamo and Digna Fango districts of the Wolayita zone were selected due to their significant potential for tomato production. Third, two tomato-producing kebeles from each district, Bilate Chericho and Bilate Eta kebeles of

Diguna Fango district and Kola Muleta and Yayke kebeles of Mirab Abaya district, were randomly selected. Lastly, respondents were selected through a random lottery method from a list of tomato producer farmers, using the data provided by the district and kebele agricultural offices. The selection of farmers from each kebele was carried out using probability proportional to the population size in each kebele. A total of 160 respondents were selected, following Yamane's (1967) formula.

$$\boldsymbol{n = \frac{N}{1+N(e)^2} = \frac{2100}{1+2100(0.076)^2} \approx 160}$$

Where:

- *n* is the sample size,
- *e* is the precision level (7.6%), and
- *N* is the total population of tomato producers in the targeted kebeles within the selected districts (N = 2100).

2.4. Method of Data Analysis

The collected data were analyzed using a combination of descriptive and econometric methods. Descriptive analysis involves calculating means, frequencies, and percentages to summarize the data. To assess relationships between variables, a chi-square test was applied for categorical variables, while a t-test was used to evaluate mean differences in continuous variables.

For econometric analysis, the Double Hurdle model was employed to examine two key aspects: the market participation decisions of tomato producers and the extent of their commercialization. This approach allowed for a comprehensive understanding of the factors influencing both the decision to participate in the market and the level of engagement in tomato commercialization.

2.4.1. Model Specification

Crop commercialization indicates the degree of participation of smallholder farmers in the output market as a seller Kabiti *et al*., (2016). As a result, the measurement of smallholder farmers' tomato commercialization tells us to what extent a given smallholder farmer is commercialized. Following the work of Von-Braun (1994), Pingali and Rosegrant (1995), and Govereh, *et al*., (1999) the tomato commercialization index at the household level was calculated using the output commercialization formula.

$$\text{Tomato commercialization index} = \frac{\text{Total value of tomato sales}}{\text{Total value of tomato produced}}$$

A commercial index value of zero indicates no commercialization of tomato, whereas a value closer to one indicates a higher degree of tomato commercialization.

Different limited dependent variable models, such as the double-hurdle model, Heckman two-stage model, and Tobit model, are often used to examine crop market participation and the intensity of that participation. However, the choice of model primarily depends on the study's objective and the characteristics of the data. In our case, the dependent variable is the tomato Crop Commercialization Index, which ranges from 0 to 1. The Heckman two-stage model is typically used to correct for sample selection bias in situations where the dependent variable is only observed for a subset of the population due to a selection process (e.g., when sales data is only available for households that participate in market). In such cases, zeros in the data often indicate unobserved outcomes rather than actual values. However, in our dataset, the zero values represent genuine observations of households with zero commercialization index or no sales. Thus, the Heckman model, which assumes the zeros are due to selection bias and attempts to "correct" them, would lead to biased estimates.

Given that the zeros in our data reflect actual outcomes rather than missing values, the Heckman two-stage model is inappropriate. Instead, the Tobit and Double Hurdle models were compared using a model specification test as outlined by Komarek (2010). This comparison helped determine the most appropriate model for analyzing the factors influencing market participation and the intensity of engagement in tomato commercialization. Based on the results, as discussed in the findings section, the double-hurdle model is more suitable for this dataset than the Tobit model.

Humphreys (2013) stated that the standard likelihood ratio test can be used to test the double-hurdle model against the Tobit model because the Tobit model is nested in the double-hurdle model. In other words, the Tobit model can be derived from the Double Hurdle model by restricting the parameters of the probit model to be equal to those of the truncated regression.

If LLprobit is the log-likelihood of probit model, LLtruncreg is the log-likelihood of truncated regressions and LLtobit is the log-likelihood value of Tobit model. Then, the likelihood ratio test (LR) can be carried out as follows:

$$LR = -2 * (\text{ LLprobit } + \text{ LLtruncreg } - \text{ LLtobit }) \quad 1$$

The test statistic follows a χ^2 distribution with degrees of freedom equal to the number of parameters included in the regression (Tobit = truncated = Probit), plus the intercept. Under the null hypothesis, it is assumed that the Tobit model is a better fit than the double-hurdle model. Conversely, rejecting the null hypothesis indicates that the double-hurdle model is an appropriate model for the data.

According to Moffatt (2005), the equations for the double hurdle can be written as:

The first hurdle in the decision to participate in the tomato market is described by Equation 2:

$$d_i^* = X_{1i}\beta_1 + u_i, u_i \sim N\ (1, 0) \quad 2$$

$d_i = 1$ if $d_i^* > 0$
$d_i = 0$ if $d_i^* \leq 0$
The second hurdle, which represents level of commercialization, is modeled as a truncated regression as follows (Equation 3):
$y_i^* = X_{2i}\beta_2 + v_i,\ v_i \sim N(0, \sigma^2)$ 3
$y_i = y_i^*$ if $y_i^* > 0$, or di = 1; $y_i = 0$ if $y_i^* \leq 0$,

Where; i represent the i[th] household head; X_{1i} and X_{2i} are vectors of explanatory variables; d_i^* is the latent or unobserved market participation decision; β_1 and β_2 are the corresponding vectors of parameters to be estimated; y_i is the observed amount of commercialization in the market; and y_i^* is the latent or unobserved amount of commercialization to the market; and u_i and v_i are uncorrelated normally distributed error terms for both decisions, respectively.

According to Humphreys (2013), the Cragg hurdle assumes no correlation between u_i and v_i ($\sigma_{12} = 0$) is estimated by the following likelihood function as follows (Equation 4):
$L = \prod_0 \left[1 - \Phi\left(\frac{x_{1i}\beta_1}{\sigma_1}\right)\right] \prod_1 \Phi\left[\frac{x_{1i}\beta_1}{\sigma_1}\right] \frac{1}{\sigma_2} \phi\left(\frac{y_i - x_{2i}\beta_2}{\sigma_2}\right)$ 4

The likelihood of the probit model and the truncated regression model under the assumption of independent error terms is the likelihood of the Cragg hurdle model. In this case, the first two terms on the left-hand side are the probit model for market participation and the third term is a truncated regression model.

2.5. Definition of Variables and Hypothesis

2.5.1. Dependent Variables

Market Participation (MP)

Is a dummy variable indicating the household's participation in the tomato market, which is regressed in the first step of the two-step estimation procedure. This variable takes a value of one if the household participates in the tomato market and a value of zero if the household does not participate in the tomato market during the production season.

Commercialization Index of Households

It is a continuous variable used in the second step of the two-step estimation procedure. It is measured in the commercialization index and represents the actual level of commercialization of tomato marketed by farm households during the production season.

2.5.2. Independent Variables

Explanatory includes demographic, socio-economic, and institutional factors affecting the tomato commercialization and level of commercialization. Table 1 presents a list of explanatory variables expected to affect market participation and the level of commercialization of tomato producers, and the hypothesized direction of association with the dependent variables. They were hypothesized based on reviewed literature and economic theory.

Table 1: Variables and Hypothesis

Variables	Units of measurement	Expected effect
Dependent variables		
Market Participation (MP)	Dummy (1, who participates in tomato market, 0, otherwise)	
Tomato commercialization of households	Index of continuous variable (1, higher level of tomato commercialization, 0, implies no commercialization)	
Independent variables		
Age of household head	Years	+
Education level	Years of schooling	+
Family size	Number	-
Experience in tomato production	Years	+
Frequency of extension contact	Number	+
Access to training on vegetable production	Dummy (1 yes, 0, otherwise)	+
Access to credit services	Dummy (1 yes, 0, otherwise)	+
Distance to the nearest market	Kilometer (km)	-
Distance to all weather road	Kilometer (km)	-

RESULTS AND DISCUSSIONS

This chapter is divided into two main sections. The first section discusses the results of the demographic, socioeconomic, and institutional characteristics of households. The second section discusses the econometric model results.

3.1. Descriptive Statistics

Age of the Household Head

The heads of the households ranged in age from 20 to 64 years, with an average age of 40 years. The average age of household heads in terms of tomato market participation was 45 years for non-market participants and 39 years for market participants. The results of the t-test indicate there was a statistically significant difference at the 1% level of significance in the average age of household heads between tomato

market participants and non-participant groups (Table 2 and Appendix).

Education Level (Years of Schooling)

Household heads' average educational attainment was 6.63 years, with a minimum of 0 and a maximum of 12 years of education; for those who participated in the tomato market, their average educational attainment was 7.48 years, while for those who did not, it was 3.5 years; the t-test result showed that the average educational attainment of household heads was statistically significant at the 1% level between those who participated in the tomato market and those who did not (Table 2 and Appendix).

Family Size

The average household size was 5 household members, with a minimum of one and a maximum of 10 household members. The average family size for families with market participants was 5, whereas the average family size for non-market participant households was 7. When comparing the average family size of household heads between tomato market participants and non-participants, the t-test showed a statistically significant difference at the 1% level (Table 2 and Appendix).

Experience in Tomato Production (Years)

Household heads' average experience in tomato production ranged from 0 to 15 years, with an average of 4.89 years. The average household head's experience in tomato production as a market participant was 5.53 years, whereas the average for non-market participants was 2.5 years. The t-test revealed a statistically significant difference at the 1% level in the average experience in tomato production between tomato market participants and non-participants (see Table 2 and Appendix).

Frequency of Extension Contact

Households had an average of 2.32 extension visits per year, with a minimum of 0 and a maximum of 5 visits. The average frequency of extension contact of households was 2.64 visits for market participants and 1.12 visits for non-market participants. The two-tailed t-test shows that there was a difference in frequency of extension contact across the market participants and non-participants and significant at a 1% significance level (Table 2 and Appendix).

Distance to the Nearest Market

Households' average distance to the nearest market was 1.23 kilometers, with a minimum of 0 and a maximum of 3 kilometers. When it came to tomato market involvement, market participants' average distance to the nearest market was 1.12 kilometers, while non-market participants were 1.64 kilometers. The t-test revealed that Participants in the tomato market and those who did not showed a statistically significant difference in the average distance to the nearest market at the 1% level (Table 2 and Appendix).

Distance to All Weather Road

Households' average distance to an all-weather road was 1.06 kilometers, with a minimum of 0.1 and a maximum of 4 kilometers. Participants in the tomato market traveled an average of 1.03 kilometers to an all-weather road, whereas non-participants traveled 1.2 kilometers. The t-test result revealed that there was no statistically significant difference in the average distance to an all-weather road between tomato market participants and non-participants (Table 2 and Appendix).

Table 2: Summary of continuous variables

Variables	Mean		Overall	t-stat.
	Market participants	Non-market participant		
Age of household head	38.58	44.76	39.89	3.47***
Education	7.48	3.5	6.63	-5.91***
Family size	4.82	6.88	5.26	5.37***
Experience in tomato farming	5.53	2.5	4.89	-4.45***
Frequency of extension contact	2.64	1.12	2.32	-5.74***
Distance to nearest market(km)	1.12	1.64	1.23	3.13***
Distance to all-weather road(km)	1.03	1.20	1.06	0.75

Note: *** p< 0.01, ** p< 0.05, * p< 0.1

Source*: Own computation using survey data, 2019.*

Access to Training

Table 3 indicates that 74.38% of households had access to tomato production, while 25.63% did not. Of those who participated in the market, 75.4% had access to training, while 24.6% did not. On the other hand, among the non-market participants, 70.59% had access to training, and 29.41% had no access to training. The chi-square test result was statistically insignificant, indicating there was no variation in access to training between market participants and non-participants.

Access to Credit Services

As shown in Table 3, 77.5% of households had no access to credit, whilst 22.5% of households had access to credit services. Of the market participants, 74.6% had no access to credit, whereas 25.4% had access to credit services. On the other hand, 88.24% of the non-

market participants had no access to credit services, while 11.76% had access to credit services. The chi-square test result was statistically significant at a 10% level of significance, indicating there was variation between market participants and non-participants by access to credit services.

Table 3: Summary of dummy variables

Variables	Category	Market participants (%)	Non-market participant (%)	Overall (%)	χ^2-stat.
Access to training	Yes	75.40	70.59	74.38	0.32
	No	24.60	29.41	25.63	
Access to credit services	Yes	25.40	11.76	22.50	2.85*
	No	74.60	88.24	77.50	

Note*: *** p< 0.01, ** p< 0.05, * p< 0.1*
Source*: Own computation using survey data, 2019.*

Level of Commercialization of Tomato

The level of commercialization was used to categorize farmers into subsistence, semi-commercialized, and commercialized farmers. According to Pingali (1997), Goitom (2009), and Musah et al. (2014), farmers were classified into three levels based on their commercialization index scores: subsistence ((0, 0.25]), semi-commercialized ((0.25, 0.5]), and commercialized (>0.5). The results revealed that the mean tomato commercialization index was 0.677 with a minimum of 0.005(subsistence) and a maximum of 1 (commercialized). Additionally, the mean tomato commercialization index of subsistence, semi-commercialized, and commercialized farmers were 0.014, 0.5, and 0.997, respectively. Moreover, the result of this study indicated that 31.75%, 1.59%, and 66.67% of farmers were subsistence, semi-commercialized, and commercialized, respectively. Therefore, the majority of the farmers fall in the commercialized category of tomato producers. This implies that the majority of farmers produce tomatoes for commercial purposes (Table 4).

Table 4: Summary of the level of tomato commercialization

Level of commercialization	Minimum	Maximum	Mean	Standard deviation	Number (%)
Subsistence	0.005	0.1	0.014	0.019	40(31.75)
Semi-commercialized	0.5	0.5	0.5	0	2(1.59)
Commercialized	0.9	1	0.997	0.016	84(66.67)
Total	0.005	1	0.677	0.459	126(100)

Source*: Own computation using survey data, 2019.*

3.2. Econometric Results

The Tobit model specification is compared with the double-hurdle model as stated in the study methodology of model specification. The test statistic for the log-likelihood ratio test of tomato commercialization is (LR = 26.415) which exceeds the critical χ^2 value of 23.209 at 1% level of statistical significance and 10 degrees of freedom. This reveals that the double-hurdle model is appropriate against Tobit. Thus, the Cragg hurdle (double hurdle) model fits the dataset.

3.2.1. Determinants of Tomato Market Participation

The results for the determinants of market participation are estimated using the probit model, and the first step of the double hurdle is displayed in Table 5. The likelihood ratio chi-square (LR chi-square) value of the probit model is 87.77 is statistically significant at 1% significance, indicating that the independent variables explain the dependent variable or the coefficients of explanatory variables were different from zero. Out of the nine explanatory variables included in the model, four variables were found to significantly influence the probability of participation in the tomato market in the study area (Table 5).

Education Level

The education level of the household head positively affected the likelihood of tomato market participation and was significant at 5 % level of significance (Table 5). The marginal effect shows that a one-year increase in the education level of household heads increases the probability of tomato producers' market participation by 1.1%, all other factors held constant. This is because education enhances farmers' ability to access information and opportunities from various markets. Consequently, a more educated farmer better understands market demands in terms of the quantity, quality, and price of tomato, thereby increasing their likelihood of market participation (Table 5). This finding agreed with the results of Bahilu *et al*., (2020), Abduselam, (2021), Dagmawe *et al*., (2022), Nigus and Tsegaye, (2022) who found that the education level of the household head has a positive effect on farmers' participation decision in the tomato, potato, date and Avocado producers output market.

Family Size

Family size had negatively affected the likelihood of tomato market participation and was significant at 1% level of significance (Table 5). The marginal effect shows that an additional member increase in family size in the family decreased the

probability of tomato producers' market participation by 4.3%, while all other factors held constant. This implies households with many children tend to consume their tomato production rather than sell to the market, as they do not produce an excess beyond their consumption needs. Consequently, their participation in the tomato market is very low. This result is in agreement with the findings of Guta *et al*., (2020), Nigus and Tsegaye, (2022) who found that family size has a negative effect on the farmers' participation decisions in the vegetable and avocado producers' output market.

Experience in Tomato Production

Experience in tomato production had positively affected the likelihood of tomato market participation and was significant at 1% level of significance (Table 5). The marginal effect shows that an additional year increase in tomato production experience increased the probability of tomato producers' market participation by 1.7%, with all other factors held constant. This implies that farmers with more experience in tomato production have greater awareness and knowledge regarding the production and marketing of tomatoes compared to non-producer farmers. Consequently, they are more likely to participate in the tomato market. This result is in consistent with Tesfaye (2021), who found that farming experience has a positive effect on the farmers' participation decisions in the onion market. Ibrahim *et al*., (2021) also found that cabbage farming experiences have positively affected the farmers' participation decisions in the cabbage market.

Frequency of Extension Contact

The frequency of extension contact had positively affected the likelihood of tomato market participation and was significant at 1% level of significance (Table 5). The marginal effect shows that an additional an addition day increase in extension visits increased the probability of tomato producers' market participation by 5%, while all other factors held constant. This is because extension agents provide farmers with guidance on modern tomato production techniques, information on market availability, and updates on new tomato varieties that boost productivity. Consequently, this support increases the likelihood of higher tomato production and greater participation in the tomato market. The finding agrees with Kassa *et al*., (2020), Banchamlak and Akalu (2022) found that the frequency of extension contact has positively affected the farmers' participation decisions in the banana and vegetable markets.

3.3. Factors Affecting the Level of Tomato Commercialization

To determine the factors influencing the level of tomato market commercialization, a truncated model was estimated in the second step of the double-hurdle model equation. The Wald chi-square value of the truncated regression model is 41.68 and statistically significant at less than 1% level indicating that explanatory variable(s) in the model explain the level of commercialization of tomato. Education, frequency of extension services, and distance to the nearest market were found to have a significant influence on the level of market participation in the tomato market (Table 5).

Education Level

The education level of household heads positively affected tomato producers' level of commercialization and was significant at the 1% significance level (Table 5). The result of the marginal effect revealed that a one-year increase in the level of education of the household head increased the level of commercialization in the tomato market by 5%, all other factors held constant. This implies that as the household head's education level increases, so does their capacity to analyze and plan profitable farming business models. With higher education, they are likely to have better critical thinking skills, greater access to relevant information, and an improved understanding of advanced agricultural techniques. This enhanced knowledge allows them to make more informed decisions, optimize resource use, and implement innovative practices, all of which contribute to increased profitability in farming operations. The result of this study agrees with Addisu (2018), Agerie *et al*., (2020), Asfaw *et al*., (2024), who found that the level of formal education increased the level of commercialization of teff, maize, and vegetables.

Frequency Extension Contact

The frequency of extension contact had positively affected the level of tomato commercialization and was significant at 1% level of significance (Table 5). The marginal effect shows that an additional day of extended visits by extension workers increased the level of tomato producer participation in commercialization by 14.5%, all other factors held constant. This implies extension services can enhance knowledge and awareness in farming households, leading to increased production and productivity. These extension services also encourage active market participation and the commercialization of tomato farming. This result is in line with the findings of Gezahegn *et al*., (2022) who found that extension services positively and significantly increased tomato and onion volume of sales in the market.

Distance to Nearest Market (km)

Distance to the nearest market had negatively affected the level of tomato market commercialization and was significant at 5% level of significance (Table 5). The marginal effect shows that an additional kilometer increase in distance for the household decreases the level of tomato producers' market commercialization by 9.1%, with all other factors held constant. This implies that households located at greater distances from the market center are less likely to participate in the market. Households who live near markets tend to achieve higher levels of tomato commercialization compared to those

farther away. This implies proximity to markets provides better access to market information and reduces transportation costs, both of which contribute to higher commercialization levels. This result is consistent with the findings of Efa *et al*., (2016), Birara *et al*., (2020) reported that an increase in market distance has a negative effect on the commercialization of teff and wheat producers.

Table 5: Regression result for double hurdle model of tomato commercialization

	1st hurdle estimation			2nd hurdle estimation		
Variables	Coef.	Std. Err.	Marginal effect	Coef.	Std. Err.	Marginal effect
Age of household head	0.038	0.026	0.004	0.003	0.008	0.002
Education level(years)	0.12**	0.048	0.011	0.074***	0.02	0.050
Family size	-0.452***	0.125	-0.043	-0.002	0.032	-0.001
Experience in tomato production	0.182***	0.051	0.017	0.006	0.014	0.004
Frequency of extension contact	0.53***	0.155	0.050	0.217***	0.042	0.145
Access to training	0.514	0.402	0.061	0.133	0.117	0.086
Access to credit services	0.501	0.434	0.038	0.013	0.114	0.009
Distance to the nearest market	-0.293	0.206	-0.028	-0.136**	0.063	-0.091
Distance to all weather road	-0.085	0.13	-0.008	-0.024	0.042	-0.016
Constant	-0.394	1.013		-0.701	0.415	
No. of Obs.	160			126		
LR /Wald chi2(9)	87.77			41.68		
Prob > chi2	0.000			0.000		
Pseudo R2	0.530					
Log-likelihood	-38.875			-33.788		

Note: *** p < 0.01, ** p < 0.05, * p < 0.1
Source: Own computation using survey data, 2019.

Appendix

Appendix Table 1: Summary of continuous variables

Variables	Obs.	Mean	Std. Dev.	Minimum	Maximum
Age of household head	160	39.894	9.545	20	64
Education level	160	6.631	3.834	0	12
Family size	160	5.256	2.155	1	10
Experience on tomato production	160	4.888	3.732	0	15
Frequency of extension contact	160	2.319	1.506	0	5
Distance to the nearest market	160	1.233	0.874	0	3
Distance to all weather road	160	1.063	1.228	0.1	4

CONCLUSION AND POLICY IMPLICATIONS

This study examines the determinants of tomato commercialization and the level of commercialization among smallholder farmers in Ethiopia, focusing on the Wolayita and Gamo zones in the Southern Region. Both descriptive statistics and the double-hurdle econometric model were employed to analyze household characteristics and identify factors influencing market participation and commercialization levels. The result indicated the average commercialization of tomato producer smallholder farmers was 67.7% indicating that these households were mainly producing for market sale.

The econometric model results indicated that the educational level of the household head, farming experience in tomato production, and frequency of extension services had a positive impact on the likelihood of tomato market participation, whereas family size had a negative impact on the likelihood of tomato market participation. Moreover, the educational level of the household head and frequency of extension contact positively affected the level of tomato commercialization. On the contrary, the distance to the nearest market negatively influenced the level of tomato commercialization.

Recognizing these factors and their extent is essential for policymaking aimed at improving market participation and the commercialization levels of farm households. Based on the results of this study, the following policy implications are forwarded. Government and other concerned bodies should enhance the educational capacity of smallholder farmers through consecutive training sessions and formal adult education programs, aimed at improving their knowledge and skills. Additionally, extension services should be provided frequently to support farmers in adopting better production methods. To mitigate the negative impact of distance from markets in tomato commercialization, investments in essential facilities are crucial. This

includes enhancing market access, infrastructure, roads, and transportation services. Thereby empowering farmers and significantly improving the commercialization process.

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