The impact of off-farm activities on rural households’ food security status in Western Ethiopia: The case of Dibatie district

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Abstract: This paper was analyzed the impact of off-farm activities on food security status of rural households in the Dibatie district of the Bebishangul Gumuz region. The study was used in a simple random sampling technique to select respondent households with proportionate sample size based on the number of households exist in sampled kebele administrations. The primary data were collected using a structured questionnaire and key informants’ interview. Both descriptive statistics and econometric model (an endogenous switching probit) were used to analyze this data at household levels. This model accounts for selection bias resulting from unobserved factors that potentially affect both household's participation and food security outcomes and also the model shows the counterfactual case of food security outcomes. Food security index is used to measure the food security status of sample households based on average kCal/day/adult equivalent. The result of this study revealed that about 59.4% of the households were food secure and 40.6% of households were food insecure. And also, about 55.4% of the households were off-farm participants and 44.6% of households were off-farm non-participants. Moreover, computing switch_probit command, the impacts of participant household have higher probability of food security status as compared with the counterfactual case of non-participants. In addition, the model result shows that variables such as

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PUBLIC INTEREST STATEMENT
In Ethiopia, agriculture is the major economic sector in which the country depends for its economic development. Because the country use agriculture led industry policy. However, agriculture is still largely traditional and subsistence type and through this it is difficult to assure food security and reduce poverty easily because of inadequate use of modern technologies in agricultural sector, high rate of population growth and the corresponding farm size reduction. As a result, the country has faced serious challenges in rural areas in terms of instability of income and food insecurity problems. Therefore, households need to cope up with the difficulties of agriculture production by diversifying their income into off-farm activities that can contribute to better food security status of rural households. So, examine the impact of farm household participation in off-farm activities on their food security status.
household size, distance to the nearest market, age of household head, education level of household head, special skill, utilization of formal credit, access to electricity and frequency of extension contact were found to have a significant influence on off-farm participation. Finally, the study suggesting that the interventions designed to promote farmers participating in off-farm activities that are made to increase food security status at the household level in the study area. This is because there could be increased productivity effects in this off-farm economy, better agricultural linkages and indeed, stronger structural transformation of the rural economy.

**Subjects:** Development Studies; Sustainable Development; Rural Development; Economics and Development

**Keywords:** switch_probit; endogenous switching model; treatment effect; off-farm; food security; Ethiopia

1. Introduction

In Ethiopia, agriculture is the dominant of economic activity. More than 85% of the labour force is engaged in agriculture main farming activities such as crop production, livestock husbandry and mixed farming system (MoFED, 2012). This agriculture sector is the main source of income about 41% of the GDP and it accounts for 80% of the exports and for 85% of the labor force or employment in the country (MoARD, 2019). However, the majority of the rural populations were dependent on marginal on-farm economic activities. As agricultural sector is characterized by decreasing farm sizes as the population increase (IFAD, 2011), low levels of output per farm and a high degree of subsistence farming (MoARD, 2010).

In Ethiopia, agriculture is characterized by traditional method of farming mainly relying on animal traction and rain fed. The country faces fluctuation in agricultural production and productivity due to weather or manmade related shocks which leads to that rural households’ income is not sufficient (Beyene, 2008). Furthermore, agricultural production has been deteriorated due to drought, erratic rainfall; backward production technologies and land degradations which are the major causes for unemployment and underemployment, poverty and food insecurity problems (World Ahmad, 2010; Asnake, 2010; World Bank, 2008; Fentie & Sundara, 2016). Therefore, farm households participating in rural off-farm activities have the significant role in employment creation, income generation and enhancing farm income activities. These off-farm activities engaged in both self-employment and wage employment on milling, weaving, handicraft, trade in grain and livestock, general trade, income from share cropped out land, collecting and selling firewood, charcoal, bakery, salt trade and pottery, selling local food and drinks (Fentie & Sundara, 2016; Teweleg, 2012; Yizengaw, 2014).

Despite the potential role of off-farm activities on-farm households’ food security status and reduction of poverty, there no clear-cut development policies that identifies and include the rural off-farm activities as an integral component of the rural economy and a source of employment in Ethiopia. Because, the policy makers in our country give almost full attention only to agricultural sector strategy as primary vehicle for rural poverty reduction and sustainability of food security in the country. However, the country faces income fluctuation from agricultural production due to high accommodation of population growth with corresponding limited farmlands and climate variability and manmade related shocks that lead to as continual increase rural poverty and food insecurity problems (IFAD, 2011; Kassie et al., 2017). Hence, off-farm activities may provide as a coping strategy outlet to manage with unexpected income losses for survival and the improvement of food security (Zerai & Gebereegziabher, 2011).

Several studies analyze the economic impacts of rural household participation in off-farm activities on-farm household’s food security by household expenditure (Amuriya, 2015;
Omonona & Agoi, 2007). However, to appropriately measure the potential for off-farm activities to improve rural food security in terms of food calorie intake, one needs an unbiased and consistent estimation of the impact of such activities. And also, few empirical studies evaluate the economic impacts of participation in off-farm activities on households’ food security through the normal effect rather than counterfactual effects (Adem, 2018; Ahmad, 2010; Kimty, 2015; Yizengaw, 2014). And some of studies employing a propensity score matching approach to control for selection bias and assess the actual relationship between non-farm participation and household food security rather than counterfactual case (Babatunde & Qaim, 2010; Osaro et al., 2016; Owusu et al., 2010; Zeleke et al., 2017). Still, this approach cannot control unobserved confounders that influence the outcome and treatment variables. Therefore, this study aims to reduce biasness and inconsistence estimation by controlling unobserved characteristics across rural households and a systematic difference between participant and non-participant households.

Beside of research method gap, the rural households’ participation in off-farm activities and the impact of these activities on households’ food security were not well identified empirically in the study area in the earlier time. This study attempts to address the gap to identify the determinant of rural household participation in off-farm activities and the impact of off-farm activities on household food security by building an endogenous switching probit (ESP) model. Therefore, to know the driving factors of rural household participation in off-farm activities is essential to improve households’ food security in the study area.

The rest of the paper is organized as follows: the next section discusses research methodology; Section 3 presents result and discussions; Section 4 draws conclusion and recommendations.

2. Research methodology

2.1. Description of the study area

Dibatie district, the study area, is located in Metekel zone of Benishangul Gumuz Regional State (Figure 1). This studyarea covers 368,289 hectares. The study district is bordered in the west by Bulen district, north by Mandura district and south by Yaso district in Abay River. It is also bordered in Dura River on the east which separate from the Amhara region. This district is around 436 km away from the capital city of Benshangul Gumuz region (Assosa) in the north-east direction. The current total human population in the district is 90,577. Out of these 46,013 are males and 44,564 are females (DDAO, 2018). The district has largest ethnic groups such as Gumuz (30.6%), Amhara (26.3%), Oromo (24%), Shinasha (16.5%) and Awi (2%) (CSA, 2007).

The mean annual temperature of the district is between 13.9 and 28.3°C. The absolute maximum temperature usually occurs from February to May and the minimum temperature also occurs from June to September. The rainy season starts in May and extends to the half of October (DDAO, 2018). The major economic activity of district is agriculture, which are finger millet, teff, groundnut, sesame and maize are the major crops produced in the district. In addition, off-farm activities are economic activities that support to on-farm activities (DDAO, 2018).

2.2. Sampling technique and sample size

This study was employed two stage sampling techniques to select sample respondents. The first stage was involved simple random sample to select three kebele administrations (namely Girth, Parzyt and Berber) out of 29 kebeles in the study area. In the second stage, probability of proportional sample size was employed to determine the number of households in sample kebeles and then, to select all respondent households by employing a lottery method in sampled kebeles. This implies that 202 respondent households were selected randomly from a total of households in three sample kebele administrations.

In this study, the sample size was determined by using Yamane formula (Yemane, 1967). This formula expressed as: \( n = \frac{N}{1 + N(e)^2} \) \( \Rightarrow n = \frac{18115}{1 + 18115(0.07)^2} = 201.8081 \approx 202 \)
Where: \( n \) denotes statistically acceptable sample size \( N \) denotes total size of target households (18,115) in the study area and \( e \) denotes level of precision/margin error (7%).

2.3. Sources and methods of data collection

For this paper, the data was collected with a purpose of off-farm activities and its impact on households’ food security. Both primary and secondary sources of data were used for this study. The primary data was collected by using structured questionnaire and key informant interview. In addition, focus group discussion was held with a group of 8–12 persons in each three sample kebeles. The structured questionnaire was used the cross-sectional data on pertaining to socio-economic, demographic, and institutional variables that influence off-farm participation and the physical consumption of each food items consumed by the household head and his/her family members. This questionnaire was first preparing in English language and then translated into Amharic language to make questions clear for the enumerator and to facilitate data collection during household survey. For the data collection, enumerators who speak the Local language and Amharic fluently were hired from the study area and then researchers were given training for enumerators on how to conduct the interview questions and the way of approach to farmers during the interview. It is administered on representative respondents. And also, secondary sources of data were gathered from different published and unpublished documents such as district administration office report.

2.4. Method of data analysis

The raw quantitative and qualitative data were collected from the survey households and then edited, coded, entered, cleaned and analyze the data by using STATA-14 software. Descriptive, inferential statistics and econometric model was used for this study.

In this study, both descriptive and inferential statistics were used to analyze the survey data. Descriptive statistics such as frequency and percentage were used for dummy variables in qualitative way and minimum maximum, mean and standard deviation were used for continuous variables that used to summarize and present the quantitative data. Inferential statistics were used t-test for the continuous and chi-square test was employed to test the significance of discrete independent variables with respect to dependent variable. Measuring food security status and econometric model are discussed below.

3. Measuring food security status

Food security is a situation when all people at all times have physical and economic access to safe, sufficient, and nutritious food needed to maintain a healthy and active life (Adeniyi & Ojo, 2013; FAO, 2008, 2013). On the other hand, food security is defined as adequate availability of and access to food for households to meet the minimum energy requirements as recommended for an active and healthy life (Hussein & Janekarnki, 2013). In most case, there are two methods widely used measure the food security status (\( Z_i \)) of households. The first method is called expenditure method the index is: Food security = food expenditure of \( i \)th household ÷ two-third of mean per capita food expenditure of all study households (Amurtiya, 2015; Omonona & Agoi, 2007). The second method is called calorie intake method. This direct daily calorie intake method (consumption calorie intake method) was represent the actual food consumption pattern of farm households (Kassie et al., 2014; Osarfo et al., 2016; Tewodros & Fikadu, 2014; Tithy et al., 2016).

\[
Z_i = \frac{A_i}{R_i}
\]

(1)

So, the minimum acceptable mean food requirement calorie intake in Ethiopia is 2,200 kCal per person per day (FAO, 2017; MoFED, 2012). Then, to identify food security status of each households, the following procedures was undertaken by physical consumption of food items in the study area. First, this physical consumption of food items converted into kilocalories through food composition table (Appendix 1) compiled by the Ethiopian Health and Nutrition Institute (EHNRI, 2000). Second, all food calories were added up and then converted to daily amounts. And then,
household members converted to adjust for household age and sex composition in to AE (Appendix 2). Finally, food security index (Zi) is constructed to determine the food security status of each household based on recommended daily calorie required approach. This is given by the following the equation (1).

$$Z_i = \text{Food security status for the } i\text{th household; } A_i = \text{Actual daily calorie intake of } i\text{th household include food consumed from own production, market purchases, and out-of-home meals and } R_i = \text{Recommended food security line of the } i\text{th household per capita daily calorie intake (2,200 kCal/day/AE). This minimum acceptable food security line (2,200 kCal/day/AE) set by (FAO, 2017; MoFED, 2012). Finally, in analysis part, food secure household } = 1 \text{if the value } Z_i \geq 1, \text{whose daily per capita calorie intake is above or on the recommended per capita daily calorie intake line (≥ 2,200 kCal/day/AE) and the household food insecure } = 0 \text{if the value } Z_i < 1 \text{. Therefore, in this paper the outcome variable is binary food security status.}$$

4. Endogenous switching probit model

The treatment variable used in the study is a dummy variable that refers to the participation of rural households in any income generating activities out of the on-farm activities. This implies that binary treatment was represented in the model by one for those the rural household who participate in off-farm activities over last year before the survey and zero for those who did not participate in off-farm activities. Binary food security is the outcome variable that represented in the model by two regression equations, the value one for those who rural household food security status and who are participants in off-farm activities and zero for the household food security status and who are not-participants.

As we use an ESP model in counterfactual case to estimate the causal effect of off-farm participation in household food security. We were to construct the relationship between outcome variable (food security status) and off-farm participation approach with a set of explanatory variables. This equation is express as followed:

Where $Z_i$ represent outcome variable, $P_i$ is an indicator variable for off-farm participation,$X_i$ are observable variables, $\beta$ and $\mu$ are vectors of parameters to be estimated, and $\epsilon_i$ is a error term. The impact of off-farm activities on the outcome variable is measured by the estimation of the parameter $\mu$. 

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Figure 1. Location map of the study area.
However, this approach might be generating biased estimator because it assumes that participation in off-farm activities is exogenously determined while it is potentially endogenous. The household who participate may have systematically different characteristics from other households who did not participate, and they may have decided to participate based on expected benefits. Unobservable characteristics of household may affect both the participation decision and outcome variables, resulting in inconsistent that estimates the effect of off-farm participation on household food security. The solution is to explicitly account for endogeneity using simultaneous equation models (Hausman, 1978).

If it is assumed that household participation in off-farm activities that have differential effects on outcome variable, separate food security outcome functions for participants and non-participants have to be specified, while at the same time accounting for endogeneity. These endogeneity, unobserved effects are correlated with both the regressed (food security) and a regressor (participation decision), the coefficient on the latter is inconsistent and biased, especially when household-level cross-sectional data and due to some econometric challenges, such as self-selection bias and endogeneity problems. These econometric problems involve both endogeneity (Hausman, 1978) and sample selection (Heckman et al., 1979).

As a result, the ESP model is adopted to address the endogeneity and sample selection problems by estimating separate regressions for participants and non-participants. The other advantage of this model over other methods such as propensity score matching, the ESP model enables to construct a counterfactual based on returns to characteristics of participants and non-participants and also it accounts unobservable factors that affect the participation decision. As a result, ESP model were used that accounts for both endogeneity and sample selection problems (Alene and Manyong, 2007; Di Falco et al., 2011). Therefore, ESP model was described the outcome of food security with two regression equations that treats participant and non-participants are defined as the next regime of outcome functions:

Regime 1 (Participants):
\[ Z_1 = \beta_1 X_1 + \epsilon_1 \text{if } P_i = 1 \]  
(3a)

Regime 0 (Non-Participants):
\[ Z_0 = \beta_0 X_1 + \epsilon_0 \text{if } P_i = 0 \]  
(3b)

\[ \text{Cov}(\epsilon_1, \epsilon_0) = \begin{bmatrix} \delta_{11}^2 & \delta_{11} \delta_{10} & \delta_{11} \delta_{20} & \delta_{20}^2 \end{bmatrix} \]  
Where \( Z_1 \) and \( Z_0 \) represent household food security for off-farm participants and non-participants, respectively; we observe \( Z_1 \) when \( P = 1 \), in which case \( Z_0 \) is unobserved, latent, or missing. Similarly, we observe \( Z_0 \) when \( P = 0 \), in which case is \( Z_1 \) missing. The treatment variable \( (P) \) and \( X_1 \) in the regime of outcome equations can overlap. Therefore, at least one explanatory variable appears in decision to off-farm participation and does not appear outcome equations in\( X_1 \). The random disturbance of participation equation is associated with the \( \epsilon_i \) random disturbances of food security outcome equations in the two regimes. They are correlated and assumed to be jointly normally distributed with a zero-mean vector of the covariance matrix:

The variance \( \delta_{00}^2 \) is assumed to be equal to 1, since the \( \beta \) coefficients in the selection model can be only estimated up to a scale factor. In addition to this, the covariance \( \delta_{12,0} \) is equal to zero because \( Z_1 \) and \( Z_0 \) are not observed together or are not observed simultaneously. As a result, the covariance between \( \epsilon_1 \) and \( \epsilon_0 \) are not defined (Long et al., 2013; Rao & Qaim, 2011). An important suggestion of the error structure is that as the error term of the selection Equation (1) \( u_i \) is correlated with the error terms of outcome functions (3a) and (3b), \( (\epsilon_1 \text{ and } \epsilon_0) \), the expected values of errors in the outcome equation on sample selection is non-zero:
\[ E(e_{1i} | p_i = 1, X_i) = \delta e_{1i} u \frac{\phi(\beta X_i)}{\Phi(\beta X_i)} = \delta e_{1i} u \lambda_{1i} \]

and

\[ E(e_{0i} | p_i = 0, X_0) = -\delta e_{0i} u \frac{\phi(\beta X_i)}{1 - \Phi(\beta X_i)} = \delta e_{0i} u \lambda_{0i} \]

Where \( \phi(\cdot) \) is the standard normal probability density function, the standard normal cumulative density function, \( \lambda_{1i} = \frac{\phi(\beta X_i)}{\Phi(\beta X_i)} \) and \( \lambda_{0i} = -\frac{\phi(\beta X_i)}{1 - \Phi(\beta X_i)} \). Where \( \lambda_{1i} \) and \( \lambda_{0i} \) are refers to the Inverse Mills Ratios predicted at \( \beta X_i \) for participants and non-participants, respectively (Greene, 2008). If the estimated covariance \( \delta_{10} \) and \( \delta_{0u} \) are statistically significant, then the decision to participate and food security outcome variable was correlated; that is we find evidence of endogenous switching and reject the null hypothesis that absence of sample selectivity bias (Maddala & Nelson, 1975). We establish the acceptability of instrumental variable by conducting a simple rejection test: if a variable is a suitable selection instrument, it affects the participation but does not affect the food security outcome between households (Table 1 and 2).

As we reply switch_probit syntax on ESP model to estimate the binary treatment and binary outcome by full information maximum likelihood estimation under the assumption of joint normality of the error terms in the selection and outcome equations (Lokshin & Sojaia, 2011). Therefore, the ESP model can be used to compare the conditional expectations of food security that participants (4a) with respect to the non-participants (4b), and to examine the expected food security in the counterfactual hypothetical cases that the participants did not food secured (4c), and that the non-participant did food secured (4d). The conditional expectations for our outcome variable in the four cases defined as followed:

\[ Pr(Z_{ii}|p_i = 1) = \beta_1 X_{ii} + \delta_{1i} u \lambda_{1i} \quad (4a) \]

This implies that the probability of being treated and having a positive outcome—the probability for participants and for household food secure

\[ Pr(Z_{ii}|p_i = 1) = \beta_1 X_{ii} + \delta_{1i} u \lambda_{1i} \quad (4b) \]

This implies that the probability of not being treated and having a zero outcome—the probability for non-participants and for household food insecure

\[ Pr(Z_{0i}|p_i = 1) = \beta_0 X_{0i} + \delta_{0i} u \lambda_{1i} \quad (4c) \]

This implies that the probability of being treated and having a zero outcome—the probability for participants and for household food insecure

\[ Pr(Z_{0i}|p_i = 1) = \beta_0 X_{0i} + \delta_{0i} u \lambda_{1i} \quad (4d) \]

| Sub-samples       | Decision stage               | Treatment effect |
|-------------------|------------------------------|------------------|
|                   | To participate               | Not to participate|
| Participant       | (a) \( Pr(Z_{1i} | p_i = 1) \) | (a) \( Pr(Z_{0i} | p_i = 1) \) | TT |
| Non participant   | (d) \( Pr(Z_{1i} | p_i = 0) \) | (b) \( Pr(Z_{0i} | p_i = 0) \) | TU |
| Heterogeneity effects | BH₁ | BH₀ | TH |

Source: Modified Di Falco et al. (2011).

Notes: (a) and (b) along the diagonal represent observed expected probability of food security.
Table 2. The definition of treatment, outcome and independent variables and working hypothesis

| No. | Variables description | Variables type | Measurement of variables in (value) | Expected sign |
|-----|-----------------------|----------------|-------------------------------------|---------------|
| 1   | Binary off-farm participation | Dummy | It is treatment variable which is participation in off-farm (participants=1, if yes; 0 if non-participants) | +ve |

**Outcome variable**

| No. | Variables description | Variables type | Measurement of variables in (value) | Expected sign |
|-----|-----------------------|----------------|-------------------------------------|---------------|
| 2   | Food security status  | Dummy | It is the outcome variable which is the value 1 for food secure households if the value $Z_i > r$ and 0 for food insecure if $Z_i < r$. |               |

| Independent variable No. | Variables description | Variables type | Measurement of variables in (value) | Expected sign |
|--------------------------|-----------------------|----------------|-------------------------------------|---------------|
| 1                        | Age of the household head | Continuous | Age of respondent in years | +ve |
| 4                        | Sex of the household head | Dummy | Sex of the respondent (1=Male and 0= Female) | +ve |
| 5                        | Education level of household head | Continuous | Formal education in year of schooling grade | +ve |
| 6                        | Household size | Continuous | Total household members in adult equivalent. | +ve |
| 7                        | Dependency ratio | Continuous | The ratio of inactive labor force (<15 year and >65 year) and working age (15-65 year) | -ve |
| 8                        | Total cultivated land | Continuous | Size of cultivated land in hectare | +/-ve |
| 9                        | Farm experience | Continuous | Farm experience in years | +ve |
| 10                       | Total livestock owned in TLU (see appendix -3) | Continuous | The respondents’ total livestock owned in tropical livestock unit | +ve |
| 11                       | Utilization of formal credit | Dummy | If the respondents utilized formal credit (1= if yes; 0= if no) | +ve |
| 12                       | Distance to the nearest market | Continuous | Walking from home to the nearest market in minute. | -ve |
| 13                       | Access to electricity | Dummy | If the respondents had access to electricity power (1= if yes; 0= if no) | +ve |
| 14                       | Frequency of extension contacts | Continuous | Household heads in number contact with extension agents per year. | +ve |
| 15                       | Training in off-farm work | Dummy | If the respondents get training (1= if yes; 0= if no) | +ve |
| 16                       | Special skill | Dummy | It takes a value of 1 if the households have special skill (making traditional medicine, masonry, handicrafts etc.) and 0 otherwise. | +ve |

Note that: FSS = Food security status
Source: Own Design, 2019.

This implies that the probability of not being treated and having a positive outcome—the probability for non-participants and for household food secure

**Average treatment effects:** It can be used to compare the difference between observed and counterfactual case of households (Lokshin & Sajaia, 2011). This implies that the model to estimate the expected effect of the treatment on treated (TT) for participant in off-farm activities was calculated as the difference between (4a) and (4 c): $Pr(Z_1|P_i = 1) - Pr(Z_0|P_i = 1) = TT$. It implies that the effect of off-farm activities on households’ food security. Similarly, the effect of the treatment on untreated (TU) for non-participant was calculated as the deference between (4d) and (4b): $Pr(Z_2|P_i = 0) - Pr(Z_0|P_i = 0) = TU$.

We can use the expected outcomes described in (4a–4d) to calculate the heterogeneity effects (Lokshin & Sajaia, 2011). This “the effect of base heterogeneity” for the group of rural households participation in off-farm activities that decided to food secured is defined as the difference between (a) and (d) and for non-participant that decided to food insecure is defined as the difference between cell (c) and cell (b).

(c) and (d) represent counterfactual expected probability of food security.

$P_i = 1$ if households Participated in off-farm activities.

$P_i = 0$ if households not participated:
Table 3. Descriptive statistics for households’ participation in off-farm activities

| Variable description and its value | Participants (N=112 (55.4%)) | Nonparticipants (N=90 (44.6%)) | Mean difference/ T-test |
|-----------------------------------|-------------------------------|---------------------------------|------------------------|
| **Treatment variable**            |                               |                                 |                        |
| Binary off-farm participation which is participant=1 and non-participants =0 |                               |                                 |                        |
| **Outcome variable**              |                               |                                 |                        |
| Binary food security which is (food secure if the value Zi ≥1; food insecure if Zi<1) |                               |                                 |                        |
| **Continuous independent variables** |                               |                                 |                        |
| Age of the household head in year | 44.732                       | 12.585                          | 42.044                 | 9.923 | 2.688* |
| Education level of household head in school grading | 3.9732                       | 3.928                           | 0.344                  | 1.367 | 3.629*** |
| Household size in adult equivalent | 5.741                        | 2.285                           | 5.811                  | 2.263 | -0.070 |
| Dependency ratio in the ratio of inactive labor force and working age | 0.357                        | 0.171                           | 0.413                  | 0.196 | -0.056** |
| Total cultivated land in hectare | 3.990                        | 1.956                           | 3.4749                 | 1.530 | 0.515** |
| Farm experience in year | 21.125                       | 13.787                          | 21.244                 | 9.762 | -0.120 |
| Total livestock owned in TLU | 7.750                        | 4.799                           | 6.276                  | 3.254 | 1.474** |
| Distance to the nearest market in walking minute | 23.982                      | 18.265                          | 66.689                 | 33.056 | -42.707*** |
| Frequency of extension contacts in number days per year. | 4.054                        | 3.052                           | 1.611                  | 1.906 | 2.443*** |
| **Dummy independent variable** | Value | Frequency | % | Frequency | % | χ²- Value |
| Sex of the household head | 1=Male | 14 | 12.50 | 21 | 23.33 | 4.088** |
| 0=Female | 98 | 87.50 | 69 | 76.67 |
| Utilization of credit | 1= if yes | 93 | 83.04 | 7 | 7.78 | 113.062*** |
| 0=if no | 19 | 16.96 | 83 | 92.22 |
| Access to electricity | 1= if yes | 81 | 72.32 | 17 | 18.89 | 57.038*** |
| 0=if no | 31 | 27.68 | 73 | 81.11 |
| Skill training in off-farm activities | 1= if yes | 94 | 83.93 | 5 | 5.56 | 122.651*** |
| 0=if no | 18 | 16.07 | 85 | 94.44 |
| Having special skill | 1= if yes | 23 | 20.54 | 2 | 2.22 | 15.433*** |
| 0=if no | 89 | 79.46 | 88 | 97.78 |

Note: ***; ** and * Significant at P < 0.01, 0.05 and p < 0.1, respectively.
Source: Survey result, 2019.

Z₁ = Food security status if households participated.

Z₀ = Food security status if households not-participated.

TT = the effect of the treatment on the treated.

TU = the effect of the treatment on the untreated.

BH = the effect of base heterogeneity for participator (i = 1), and non-participator (i = 0).
5. Results and discussion

5.1. Demographic and socio-economic characteristics of sample households

The survey result of this study was presented in both categorical and continuous variables with sample households’ participation status in the study area. Thus, the participation status of sample households, about 55.4% of households were off-farm participants and 44.6% of households were off-farm non-participants. The mean age of participant households was found 44.73 years and that of mean age non-participant households was 42.04 years with the standard deviation of 9.92. A t-test revealed that statistically significant mean age difference between participant and non-participant households’ age at 10% significant level (Table 3).

The mean of education level of sample households for participant and non-participant households were 3.97 and 0.34 grades, respectively. A t-test indicated that there is statistically significant mean education level difference between participant and non-participants households at 1% significant level. And also, the mean of dependency ratio for participant households was 0.36 and the mean of dependency ratio for non-participant households was 0.41. The t-test indicated that there is significant mean dependence ratio difference between participants and non-participant households at 5% significant level (Table 3).

The mean of walking minute for participant and non-participant households were 23.98 and 67.00 minutes with the standard deviation of 18.27 and 33.06, respectively. Therefore, the mean of walking minute of participant households was greater than mean of walking minute for non-participants. The t-test indicated that average walking minute was significant mean difference between participant and non-participant households at 1% significant level (Table 3).

Finally, the mean of sample households did utilize formal credit and didn’t utilize formal credit were 49.5% and 50.5%, respectively. From participant households, 83.04% of households did utilized formal credit and 16.96% of households didn’t utilized formal credit. Similarly, about 7.78% of non-participant households did utilized formal loan and 92.22% non-participant households didn’t utilized formal loan. A survey result revealed that there is statistically significant association between participants and non-participant households in terms of utilization of formal credit at 1% significance level (Table 3). Similarly, we can interpret other significant independent variables in this way.

The key informant interview with the development agents also supported this result, as farm households earn more income from their farm; they choose to reinvest their income on self-employment activities off the farm. Thus, in the study kebeles, large farm land can be linked with greater income, saving and then investment in self-employment activities off the farm. On the other hand, households with small farm land did not get surplus income either to start business or to save in financial institutions to guarantee loan service. Thus, farmers with small farm land are believed to be discouraged to participate in off-farm-activities. Further focus group discussion showed that farm households with small land size choose to move to towns for searching daily wage work for the survival of their family.

5.2. Food security status of rural households in the study area

In this article, household caloric intake was used to measure household food security by physical consumption of food items in the study area. The rural household whose calorific consumption is ≥ 2,200 kCal/day/AE was categorized as food secure, whereas; household caloric consumption is <2,200 kCal/day/AE was household categorized as food insecure. Accordingly, in this article the percentages of food secure and insecure households of all respondents in the study area were found to be 59.4% and 40.6%, respectively. The mean energy intake of all respondent households was 2431.68 kCal/day/AE. The mean energy intake of food secure households is 2848.53 kCal/day/AE and food insecure was 1821.65 kCal/day/AE. The minimum and maximum calorie intake for
food secure households was 2208.14 and 4811.22 kCal/day/AE, respectively. While the minimum and maximum available of calorie for food insecure households was 942.37 and 2198.85 kCal/day/AE, respectively.

The survey results also revealed that household food security status with their participation status in sample kebeles. The two groups of households (participants and non-participant households), about 37.6% and 3% of the households were food insecure from non-participants and participants, respectively, and also 6.9% and 52.5% of the households were food secure households who are non-participant and participant households, respectively. The result of the chi-square test showed that there is a statistically significant association between households’ food security status across their participation status at a 1% probability level (Table 4).

5.3. Econometric analysis
Before the discussion of econometric results, we need to compute estimation diagnosis test. So, we expect household participation is an endogenous variable and we have to estimate the outcome of food security status. The 2SLS (two stage least square) estimator is useful to have a test endogeneity of explanatory variables. Accordingly, to test endogenous variables that we use Wu-Hausman F-test under null hypothesis of explanatory variables are exogenous. The result confirms that the household participation is in reality endogenous with their food security outcome because the p-value of the test is less than 10% probability level (see Appendix 4). As a result, we use ESP model to control for such endogeneity problem.

The overall significance of the model indicated that the likelihood ratio test for three equations are joint independence of outcome and selection (treatment) equations that are significantly joint determined at less than 5% probability level at the bottom line of ESP model result (see Appendix 5). Therefore, the likelihood ratio test result suggests that the three equations are jointly dependent, providing evidence of endogeneity that needs to be controlled in the model specification of outcome equations and model consistency condition being satisfied. This indicates that the overall significance of the model is sound. So, the determinants of rural household participation in off-farm activities and its impact on households’ food security status were discussed in the following section.

6. Determinants of rural household participation in off-farm activities
In this section, 14 explanatory variables in selection (treatment) equation were used to ESP model to estimate the determinants of household participation in off-farm activities. The estimated results also demonstrate that there are systematic differences across the two regimes. For example, the household heads’ education level has a significant and positive correlation with the food security status for only one regime (participants). This result suggests that the effects of education are greater among the off-farm participants. This is because better educated participants may be more productive in off-farm activities than their counterparts in the non-participant group. The results confirm the important role of education and/or technical training in contributing to the improvement in rural household food security status. This result is in line with the findings of (Kimty, 2015).

| Table 4. Distribution of households’ food security status by participation groups |
|---------------------------------|-----------------|-----------------|-----------|---------|
| Food security status            | Participants    | Non-participants| Total     | χ² value |
|---------------------------------|-----------------|-----------------|-----------|---------|
| Food secure                     | 106             | 14              | 120       | 129.43*** |
| Food insecure                   | 6               | 76              | 82        | 40.6    |
| Total                           | 112             | 90              | 202       | 100     |

Source: Survey result, 2019.
Table 5: Endogenous switching probit models for determinants of off-farm participation

| Independent variables | Independent treatment equation | Jointly estimated probit<sup>2, 3</sup> |
|-----------------------|---------------------------------|----------------------------------------|
|                       | Binary off farm participation (1/0) | Participants | Nonparticipants |
|                       | Marginal effect | Coef | Stand. err | Coef | Stand. err | Coef | Stand. err |
| Sex of household head | -0.0075 | -0.1409 | 1.0654 | 0.6509 | 0.8658 | -0.2420 | 0.9458 |
| Age of household head | 0.0184 | 0.5247<sup>**</sup> | 0.2737 | -0.1497 | 0.2031 | -0.3266 | 0.2888 |
| Member of household's size | 0.0153 | 0.3185<sup>*</sup> | 0.2321 | -0.3924 | 0.1823 | 0.2192 | 0.1376 |
| Dependency ratio | 0.0405 | 0.8354 | 2.5569 | -0.8579 | 2.7757 | -3.7523 | 3.2573 |
| Education of household head | 0.0282 | 0.4765<sup>***</sup> | 0.2023 | 0.0940<sup>**</sup> | 0.0846 | 1.4189 | 0.7119 |
| Total cultivated land | 0.0008 | 0.0672 | 0.2086 | 0.4718 | 0.3174 | 0.4035 | 0.3706 |
| Farm experience | -0.0001 | -0.0016 | 0.0014 | 0.0003 | 0.0012 | 0.0062<sup>**</sup> | 0.0027 |
| Owned livestock in TLU | -0.0027 | -0.0387 | 0.1397 | 0.1870 | 0.1748 | 0.4209<sup>*</sup> | 0.2549 |
| Frequency extension contact | 0.0402 | 0.8475<sup>***</sup> | 0.3752 | -0.0860 | 0.1584 | 0.2345 | 0.2755 |
| Access to formal credit | 0.5215 | 4.4022<sup>**</sup> | 1.8339 | 1.1785 | 0.8701 | 3.4289 | 1.0354 |
| Distance to nearest market | -0.0019 | -0.0431<sup>**</sup> | 0.0204 | -0.0220 | 0.0178 | 0.0131 | 0.0172 |
| Having special skill | 0.0754 | 5.6367<sup>***</sup> | 1.8750 |  |  |  |  |
| Off-farm training | 0.1049 | 1.4549 | 1.0596 |  |  |  |  |
| Access to electricity | 0.4346 | 4.1924<sup>***</sup> | 1.8004 |  |  |  |  |
| Constant | -0.0075 | 0.3319<sup>*</sup> | 5.236 | 4.5302 | 4.6946 | -0.6445<sup>**</sup> | 7.3484 |

Number of observations: 202 Log likelihood: -31.6089.
Wald chi<sup>2</sup>(16): 18.34 Prob > chi<sup>2</sup>: 0.0003.

Note: ***, ** and * Significant at P < 0.01, 0.05 and 0.1, respectively.
Source: Survey result, 2019.

In addition to this, there are systematic differences across participant and nonparticipant groups. The farming experience in years has a significantly positive relationship with food security for only the nonparticipants at the 5% level of significance. This finding suggests that the off-farm non-participants can have more farming experience than the nonparticipants. Because nonparticipants households have more experience in the farm sector than off-farm income generating activities. Furthermore, the results indicate that livestock holding in tropical livestock unit has a significant and positive correlation with only the nonparticipant households at the 10% level of significance. This finding suggests that the off-farm non-participants can use their own livestock holding in a more productive way than the participants.

As the model independent treatment equation result revealed that the variable education had a positive and significant effect on the probability of off-farm participation at less than 1% significant level. As noted in the model result, the heads of off-farm participant households are better educated than those of nonparticipant households. Therefore, adding one-year education level can increase the chance of being to participate in off-farm activities by 2.8%, ceteris paribus. This result is in line with the findings of (Adem, 2018).

Distance to nearest market in minute found to be a significant and negatively influence on off-farm participation at 5% level of significant. The negative sign coefficient of distance to nearest
market indicates that household participation in off-farm activities decrease as walking minute to nearest market increase. Specifically, the probability of being household participating in off-farm activities decreased by 0.19% as distance to nearest market increased by one minute, all other things are held constant. This result is similar with the findings of (Beyene, 2008; Fentie & Sundara, 2016; Yizengaw, 2014).

Special skill of household member has a positive and significant influence on household participation in off-farm activities at 1% level of significant. This implies that having additional special skills of household members were increases, participation in off-farm activities increased by 7.5%, being the other things remained constant. This result is in line with the findings of (Zerai & Gebereegziabher, 2011).

The results a model indicated that access to electricity power has a positive and significant influence on-farm household participation in off-farm activities at 1% significant level. Other things remain constant; being the probability of access to electricity power would increase in one unit, the probability of being household participation in off-farm activities increased by 0.4346 probability levels. The result is similar with the findings of (Berhane, 2010; Zerai & Gebereegziabher, 2011; Adem, 2018).

Utilization of formal credit is completely in agreement with the prior expectation and it has a positive and significant effect on-farm household participation in off-farm activities in the study area at 5% significant level. This was due to the fact that households which have an opportunity to receive credit would build their capacity to participate in off-farm activities. The marginal effect of the model result show that, the probability of being household participation in off-farm activities increased by 52.15% as the household did utilized formal credit increased in one unit, other things are held constant. This result is in line with the findings of (Asnake, 2010; Zerai & Gebereegziabher, 2011; Zewdie & Sivakumar, 2017). Similarly, we can interpret other significant variables in this way

7. The impact of off-farm activities on households’ food security
The outcome variable considered in the analyses is binary food security (household food secured = 1 and food insecure = 0) and a binary treatment (household participants = 1 and non-participants = 0). Then, an ESP model (probit outcome) was used for the impact analysis by employing \textit{switch_probit} command. After estimated the model, we predict the actual and counterfactual case of each conditional expectations. Finally, to interpret the actual and counterfactual case of conditional expectations and coefficient of treatment effects in off-farm participation that is the average treatment effect for the treated (ATT) and average treatment effect for the untreated (ATU) in Table 5 and 6.

The expected mean probabilities of food security under actual or observed outcome conditions of treatment effects were presented in cell (a) and (b). In actual outcome condition (a), expected mean probability of food security by households that participated is 0.517 of mean probability level for food security, while observed outcome condition (b), about 0.0708 of mean probability levels for food insecurity for households that they did not participated. Counterfactual case (c), participant

| Table 6. Average probability of food security, and treatment and heterogeneity effects: Outcome variable = Binary food security |
|---------------------------------------------------------------|
| Participation Status | Decision stage | Treatment effect |
|----------------------|----------------|------------------|
|                      | To participate | Not to participate |
| Participants         | (a) 0.5171     | (c) 0.0331       | 0.4841 (14.1165) *** = ATT |
| Non-participants     | (d) 0.3790     | (b) 0.0708       | 0.3082 (8.7523) *** = ATU |
| Heterogeneity effect | BH₁ = 0.1381 (12.2488) *** | BH₂ = -0.0377 (10.4877) *** | 0.1759 = TH |

Note: *** imply significance at less than 1%.
Source: survey result, 2019.
households would have on average 0.331 of mean probability of food security status if they had not participating. Counterfactual cases (d), non-participant households would have on average 0.379 of mean probability for food security status if they had participating.

The difference between cell (a) and (c) for participant households and the difference between cell (d) and (b) for non-participant households, which indicated that the ATT and ATU, respectively. The last column of Table 6 presented that the treatment effect of off-farm participation on the mean probabilities of food security status at its significant levels. ATT result indicated that farm households who actually participate in off-farm activities would have on average about 0.484 higher mean probability of food security as compared with the counterfactual case (c). This implies that participant households in off-farm activities had higher mean probability of consuming than food security line (2,200 kCal/day/AE) as compared with the counterfactual case in cell (c) or if they did not participate. This result is similar with the findings of (Babatunde & Qaim, 2010; Osarfo et al., 2016; Owusu et al., 2010; Sénakpon et al., 2016).

Likewise, the ATU show that every member of households who did not participate in off-farm activities would have on average 0.3082 less probability of food security as compare with the counterfactual case in cell (d) or if they had participated. This result is similar with the findings of (Osarfo et al., 2016; Owusu et al., 2010; Sénakpon et al., 2016).

Therefore, the result of the study implies that farm household participation in off-farm activities has a positive and significant impact on the mean probability of food security than farm households that they did not participate. The transitional heterogeneity effect is also a positive and significantly higher probability for the rural households that actually did to participate than those did not participated.

8. Conclusions and recommendations
Ethiopia is characterized by a context of uncontrolled population growth and recurrent drought, imperfect factors markets, food insecurity and unemployment. Particularly in rural areas, farm households face constraint in terms of inputs and climate change that may hinder agricultural production and threaten food security. The main aim of this study attempts to examine the major determinants of rural household participation in off-farm employment and its impact on households’ food security status. The primary data were collected from 202 sample households in the study area at household levels. The method of data analysis in this study was carried out descriptive statistics and econometric model. An ESP model was used to evaluate households’ food security from their participation in off-farm activities.

Furthermore, to estimate the impact of off-farm employment in household food security status, we have found that participation in off-farm activities on average increase the probability of food security status of households. Since, ATT indicated that households who actually participating in off-farm activities would have on average higher probability of food security as compared with the counterfactual case of they did not participated. The ATU also show that every member of households who did not participating in off-farm activities would have on average less probability of food security as compare with the counterfactual case if they had participated. Therefore, the result implies that participation in off-farm activities significantly increase the probability of food security than rural households that did not to participate.

As we recommend, rural development policies aimed to reduce food insecurity problem should focus on both the on farm and off-farm sectors because off-farm activities have been increasing households’ income and reinvested into agriculture for increased production. So, we would like to propose as a policy that off-farm participation approach should be used to ensure sustainability of farmers’ food security through education services, recognized and support the special skill and providing credit services as well as infrastructures like road and electricity power that enhance
alternative means of livelihood opportunities to farm household participating in off-farm activities and decreasing their constraints in order to improve households food security status.

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Notes
1. Kebele = is the smallest administration unit in the government structure.
2. Probit model is estimated independently from the outcome regime equations. The Probit model is jointly estimated with the outcome regime equations

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Appendix

Appendix 1: Conversion factor of calorie content in each food items

| Food Items       | Unit | Calorie | Food Items       | Unit | Calorie |
|------------------|------|---------|------------------|------|---------|
| Wheat            | Kg   | 3570    | Sweet Potato     | Kg   | 1360**  |
| Teff             | Kg   | 3589    | Irish Potato     | Kg   | 1037**  |
| Barely           | Kg   | 3723    | Oats             | Kg   | 3599**  |
| Lentils          | Kg   | 3522    | Egg              | Each | 61      |
| Hose bean        | Kg   | 3514    | Honey            | Kg   | 3605    |
| Sorghum          | Kg   | 3805    | Red Pepper       | Kg   | 933     |
| Peas             | Kg   | 3553    | Maize            | Kg   | 3560    |
| Vetch            | Kg   | 3470    | Millet           | Kg   | 3260    |
| Linseed          | Kg   | 5109    | Check peas       | Kg   | 3630    |
| Sugar            | Kg   | 3850    | Onion            | Kg   | 713**   |
| Coffee           | Kg   | 1103    | Garlic           | Kg   | 118     |
| Meat             | Kg   | 1148    | Rice             | Kg   | 3640*** |
| Milk             | Lit  | 737     | Groundnut        | Kg   | 3320*** |
| Butter           | Kg   | 7363    | Tomato           | Kg   | 70***   |
| Edible oil       | Lit  | 8964**  | Spagheti/Macaroni| Kg | 3550*    |

Source: EHNRI, 2000. * Dire Dawa Food Complex, **EHNRI, 1998, ***WHO.

Appendix 2: Conversion factor for adult equivalent (AE)

| Age group | Male | Female |
|-----------|------|--------|
| <10       | 0.6  | 0.6    |
| 10-13     | 0.9  | 0.8    |
| >13       | 1    | 0.75   |

Source: Starck et al., 1991

Appendix 3: Conversion factor of tropical livestock unit (TLU)

| Livestock Category | TLU  | Livestock Category | TLU  |
|--------------------|------|--------------------|------|
| Ox Cow             | 1    | Donkey (Young)     | 0.35 |
|                    | 1    | Horse              | 1.1  |
| Woyfen             | 0.34 | Sheep and Goat (Adult) | 0.13 |
| Heifer             | 0.75 | Sheep (Young)      | 0.06 |
| Calf               | 0.25 | Goat (Young)       | 0.06 |
| Donkey (Adult)     | 0.7  | Hen                | 0.013|

Source: Starck et al., 1991.
Appendix 4: Tests of endogeneity
Ho: variables are exogenous

Durbin (score) $\chi^2$ (1) = 3.23148 ($p = 0.0722$)

Wu-Hausman $F$ (1,187) = 3.04015 ($p = 0.0829$)

Robust score $\chi^2$ (1) = 3.63019 ($p = 0.0567$)

Robust regression $F$ (1,187) = 4.30037 ($p = 0.0395$)

Appendix 5: Estimated Coefficients from Endogenous Switching Probit Regression: Binary outcomes and binary selection

| Endogenous switching probit model | Number of obs = | 202 |
|---------------------------------|----------------|-----|
|                                 | Wald $\chi^2$(16) = | 18.34 |
| Log likelihood = | $-31.60891$ | 0.0003 |

| Off-farm participation | Coef. | Std. Err. | Z | $P>z$ | [95% Conf. Interval] |
|------------------------|-------|-----------|---|-------|---------------------|
| Sex headed             | $-0.1409197$ | 1.065365 | $-0.13$ | 0.895 | $-2.228996$ | $1.947157$ |
| Age headed             | $0.5247308$ | $0.2736656$ | $-1.92$ | 0.020 | $-1.061105$ | $0.0116438$ |
| Size household member  | $-0.3185421$ | $0.2321433$ | $1.37$ | $0.070$ | $-0.1364504$ | $0.7735345$ |
| Dependency ratio       | $0.8354176$ | $2.556886$ | $0.33$ | $0.744$ | $-4.175987$ | $5.846822$ |
| Education              | $0.476538$ | $0.202331$ | $2.36$ | $0.009$ | $0.0799766$ | $0.8730995$ |
| Special Skill          | $5.636665$ | $1.875001$ | $0.32$ | $0.747$ | $-0.3416122$ | $1.093849$ |
| Off-farm training      | $1.454883$ | $1.059596$ | $1.37$ | $0.170$ | $-0.6218861$ | $3.531652$ |
| Land size              | $0.067173$ | $0.2085677$ | $0.32$ | $0.747$ | $-0.3416122$ | $0.745952$ |
| Farm Experience        | $0.0015533$ | $0.0036975$ | $1.13$ | $0.257$ | $-0.0042379$ | $0.0039542$ |
| Owned livestock         | $-0.0386984$ | $0.1397088$ | $-0.28$ | $0.782$ | $-0.0042379$ | $0.0039542$ |
| Extension contact       | $0.847539$ | $1.752116$ | $2.26$ | $0.004$ | $0.1121378$ | $1.58294$ |
| Credit                 | $4.402244$ | $1.833866$ | $2.40$ | $0.016$ | $0.807932$ | $7.996535$ |
| Market distance         | $-0.0430506$ | $0.020426$ | $-2.11$ | $0.035$ | $-0.0830848$ | $-0.0030164$ |
| Electricity             | $4.192432$ | $1.800406$ | $2.33$ | $0.002$ | $0.6637009$ | $7.721164$ |
| _cons                  | $4.530175$ | $4.694597$ | $0.96$ | $0.335$ | $-4.671066$ | $13.73142$ |

_FSS_1 (Participants)

| Off-farm participation | Coef. | Std. Err. | Z | $P>z$ | [95% Conf. Interval] |
|------------------------|-------|-----------|---|-------|---------------------|
| Sex headed             | $0.650947$ | $0.8658775$ | $0.75$ | $0.452$ | $-1.046142$ | $2.348036$ |
| Education              | $0.0939819$ | $0.0845915$ | $1.11$ | $0.046$ | $-0.0718144$ | $0.257982$ |
| Dependency ratio       | $-0.8578647$ | $2.77568$ | $-0.31$ | $0.757$ | $-6.298097$ | $4.582368$ |
| Land size              | $0.4717662$ | $0.3173952$ | $1.49$ | $0.137$ | $-0.1503171$ | $1.093849$ |
| Farm Experience        | $0.0002736$ | $0.001227$ | $0.22$ | $0.824$ | $-0.0021312$ | $0.0026785$ |
| Owned livestock         | $0.1870429$ | $0.1747834$ | $1.07$ | $0.285$ | $-0.1555263$ | $0.5296122$ |
| Extension contact       | $-0.0859565$ | $0.1583775$ | $-0.54$ | $0.587$ | $-0.3963706$ | $0.2244577$ |
| Size household member  | $-0.3924134$ | $0.1823157$ | $0.43$ | $0.667$ | $-0.003189$ | $0.0049861$ |
| Age headed             | $0.1497444$ | $0.2031259$ | $-0.74$ | $0.461$ | $-0.5478638$ | $0.2483751$ |
| Market distance         | $-0.0219567$ | $0.0177996$ | $-1.23$ | $0.217$ | $-0.0568432$ | $0.0129298$ |
| Credit                 | $1.178537$ | $0.870125$ | $1.37$ | $0.177$ | $1.427966$ | $4.753997$ |
| _cons                  | $4.530175$ | $4.694597$ | $0.96$ | $0.335$ | $-4.671066$ | $13.73142$ |

_FSS_0 (Non-Participants)

(Continued)
|                                    | Coef | Std. Err | t     | Prob > | t     | Coef | Std. Err | t     | Prob > | t     |
|------------------------------------|------|----------|-------|--------|-------|------|----------|-------|--------|-------|
| Sex headed                         | -0.2419659 | 0.9458063 | -0.26 | 0.798  | -2.095712 | 1.61178 |
| Education                          | 1.418879 | 0.7119169 | 1.99  | 0.267  | 0.0235473 | 2.81421 |
| Dependency ratio                   | -3.752265 | 3.257332 | -1.15 | 0.249  | -10.13652 | 2.631988 |
| Land size                          | 0.4035443 | 0.3705942 | 1.09  | 0.276  | -3.228069 | 1.129896 |
| Farm Experience                    | 0.006249 | 0.0027438 | 2.28  | 0.023  | 0.0008713 | 0.116268 |
| Owned livestock                    | 0.4209304 | 0.2549355 | 1.65  | 0.099  | -0.0787339 | 0.9205947 |
| Extension contact                  | 0.2345578 | 0.2754835 | 0.85  | 0.395  | -3.053799 | 0.774955 |
| Size household member              | 0.2191545 | 0.1375682 | 0.72  | 0.472  | -0.0030255 | 0.0065344 |
| Age headed                         | -3.3266357 | 0.288817 | -1.13 | 0.258  | -0.8927065 | 0.2394351 |
| Market distance                    | 0.0130752 | 0.0172002 | 0.76  | 0.447  | -0.0206366 | 0.046787 |
| Credit                             | 3.428841 | 1.035412 | 3.31  | 0.001  | -0.8363582 | 4.001432 |
| _cons                              | -0.6445302 | 0.7348374 | -0.09 | 0.930  | -15.04708 | 13.75802 |
| rho0                                | -14.9218 | 1162.328 | -0.09 | 0.930  | -15.04708 | 13.75802 |
| rho1                                | -17.19948 | 50.09574 | 1.65  | 0.102  | -0.0030255 | 0.0065344 |
| LR test of independent eqns. (rho0=0): chi²(2) = 5.29 Prob > chi² = 0.0410 | 1

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