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Rural Shadow Wages and Youth Agricultural Labor Supply in Ethiopia: Evidence from Farm Panel Data

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Abstract

The majority of the youth in Ethiopia live in rural areas where agriculture is the main source of livelihood. Using gender- and age-specific values of agricultural labor return (shadow wages), we systematically analyse trends, patterns and prospects of youth's labor supply in agriculture across space (farm locations). We also analyse whether the household male and female youth members' agricultural labor supply is responsive to economic incentives. We investigate these using shadow wages estimation techniques applied to farm-household panel data collected during the 2010/11 and 2014/15 agricultural seasons. The results indicate that trends and patterns of the youth's involvement in agriculture vary across gender and farm work locations, and so do their labor returns. Yet the on-farm participation for youth members is declining across time irrespective of gender, whilst their participation in off-farm activities is increasing. The findings also suggest that changes in agricultural shadow wages matter for the youth's involvement in the sector, but their impact differs for male and female youth. The results are consistent after controlling for individual heterogeneity, sample selection and instrumenting for possible endogeneity. In addition, we find that youth's intentions and actual engagement in agricultural production vary greatly. This suggests that the frequent narrative of youth disengaging from agriculture may be a result of methodological flaws or data limitations. Taking into account the intensity of the youth's involvement in family farm, own farm and off-farm work, the results challenge the presumption that youth are abandoning agriculture, at least in agricultural potential areas of Ethiopia. Instead the youth's involvement makes an important economic contribution to the operation of the family farm. Therefore, it is necessary to invest in agricultural development to enhance productivity and employment opportunities; and structural transformation that addresses the imperfections and rigidities in labor and other input markets to make agriculture more attractive to youth.

Keywords: youth, labor productivity, shadow wage, economic incentives, shadow income, agricultural labor supply

JEL codes: D13, J22, J23, Q12

1. Introduction

The composition of the population and its distribution across the globe indicates that Africa South of the Sahara (SSA) has the world's youngest population and is home to over 200 million young people (aged between 15 and 24 years). This trend is expected to continue for the coming decades. Seventy percent of youth reside in rural areas and are employed primarily in the agricultural sector (Omoti, 2012). This poses a great challenge for youth unemployment, but also an opportunity for youth to become the engine of the development of new agricultural enterprises in farming, research, processing, packaging, and retailing food stuffs. As is the case in most developing countries, agricultural labor in Ethiopia is mainly composed of unpaid family work and self-employment (CSA, 2005). Rural youth are the dominant contributors of agricultural labor and constitute the lion's share of the population of Ethiopia.

Literature on the analytical or empirical estimation of the labor demand and supply decisions of agricultural households in developing countries extensively uses the empirical advantage of separability (see for instance, Singah and Strauss, 1986; Barnum and Squire, 1979; Rosenzweig, 1980; Benjamin, 1992; Bezu and Holden, 2014; Ahaibw et al., 2013; Agwu et al., 2014). When labor markets are imperfect, a common feature of developing countries, including Ethiopia, empirical results based on such an approach are likely to mislead policy conclusions. Indeed, a growing literature has indicated that empirical findings cast doubt on the perfect substitutability of farm labor and demonstrate the importance of the gender division of labor as well as the inappropriateness of aggregating the different age groups of a household labor force. Specifically, existing studies on youth employment often suffer from methodological bias, data limitations and empirical inadequacy. Most studies use the aggregated or homogenous approach of measuring labor supply of agricultural households (Benjamin and Kimhi, 2006; Ahearn et al., 2006; Jacoby, 1993; Skoufias, 1994; Kien, 2009; Dupraz and Latruffe, 2015). As a result it is difficult to distinguish whether and to what extent labor is spent on-farm and/or off-farm and on which household members and age categories the analysis is focusing. In addition, the literature on youth's employment in agriculture is scant and the findings are inconclusive as to whether youth are leaving agriculture or not (Bezu and Holden, 2014; Ahaibw et al., 2013; Agwu et al., 2014). Furthermore, there is little empirical evidence documenting the rapidly changing number of working hours for different age cohorts and the subsequent effects on agricultural production and productivity (Calves and Schoumaker, 2004).

In fact, *closer examination* of the existing *literature* suggests that the recurrent narrative of youth exit from the agricultural sector does not reflect the trend and patterns of participation in agriculture but may rather arise methodological issues. Data limitations (especially the absence of panel data) and empirical inadequacy have also contributed to the inconclusive findings. Often the existing studies use stated intensions (for instance, intention to stay in or exit from agriculture, or having agriculture as a primary occupation) as an outcome variable rather than the actual time spent in agriculture in analysing youth participation in agricultural activities. The main problem with this type of analysis is its inadequacy to capture actual engagement of youth as well as other household members in agriculture across time, space and gender. Evidence shows also that actual engagement and intensions vary greatly (Omoti, 2012).

Methodologically, working with shadow wages allows to account for the simultaneity between production and consumption decisions of the household and its members (Deolalikar and Vijverberg, 1983, 1987; Jacoby, 1993; Skoufias, 1994; Schultz, 1999; Benjamin and Kimhi, 2006; and Chang et al., 2012). Non-separability may arise for several reasons: binding labor time constraints in off-farm employment, imperfect substitutability between family labor and hired labor; farmers or youth preference towards on-farm or off-farm employment, to list a few. For instance, Chang et al. (2012) argued that the validity of the separation method depend crucially on whether the availability of agricultural off-farm jobs is limited or not. As we will show empirically later, in line with Bedemo (2013), the non-separability assumption best fits the Ethiopian rural setting.

Migration history in Ethiopia also shows that rural youth prefer rural over urban destinations (CSA, 2013). A recent survey indicates that more than 55 percent of youth migrants in Ethiopia went to another rural areas, where they tend to find work on large farms or plantations as hired laborers (de Brauw, 2014). The same study indicates that those who migrate from urban back to rural areas account for 13 percent. These figures are also consistent with the recent national statistics on migration. This reflects that rural employment opportunities (e.g. off-farm labor) play a vital role as drivers of internal migration and as a source of livelihood for participating youth or households. Hence, it is important to analyse how off-farm employment is supporting the livelihood of the rural youth, how it has evolved over time and what explains this evolution.

There are several reasons why it is necessary to analyse the link between youth labor supply in agriculture and labor productivity in the presence of imperfect labor markets. First, agriculture is the main source of livelihood for rural people, including the youth. In addition, higher agricultural productivity and/or labor productivity make the incentive to move out of agriculture less attractive. As productivity increases, wages rise and thus labor supply increases. In some seasons and places, wages in agriculture are higher than wages in other sectors. Furthermore, the rising productivity in agriculture and rising urban unemployment is expected to force rural youth to migrate back to rural areas. There are well documented studies on the impact of out-migration on agricultural productivity or vice versa (de Brauw, 2014; Bezu and Holden, 2014). However, there is scant information on the link between labor productivity and the youth's labor supply. Second, youth individuals, especially those living with their parents are at the age in which they make decisions about when to finish their schooling (for those in school), where to work, and what type of work to pursue after their education is completed. Third, Ethiopian agriculture is manual labor intensive, and the youth are typically considered among the most productive manual laborers. Thus, it is crucial to analyse whether youth labor supply is responsive to economic incentives such as shadow wages. Finally, the household needs to use surplus labor time among its members to buffer household income and/or to reallocate family labor due to low on-farm returns, it is easy to do so using youth labor, especially for off-farm activities. Youth are less likely to migrate with children or the remainder of their family. The increasing trend of off-farm employment in rural areas is an indication of this (Bezu and Holden, 2014; Bachewe et al., 2016).

This suggests that it is important to look at whether and how the youth's labor supply in agriculture, on- and off-farm, is responsive to agricultural wages (rural shadow wages) and whether this differs across gender and labor categories. It is equally important to examine what factors determine these dynamics and whether agriculture could also be a potential source of employment and under what condition it offers opportunities for youth employment.

Our study goes beyond the previous studies in several ways. First, unlike the previous literature on the topic, we work with plot-level actual time spent by different members of the farming households, disaggregated by gender and age, across several years. We feel that this is an improvement from studies working with stated intentions of labor allocation or categorical definitions of the activities (e.g. "primary involved in agriculture"). This enables us to also examine the intensity of youth's participation in agriculture. Second, we apply the non-separability approach to estimate and analyse the agricultural labor supply of youth. This approach accounts for simultaneity between production and consumption decisions of the households and widespread labor market failures (Deolalikar and Vijverberg, 1983, 1987; Jacoby, 1993; Skoufias, 1994; Schultz, 1999; Benjamin and Kimber, 2006; and Chang et al., 2012). This approach provides better analysis and fit to the Ethiopian rural setting. Third, the panel data allows us to control for the possible sources of endogeneity, a common problem often unsatisfactorily addressed in the existing studies. Finally, migrant youth who left the household to work elsewhere were tracked and included in the analysis. This provides more accuracy in assessing youth involvement in agriculture across gender, space and time. It also avoids a selection bias in the sample of youth.

The objective of the study is twofold. First, we analyse the trends, patterns and prospects of youth's involvement in agriculture by gender and labor type (on-farm and off-farm). Second, we examine the determinants of youth's supply of farm labor. Specifically, we examine the effects of gender and age specific rural shadow wages on youth labor supply at farm-level in agricultural potential areas of Ethiopia. Our results suggest that trends and patterns of youth involvement in agriculture vary across gender and work locations, and so do their marginal products. In addition, changes in economic incentives such as agricultural labor returns (shadow wages) matter for youth involvement in agriculture, but the impact of it induces different outcomes for male and female youth labor supply. Our estimation approach tests the existence of separability - the hypothesis being strongly rejected in the estimation in favour of a non-separable model. Moreover, we find that actual engagement and intensions vary greatly, suggesting that narrative about youth exiting agriculture is founded on data, methods and models rather than effective trends and patterns. The remainder of the paper is organized as follows: part 2 is a brief description of the theoretical model. Part 3 presents the background and a detailed data description. Part 4 provides descriptive statistics. Part 5 describes the empirical estimation strategy for youth's labor supply functions. Part 6 presents the results of the econometric estimation and Part 7 tests the separability assumption. Finally, Part 8 concludes and discusses policy implications.

2. The theoretical model to estimate youth labor supply

Farm labor input differs not only between men and women, but also according to age, and so does labor productivity. Hence, we extend the notion of farm household time allocation model to estimate the labor supply of youth, disaggregating the farm household agricultural labor in terms of gender and age groups.

We use a utility maximization approach based on the model of structural time allocation of the agricultural household members (mainly youth male and female members) (Becker, 1965; Manser and Brown, 1980). In this approach resource allocation decisions (including time) of rural residents is a constrained optimization problem. The model employed here is a version of Gronau (1977) modified by Jacoby (1993) and employed by Skoufias (1994). Economic decisions such as supplying labor are significantly affected by choices made within households. Each type of labor input is specified as having a different effect on agricultural output and evolves over time. The model is thus non-separable by construction. We assume that a household consists of male mature members, male youth members, female mature members, female youth members and children. We further assume that male and female members' labor as well as youth and mature members labor are not necessarily substitutes. Hence, there would be labor quality differentials within households across gender and age groups. Similar to Lopez (1984), we are also explicitly considering cases where household members, including youth members, have preferences over working on or off-farm. Households allocate their time endowment (T) among at least four main activities: Leisure (L_i), household production (S_i), market work (M_i) and farm work (F_i); where subscript i indexes male (m) and female (f) youth members, mature members and children. The time devoted to market work yields a wage, which allows the purchase of market goods (G). The effective real wage for off-farm work, $W_{i,}$ is assumed to be constant. We further consider that household members jointly choose consumption of home and agricultural produced goods, market goods and household leisure time.

Time allocated to household production combined with other fixed inputs (denoted here by vector K) yields a household produced composite commodity (X) described by the production function:

$$X = X(S_{my}, S_{fy}, S_{mm}, S_{fm}, S_c; K) \qquad (1)$$

$$S = S_{mm} + S_{fy} + S_{mm} + S_{fm} + S_c \qquad (2)$$

Where $_{my,\ fy,\ mm\ fm}$ *and* $_c$ denotes male youth household members, female youth household members, male mature household members, female mature household members and children, respectively.

The household produced commodity X is assumed to be a perfect substitute with the composite agriculture commodity that is either produced by the household or purchased from the market. The production function for the composite agricultural commodity produced by the household is specified as:

$$\Gamma(F_{my}, F_{fy}, F_{mm}, F_{fm}, F_c,\ H_{my}, H_{fy}, H_{mm}, H_{fm}, H_c; A) \tag{3}$$

Where Γ a concave function; F denotes family labor; H denotes hired labor; subscript *i* is as defined earlier; A is a vector of fixed factors such as land. Hired labor for the different groups is paid at the corresponding real wage rates W_i^h. In addition, due to transportation or transaction costs, the wage received by family members participating in off-farm may differ from the wages paid out to hired labor (i.e. $W_i \neq W_i^h$). Given this set of information, households are assumed to choose G, S_i, F_i, M_i, H_i so as to maximise their utility:

$$Max\ U(C, L_{my}, L_{fy}, L_{mm}, L_{fm}, L_c; \boldsymbol{Z}) \tag{4}$$

Subject to

$$C = G + X \tag{5}$$

$$X = X\left(S_{my}, S_{fy}, S_{mm}, S_{fm}, S_c; K\right) \tag{6}$$

[1]

$$G = \Gamma\left(F_{my}, F_{fy}, F_{mm}, F_{fm}, F_c,\ H_{my}, H_{fy}, H_{mm}, H_{fm}, H_c; A\right)$$

$$- \sum_{i=1}^{5} W_i^h H_i + \sum_{i=1}^{5} W_i M_i + \mathbf{I} \tag{7}$$

[2]

$$T = L_i + H_i + M_i + F_i \tag{8}$$

$$M_i \geq 0 \qquad \text{i} = \{my, fy, mm, fm, c\} \tag{9}$$

Where C is total household consumption; Z is a vector of individuals (groups) or household characteristics influencing preferences; $\boldsymbol{I}$ is real non-labor income (transfers, gifts, remittances, etc) and i is as defined earlier.

Substituting some of the constraints into the utility function specified in Eq.(4), the Lagrangean function can be formulated as follows:

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[1] Can be expressed as $X = X\left(S_{my}, S_{fy}, S_{mm}, S_{fm}, S_c; K\right)$ in its long form.

[2] $\sum_{i=1}^{5} W_i^h = W_{my}^h + W_{fy}^h + W_{mm}^h + W_{fm}^h + W_c^h$ in its long form

$$U[G + X(S_{my}, S_{fy}, S_{mm}, S_{fm}, S_c; K), T - S_{my} - M_{my} - F_{my},\ T - S_{fy} - M_{fy} - F_{fy},$$
$$T - S_{mm} - M_{mm} - F_{mm},\ T - S_{fm} - M_{fm} - F_{fm}, T - S_c - M_c - F_c); \mathrm{Z}]$$
$$+\lambda \begin{bmatrix} \Gamma(F_{my}, F_{fy}, F_{mm}, F_{fm}, F_c,\ H_{my}, H_{fy}, H_{mm}, H_{fm}, H_c; A) \\ - \sum_{i=1}^{5} W_i^h H_i + \sum_{i=1}^{5} W_i M_i + \boldsymbol{I} - G \end{bmatrix} + \sum_{i=1}^{5} \mu_i M_i \qquad (10)$$

Where λ and μ are the lagrangean multipliers associated with the income inequality constraint and inequality constraints on market work of each labor type (i.e. $M_i \geq 0$), respectively.

Maximising the lagrangean with respect to F_i,S_i,H_i,M_i where $i = my, fy, mm, fm, c$) results the following first order condition[3]:

$$\frac{\frac{\partial U}{\partial L_i}}{\frac{\partial U}{\partial C}} = W_i^* = W_i + \mu_i/\lambda \qquad (11)$$

$$\frac{\partial \Gamma}{\partial H_i} = W_i^h \qquad (12)$$

$$\frac{\partial \Gamma}{\partial F_i} = W_i^* \qquad (13)$$

$$\frac{\partial \mathrm{X}}{\partial S_i} = W_i^* \qquad (14)$$

Where W_i^* is a "shadow wage rate" of labor type i $\in \{my, fy, mm, fm, c\}$. Equation (11) states that household will equate the marginal rate of substitution between consumption and leisure of family labor type i and the ''shadow wage rate'' W_i^* of labor type i. Equation (12) state that hired labor will be utilized until the marginal product of hired labor of each gender and age category is equal to the wage rate paid out to hired labor. Similarly, Equation (13) and (14) implies that at the optimum, family labor of type i on farm will be utilized up to the point where the marginal productivity on the farm or at home is equal to the respective shadow wage rate. If a person is working in the market then his/her shadow wage rate will

[3] We assume that members participate in non-leisure activities to obtain the optimal choices. For details on this we refer the reader to (Skoufias, 1994).

be equal to the respective market wage rate W_i for that gender and age group (i.e. $W_i^* = W_i$), since the complementary slackness condition requires that $\mu_i = 0$ if $M_i > 0$. In contrast, if a person is not working in the labor market, then the shadow wage rate[4], W_i^*will be in general greater than Wi (Skoufias, 1994) because $\mu_i \geq 0$ if $M_i = 0$. In the later case (i.e. $M_i = 0$), the optimum will occur at $\frac{\frac{\partial U}{\partial L_i}}{\frac{\partial U}{\partial C}} = W_i^*$, see Eq(11) indicated above. Under this condition, the market wage rate W may underestimate the opportunity cost of time of such households. Thus, at the optimum we can redefine the full income of the household as follows:

$$\boldsymbol{I}^* = \max_{h_i F_i}\{\Gamma(F_{my}, F_{fy}, F_{mm}, F_{fm}, F_c,\ H_{my}, H_{fy}, H_{mm}, H_{fm}, H_c; A) - \sum_{i=1}^{5} W_i^h\, H_i \sum_{i=1}^{5} W_i^*\, F_i\} + \max_{S_i}\{\mathrm{X}(S_{my}, S_{fy}, S_{mm}, S_{fm}, S_c; K) - \sum_{i=1}^{5} W_i^*\, S_i\} \boldsymbol{+ I} \quad (15)$$

Linearizing the budget constraint at the optimum allows one to reformulate the leisure hours for each family labor type as the solution to a traditional model of family labor supply. Thus, the equilibrium solution can be expressed as:

$$Max\ U[G + X^*, L_{my} L_{fy} L_{mm} L_{fm}, L_c\ \mathbf{Z}] \quad (16)$$

Subject to the constraints

$$G + X^* + \sum_{i=1}^{5} W_i^*\, L_i = \boldsymbol{I}^* + \sum_{i=1}^{5} W_i^*\, T_i \quad i \in \{my, fy, mm, fm, c\} \quad (17)$$

The left hand side of (17) is the value of total expenditure on goods and leisure with X* denoting the amount of X commodity produced at the optimum; H_i^* , W_i^*, being the shadow values of time defined above. The right hand side of the equation (17) is the "shadow full income". The solution to this revised utility maximization problem results in the structural demand functions for leisure or the corresponding structural labor supply functions of the following form, respectively:

$$L_i^* = L_i(W_{my}^*, W_{fy}^*, W_{mm}^*, W_{mf}^*, W_c^*, I^*;\ Z) \quad (18)$$

$$D_i^* = D_i(W_{my}^*, W_{fy}^*, W_{mm}^*, W_{mf}^*, W_c^*, I^*;\ Z) \quad (19)$$

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[4] At the equilibrium point, the shadow wage of each farm worker is the marginal product of their labor in farming (Jacoby, 1993).

Where $D_i^* = T - Li = F_i^* + S_i^*$; if Mi*=0 (20)

$D_i^* = T - Li = F_i^* + S_i^* + M_i^*$; if Mi* >0 (21)

Where D_i^* refers to the total working days for family labor of type *i* spent on-farm and off-farm (market work) and labor days allocated to the production of the composite commodity X. For simplicity D_i^* refers to total labor days spent on production of crops on-farm and off-farm, aggregated from each parcel and crop at household level for the respective gender and age categories, and we exclude labor days allocated to animal production in the empirical analysis.

In practice, an estimate of shadow wage rate W_i^* could be obtained either from marginal product of each type of family labor in agricultural production or from the marginal product of family labor in the production of commodity X. Since we have collected detailed information on crop production (disaggregated by age and gender), we estimate the marginal product of family labor from the parameters of the agricultural production. This is particularly useful in estimating the value of time for household members such as youth students and domestic workers who do not sell their labor time. The detailed estimation method is presented in the empirical analysis. Note that the core difference between labor supply derived from this framework and the one derived from the more conventional labor supply model using the observed market wages and full income, is that W_i^* and I^* are endogenous variables since both are correlated with the unobservable characteristics. This is because of the fact that the estimated marginal productivities of each family labor depend on their respective actual days of work causing the causality to run from the hours worked to the estimated wages as well. In order to control for reverse causality in estimation (working days to wage), we estimate the labor supply equation (19) using fixed effects instrumental variables (FE-IV), a point we will discuss later with the empirical estimation.

3. The data set

This study is based on a household and youth panel survey conducted in Oromia region, one of the largest regions in Ethiopia, in woredas selected for Agricultural Growth Program (AGP). Increasing smallholder productivity and value-addition in the agricultural sector are core elements of the Ethiopian government's approach to poverty reduction. The program is a component of this broad effort. The AGP is a five year program to increase agricultural productivity and market access for key crop and livestock products in agricultural potential areas of Ethiopia with increased participation of women and youth (AGP baseline report, 2011). The program focuses on agricultural productivity growth in four major regions (Oromia, Amhara, SNNP and Tigray) deemed to possess high agricultural growth potential that can be realized with appropriate interventions. The AGP has two main components: agricultural production and commercialization, and small-scale rural infrastructure development and management. The base survey covered 93 woredas (305 enumeration areas) called AGP sites from Oromia, Amhara, SNNP and Tigray regions. In these woredas, crop production and animal husbandry are the main livelihood means for households. In addition, off-farm employment opportunities play a vital role in the livelihood of households. We built on a baseline study of 926 households from Oromia region that were surveyed in 2010. The base survey was conducted by the collaboration of Central statistical Authority (CSA) of Ethiopia and Ethiopian Strategic Support Program (ESSP) of the International Food Policy Research Institute (IFPRI) during July 3-22, 2010. AGP participating woredas were selected based on multiple criteria: agricultural potential or productivity, access to market (access to cities of 50,000 population or over in less than 5 hours), natural resource endowment, suitable rainfall and soil for crops and fodder production, potential for development of small-scale irrigation facilities, and institutional plurality of service providers such as cooperatives and farmer groups.

Of the original 926 AGP households in Oromia region, 525 who have at least one youth member were randomly selected and surveyed again during December 2014 and January 2015. We purposively selected Oromia region out of the four AGP regions. Of the original 27 AGP woredas in the region, we covered only 12 randomly selected AGP woredas. Due to cost and time related factors we predetermined to cover 12 woredas. Each woreda contains 3 enumeration areas (EAs). Thus, a total of 36 enumeration areas spread out among the 12 woredas were covered during the follow-up survey. In each woreda 78 households were covered during base survey. The selection of households for this study were identified using (stratified) multistage random sampling based on the following additional criteria: youth population density, youth migration history, the desired number of respondents, availability of youth members in the household during base survey, possibilities of tracking migrant youth, and the sample sizes in the fresh list of selected AGP, because a sufficient sample size was needed to account for unavailable respondents (who may have migrated or died during the interim). This study focuses exclusively on households who have either youth members or youth household heads. The AGP baseline slightly oversamples households headed by both young and mature females relative to their share implied by census survey in 2007. Since the original survey was designed with multiple objectives, detailed information on the amount of time allocated per each youth individual per plot was not available. Nevertheless, time allocated per plot for the respective gender and age groups (i.e. disaggregated by gender and farm plot) within the household were available upon which the second round survey built on for the estimation of youth labor supply in agriculture. It was possible to construct a panel data set since AGP baseline collected detail information on labor allocation of household members disaggregated by gender and farm plot.

Following the selection of the 12 woredas, the next step was to determine the survey sample households. Once complete lists of the households in each selected AGP woreda were prepared from the base survey, households without youth members were dropped from the listing. After carefully preparing fresh list of households with youth household head and youth members [based on AGP baseline data], on average, 44 households per woreda were randomly selected based on probability-proportion-to-size sampling to maintain an equal distribution of sample respondents in each woreda. Put differently, given our interest in youth labor supply in agriculture, determination of sample size, and apportionment of the sample households per the 12 selected woredas were based on a proportional sampling technique. One of the main challenges in the process was how to allocate the survey samples across enumeration areas, for which a proportional sampling method was used. This follow-up survey was determined to survey about 525 households (with the expectation to address about 2100 youth individuals) from the 12 AGP woredas. Of the 926 original households in Oromia region, 525 households were surveyed again during the months of December 2014 and January 2015. Based on the list of names from the baseline survey, the number of households selected was based on $\left(\frac{N}{n}\right)th$, where n denotes the current sample size and N denotes the base year sample size (limited to households with youth members). A complete list of households was used to select the survey respondents.

Once the required sample per the randomly selected woredas were determined, the respective woreda and kebele administrators were consulted to determine the availability of sample households. Reappointment was made if member of the qualified households were not available at the time of appointment. In cases of unavailability of sample households due to death or difficulty to track for those who moved, the next household on the contingency list was chosen as a replacement. Youth migrants were identified from the household survey as either youth (siblings) of the household head or youth household members who left the household to work elsewhere (rural, urban) for at least 3 months during the year. In some instances, migrant youth were tracked and interviewed (the success rate was so low, about 20 percent). These were included in the analyses of off-farm labor supply. We have also checked whether attrition resulted from migration of youth biases our estimation or not. We find that over all the main characteristics (or observables) of migrant youth (i.e. those we were not able to track) are similar in other respects to youth with complete data (i.e. youth who are covered during the second round) (see Appendix Table A). The results are annexed. Accordingly, a total of 525 households (202 youth household heads and 323 mature household heads) who have at least one youth member were surveyed again (Table 1). Due to missing key variables (such as income, education) for some households, only 2044 youth individuals from 520 households in 36 enumeration areas of Oromia region were used in the analysis. For robustness check and different study, a subsample of 659 youth from the same household were randomly selected during the second wave and used for individual labor supply analysis (a total of 1320 individuals from the two waves).

There is no consensus regarding the age bracket that defines youth. For instance, UN defines youth as persons within the age interval of 15 to 24. The African Youth Charter extends the upper age bracket to 34(thus, defines youth as persons between the ages of 15-35) (UN, 2014). The Ethiopia's National Youth Policy defines youth as persons between the ages of 15-34. Given the Ethiopian rural context, especially children's contribution to the household income and in line with Ethiopia's National Youth Policy, in this paper we define youth over the age interval of 13 to 34. Distribution of households and youth across the sample woredas is presented in Table 1. The geographic location of the study sites are presented in Figure 1.

Table 1: Ethiopian study areas, sample sizes and distribution across the study areas

Woreda	EAs per woreda	AGP sample	Number of sampled Youth headed households	Number of sampled mature headed households	no of sampled youth members (for household based analysis of youth labor supply)			no of sampled youth members (for individual based analysis of youth labor supply)			Average number of youth per sampled household		
					Male	Female	Total	Male	Female	Total	Male	Female	Total
Shirka	3	109	16	37	127	95	212	62	47	109	1.2	0.9	2.0
Agarfa	3	122	21	33	130	108	248	66	56	122	1.2	1.0	2.3
Dugda	3	70	17	15	77	64	141	37	33	70	1.2	1.0	2.2
Guduru	3	109	11	24	105	112	217	52	57	109	1.5	1.6	3.1
Jima Rare	3	132	16	34	130	140	260	64	68	132	1.3	1.4	2.6
Bedele Zuriya	3	108	16	31	122	94	216	59	49	108	1.3	1.0	2.3
Gechi	3	121	18	30	125	115	240	64	57	121	1.3	1.2	2.5
Limu seka	3	95	20	29	98	88	186	50	46	95	1.0	0.9	1.9
Abichugna	3	108	14	31	108	108	216	55	53	108	1.2	1.2	2.4
Weliso	3	75	17	17	82	68	150	42	33	75	1.2	1.0	2.2
Dinsho	3	110	22	26	86	134	221	44	65	110	0.9	1.4	2.3
Dendi	3	61	14	16	60	60	120	30	30	61	1.0	1.0	2.0
Total	36	1217	202	323	1022	1022	2144	695	592	1320	1.2	1.1	2.3

Source: Own computation based on AGP baseline survey

Figure 1 below depicts the target woredas and the distribution of AGP woredas covered during the two rounds of the survey.

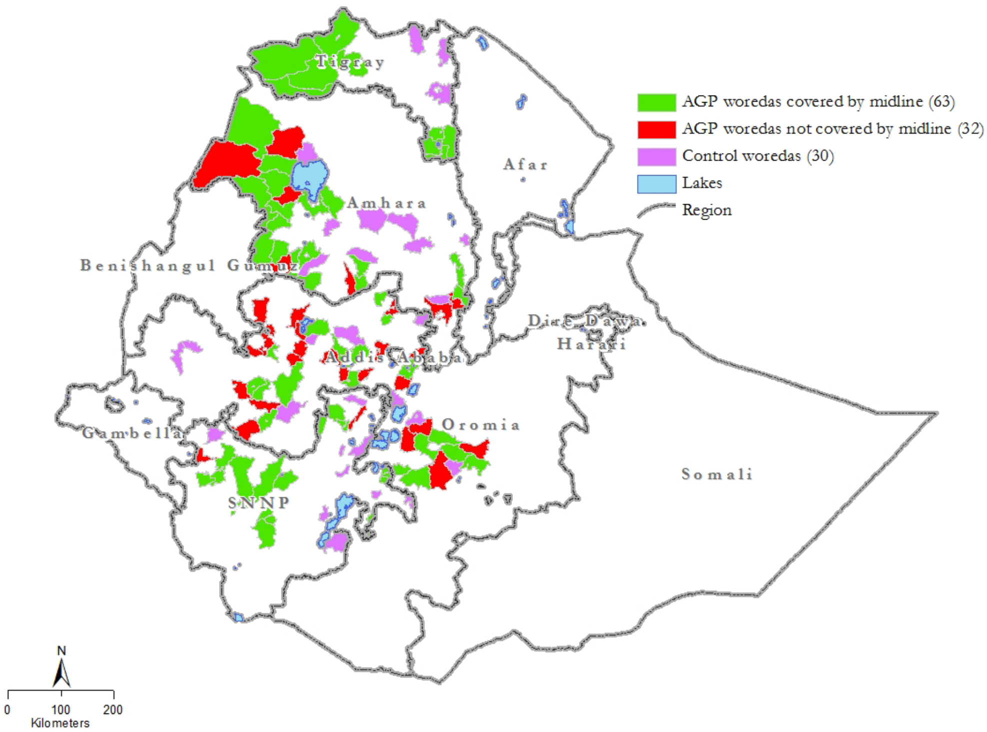

Figure 1: AGP woredas

The primary research had three phases: first, focus group discussions to understand the context and to examine how households allocate youth labor and other family members; second, a pre-test of the added questions to the survey modules that was not included during the baseline study; third, the formal survey. Two types of questionnaires were administered to one household: head questionnaire and youth questionnaire. The survey collected detail information on youth characteristics, household characteristics, wealth, agricultural production such as farms, production inputs including detail labor allocated to each plot and crop for household members (categorized by age, gender and farm type) and other inputs, outputs, plot tenure, and other farm characteristics and off-farm activities. We aggregated labor hours spent on-farm and off-farm into adult equivalent labor days (AELD)[5] from each plots and crops at household for the respective age and gender categories. The aggregation method is presented in annex 3. Community questionnaire to capture community level

[5] One AELD represents 8 hours. An adult equivalent labor day equals the amount of labor an adult male spent during a working day. Adult equivalent labor days were obtained as a weighted sum of labor days reported for adult males (weight=1), adult females (weight=0.84) and children below the age of 14 (weight=0.48). It is important to note as a caveat that the labor days reported by respondents were not necessarily equal to full working days in every case. It is also unlikely that these days were identical across crops and/or activities. Labor allocation for the respective gender and age groups for the respective household was obtained at plot level in working days and later converted to adult equivalent labor days (AELD) at household level. Information on household members' labor utilization per plot per crop was collected for the main agricultural production season (meher season) and only for crop production. It was then aggregated into total AELD per household per farm type (on-farm and off-farm) for the respective gender and age group. The exclusion of household labor utilization during the Belg season (short rainy season) may underestimate the total supply of labor.

characteristics was administered separately. Enumerators familiar with Computer Assisted Personal Interviewing (CAPI) technique were recruited and provided intensive training prior to data collection. The use of CAPI helps to ensure the quality of our data by preventing measurement error, maintaining consistency and avoiding missing data.

4. Descriptive statistics of youth and household head

In this section we provide the descriptive statistics for main variables of interest. Table 2 provides basic overview statistics of the youth and household in the sample. As expected, our sample contains more male youth than female. We found that 66% of youth in our sample who live with their parents at the time of baseline study has decreased to 62%. Migration and marriage are the two main reasons for this change. On average, youth in our sample have completed three years of education at the time of baseline study. The average years of education of the youth in our sample at the time of second round survey were four. The average number of youth per household was about 2.

Table 2. Main characteristics of youth and household head

	2011	2015
Youth characteristics		
Male youth (%)	61.02	59.05
Female youth (%)	38.98	40.95
Youth household headed (%)	34.25	38.48
Live with parents (%)	65.75	61.52
Average education of the youth (years)	2.54	3.78
Average number of youth per household	2.39	2.23
Household head characteristics		
Average education of the household head (years)	1.63	1.92
Household head is male (%)	72.44	69.90
Household head is female (%)	27.56	30.10

Source: survey results

As indicated in Table 3 trends and patterns of youth participation in agriculture vary by gender. For instance, 63% of male youth members' main occupation was farming (full-time farmer either on own-farm or family farm) in 2010; while it was about 39% for female youth members. Main occupation here refers to the main activities of the youth. In 2015, about 68% and 42% of male and female youth members' reported full-time farming on either their own or family farm as their main occupation, respectively.

On average, 2014/15 on-farm labor supply for both male and female youth members is declining compared to 2010/11 agricultural season; whereas off-farm labor supply is increasing for both. In 2010/11 meher[6] season, the average labor days (in AELD) used on on-farm for all crops cultivated for male and female youth members at household level were 57 and 20 labor days (in AELD), respectively. In 2014/15, these figures have decreased to 52 and

[6] Meher season is the main agricultural season linked to long rainy season from May to January. It accounts for about 90-95% of the annual crop production of Ethiopia.

15 labor days for male and female youth members, respectively. In 2010/11 meher season, on average, a household utilized about 6.93 labor days (in AELD) which were contributed by male youth members and 6.24 labor days contributed by female youth members in off-farm[7] activities. However, in 2014/15 meher season, the average household level labor supplied to off-farm for male and female youth members have increased to 10.39 and 7.01, respectively (Table 4). Whilst there is an increasing trend in total labor supply (which is the sum of labor days supplied to on-farm and off-farm during meher season by male youth, female youth, male mature, female mature and children) at household level, there is a decreasing trend in labor demand (the sum of labor used on the farm in AELD including hired labor).

Table 3. Summary of main occupation as reported by the youth

Main occupation	2010			2015		
	Male youth (%)	Female youth (%)	All youth (%)	Male youth (%)	Female youth (%)	All youth (%)
Full-time Farming (own or family)	63.34	38.77	54.46	68.58	42.73	58.42
Off-farm	1.5	3.08	2.07	4.24	11.45	6.53
Student	35.16	58.15	43.47	27.18	45.81	35.02

Source: survey results

Table 4: Average youth members and household labor supply and demand per hectare (in adult equivalent labor days-AELD) for main agricultural season

	Male youth members Contribution per household		Female youth members contribution per household		Household	
Year	On-farm	Off-farm	On-farm	Off-farm	Total demand	Total supply
2010/11	69.88	6.93	20.31	6.24	95.92 (102)	109.67
2014/15	63.98	10.39	15.28	7.01	94.62	112.41
Total	65.60	8.66	16.91	6.77	95.26	111.07
Mean diff	-5.24	3.46	-5.03	0.77	-1.29	3.74
P-value	0.25	0.13	0.05	0.51	0.41	0.34
N	1159	1159	1022	1022	1022	1022

Source: Survey results

Note: Total household labor is the sum of on-farm and off-farm labor supply of all household members per household. The null hypothesis is that the mean difference between the two years agricultural seasons is zero, i.e. Diff = mean (2014) - mean (2011)=0.

The summary of reports regarding youth intensions to engage in agriculture during base survey in comparison to their actual engagement after five years is presented in Table 5. In

[7] off-farm in this context includes off-farm farming employment, business and other income generating activities

2010/11 (at the time of base survey) youth were asked about their career intentions/plan, given their current occupation. After five years, they were asked again their realized occupation. As one can see from Table 5, only 32% of youth respondents during base survey had been considering agriculture employment as their intended occupation. Contrary to their intentions, however, a significantly higher percent (51%) of them have ended working in agriculture in 2014/15. This means that a significant number of youth were not able to find employment outside agriculture and fail to work in line with their preferences. In 2014/15, the respondents were asked again about their future occupation preferences. About 28% of the youth sample are considering agriculture as their future occupation. It's also interesting to note that in 2010/11, 12% of youth respondents' main occupation was off-farm (such as farm wage employment, businesses and other non-farm income generating activities). Although 26 % of survey respondents had planned to work in off-farm by 2014/15, only 14% of them have succeeded. The intention to work in off-farm activities is somehow in line with the actual engagement, however, there is still a mismatch between youth intention and actual engagement. These suggest that youth intentions and actual engagement vary greatly. Thus, some studies who have found evidence that youth are abandoning agriculture (based on intentions than using actual engagement as outcome variable) would be misleading and result in methodological flaws. We find less discrepancy between youth's intention to study and actual enrolment. It's also interesting to note that youngsters who are currently working (who are dropouts at the time survey) are planning to go back to school (as reflected by higher number of youngsters with future intentions to study are greater than the number of current students) (Table 5, row 2).

Table 5. Youth livelihood occupation: actual engagement and intensions

	Livelihood occupation (% of their respective category)											
	During base survey						During follow-up survey					
Category	Main occupation (actual engagement): 2010/11			Intended/planned occupation: 2010/11-2014/15)			Main occupation realised (actual engagement): 2014/15			Future occupation (intended/planned occupation) from 2015-2020		
	Male	Female	All	Male	Female	All	Male	Female	All	Male	Female	All
Farming	43	23	34	42	20	32	62	37	51	35	18	28
Student / further study	33	56	42	35	56	42	28	46	35	34	59	42
Off-farm	8	10	12	21	20	26	10	17	14	31	23	30

Source: Survey results

Note: off-farm in this context includes off-farm farming employment, business and other income generating activities. The sum of the percentage figures may not add 100 as the percentage figures exclude unemployed youth and those who said don't know.

Different factors have contributed to the mismatch between what was planned and achieved and part of the underlying factors has resulted in increased participation of youth in agriculture. These include demand for family labor (60%), absence of other viable means of livelihood in the areas (19%) and profitability of agriculture (12%).

Summary of variables used in the estimation of agricultural production function is presented in Table 6.

Table 6: Definition, Mean and standard deviation of other variables used in the estimation of the agricultural production: main agricultural season

		2010/11		2014/15	
Variable	Variable descriptions	Mean	Standard deviation	Mean	Standard deviation
Totoutput	Total output value in 2011 prices-crop only	10812.89	24909.85	13431.54	24650.95
MYL	Total working days of family labor contributed by male youth members (in AELD)	69.05	58.19	63.04	84.75
FYL	Total working days of family labor contributed by female youth members (in AELD)	21.31	31.73	20.28	28.34
AML	Total working days of mature family labor contributed by male members (in AELD)	50.06	43.25	26.98	39.44
AFL	Total working days of mature family labor contributed by female members (in AELD)	16.17	16.43	19.72	25.78
CL	Total working days of family child labor (in AELD)	5.82	12.62	6.44	12.64
THHL	Total working days contributed by all members of the household in AELD (MYL+FYL+AML+AFL+ CL)	114.38	101.26	106.96	126.55
HL	Total hired labor days	6.06	20.94	14.37	78.75
OXEN	Total oxen owned (TLU)	1.78	2.49	2.18	2.62
AREA	Total cropped areas in hectares	2.08	3.18	1.66	2.165
SEEDVAL	Value of seeds (2010/11 birr)	277.00	734.37	309.59	834.31
FERRVAL	Value of fertilizer (2011 birr)	740.96	1164.15	802.84	1344.83
WEEDVAL	Value of seeds	46.55	193.411	53.49	220.80
Extension	Frequency of extension visits	0.88	1.88	0.86	1.87
Expert	Frequency of expert visit per crop calendar	1.79	0.40	1.80	0.39
Age_head	Age of household head in years	41.71	15.18	43.09	15.30
Sex_head	Sex of head of the household (1=male; 2=female	1.27	0.44	1.30	0.45
Educ_head	Education of the household head in completed years	1.63	2.67	1.96	2.94
Age_youth	Average age of the youth in completed years	19.37	6.63	22.22	6.07
Educ_youth	Average education of youth in completed years	2.51	2.58	3.86	3.24
Number of households		521		511	

Source: Survey results Note: All value variables such as asset values, and others are deflated to 2011 prices.

5. Empirical analysis

Most agricultural labor studies in developing countries rarely analyse the agricultural labor supply disaggregated by gender and age group. To estimate labor supply of youth members in agricultural households, our empirical estimation strategy relies on the use of shadow wages. The use of shadow wages accounts for simultaneity between production and consumption decision of the households and widespread labor market failure. Following Jacoby (1993), Skoufias (1994) and Chang (2012) the estimation of youth labor supply consists of three main steps.

First, we obtain the estimates of the marginal productivities of the different family labor[8] (male youth, female youth, male mature, female mature and children) and hired labor estimated from a Cobb-Douglas (C-D) production function specified as heterogeneous inputs. C-D production function is widely used in developing countries mainly because of its simplicity to interpret and compute the parameters of interest. However, C-D production function has limitations in functional specification, simplest assumption of homogeneity, sensitivity to the choice of inputs and it restricts that marginal rate of technical substation depends only on the ratios of labor inputs and not on other inputs. Consequently, C-D production function assumes substitution is between labors only. However, in reality farming machines may substitute labor, hence we need to use interactions such as labor with farm implements.

To complement our findings, we replicated the analysis using the more flexible functional form of production function such as the translog. The use of translog helps to overcome this inherent limitations of C-D production function but it's difficult to estimate. Both production functions require intensive data and computation. Since neither measure is perfect, we adopted also Kien (2008) approach of estimating shadow wages and shadow income which does not require the estimation of production function (see Kien, 2008 for the details). Kien (2008) proposed an alternative approach to estimate the shadow wage based on the observation that the shadow wage is the marginal product of labor at optimal point of both farm and household production functions without estimating the production function for the analysis of agricultural labor supply regardless of market failures. He suggested the use of expected output instead of estimating the predicted output from the production function. Advantages of his approach incudes less data requirement, requires no assumption on the functional form and reduces errors from estimating the production function that will contaminate shadow wage. It should be noted, however, that the two approaches to the estimation of shadow wages are based on developing a time allocation model and the key observations come from the fact that the shadow wage is the value of the marginal product

[8] The labor working days are collected at plot level, but aggregated to household level

of labor at the optimal point on the production function curve. The estimation results from translog and Kien approach are available upon request.

Multiple crop outputs are aggregated into a single output measure using the medians of their reported prices within each villages. We considered only crop output and didn't include livestock products such as the sales of dairy, skins and hides, and other animal products. We checked the robustness of our results by including these output values for whom the data was reported and found similar conclusions. We included draught animal as an input into the production of crops.

We specify the C-D production function as:

$$\ln Y_{(h,t)} = \sum_{j=1}^{5} \beta_j \ln X_j(ht) + \beta_6 \ \ln(K_{ht}) + \beta_7 \ln(F_{ht}) + X_{it}\theta + \mu(h) + \tau(t\ ) + \varepsilon(_{h,t}) \quad (22)$$

Where $\ln Y_{(h,,t)}$ denotes the total value of agricultural crops produced by farmer h in year t; β_j's are parameters to be estimated(the marginal productivity of labor category j), Xj (h,t) is the total quantity of labor input used and/or contributed by members (youth, mature and children disaggregated by gender) in household h in year t; K_{ht} is the value of other variable input[9] used by in household h in year t; F_{ht} is set of fixed inputs used by household h in year t; X_{it} is a vector of household and youth observable characteristics in year t and $\mu(h,k)$ is household fixed effect that captures the time invariant household-specific heterogeneity that can arise from the omission of some key variables such as household managerial or soil characteristics;; $\tau(t,k)$ is a year effect common to all households such as rainfall and the last term $\varepsilon(_{h,t})$ is a random disturbance term. All variables measured in monetary terms such as output, seed and other inputs are deflated to 2011 prices. We use both the fixed effects and random effects specification for comparison. District-level fixed effects are applied to all estimations in order to account for the factors of this nature that are invariant within districts and that could bear influence on gendered productivity levels. Standard errors are clustered at household level in order to account for correlation individuals situated in the same household.

Second, based on the coefficients estimated from equation (22), the shadow wage rates for male and female youth members' labor days in household *h* in year *t* are derived using the following expressions:

[9] In general inputs include fixed inputs such as land and variable inputs such as labor disaggregated by age category and gender, fertilizer, improved seeds, local seeds, irrigation, extension services and oxen draught.

$\widehat{W}^*_{my}(h,t) = \frac{\hat{Y}_{(h,,t)}}{MYL(h,t)}\widehat{\beta_{MYL}}$ and (23)

$\widehat{W}^*_{fy}(h,t) = \frac{\hat{Y}_{(h,t)}}{FYL(h,t)}\widehat{\beta_{FYL}}$ (24)

Where $\widehat{W^*_{my}} \& \widehat{W^*_{my}}$ are shadow wages for male and female youth members, respectively; $\hat{Y}_{(h,k,t)}$ denotes the fitted value of output for household h in year t; MYL is total working days of family labor contributed by male youth members in year t; FYL total working days of family labor contributed by female youth members in year t; $\widehat{W^*_{my}} \widehat{\& W^*_{fy}}$ are shadow wages for male and female youth members derived from the estimated coefficients of $\widehat{\beta_J}$ referred in equation (22) above (it refers to the marginal productivity of labor); subscripts *my* and fy denote male and female youth members in household h in year *t*, respectively .

Similarly, the shadow wage rates for male and female mature members' labor days in the household h in year t are derived as follows:

$\widehat{W}^*_{mm}(h,t) = \frac{\hat{Y}_{(h,t)}}{AML(ht)}\widehat{\beta_{AML}}$ and (25)

$\widehat{W}^*_{fm}(h,t) = \frac{\hat{Y}_{(h,t)}}{AFL(h,t)}\widehat{\beta_{AFL}}$ (26)

Where *mm* and *fm* denotes male and female mature members in the household h, respectively; AML is the total labor for male mature members' (excluding male youth labor) and *AFL* is total labor for female mature members' (excluding female youth labor); the rest as defined earlier.

Once we estimate the shadow wages, the next step is the estimation of shadow income $\hat{I}(h,t)$ of the household, h to which the youth belong. This can be derived from the expression:

$$\hat{I}(h,t) = \hat{Y}_{(h,,t)} - \widehat{W}^*_{my}(h,,t) * MYL(h,t) - \widehat{W}^*_{fy}(h,t) * FYL(h,t) - \widehat{W}^*_{mm}(h,t) * MML(h,t) - \widehat{W}^*_{fm}(h,t) * MFL(h,t) - W_{my}(h,t) * HMYL(h,t) - W_{fy}(h,t) * HFYL(h,t) - W_{mm}(h,t) * HAML(h,t) - W_{fm}(h,t) * HFYL(h,t) - W_{ox}(h,t) * OXEN(h,t) - SEEDVAL(h,t) \; - OTHERINP(ht) + \Pi\mathrm{p}(\mathrm{h,t}) + \mathrm{V}(\mathrm{h,t}) \quad (27)$$

Where W_{my}, W_{mm}, W_{fy}, W_{fm}, W_{ox} are the village average wage rates for male youth, male mature, female youth, and female mature and oxen labor services, for household h, in time t, respectively. $\Pi\mathrm{p}(\mathrm{h}, \mathrm{t})$ is the sum of net returns from the sale of livestock products, livestock sales and off-farm income and $\mathrm{V}(\mathrm{h}, \mathrm{t})$ is income from land rent, oxen rent, handicrafts, business (trade) and transfers received by household h in year t.

The third stage of estimation[10] is the estimation of male and female youth members' labor supply, i.e. total working (labor days) in AELD used on-farm and off-farm are regressed on the shadow wage rates and shadow income. In other words, the shadow wages and shadow income in step two is inserted into labor supply for estimation. We aggregated working days spent on each plot for crop production [agricultural activities] for the respective male youth, female youth, male mature, female mature and children of farm household to household level. Since our main focus is on the trend and analysis of factors affecting labor supply, these aggregation may not necessarily affect the core objective of our analysis. We matched these working days (aggregated per sex and per age group per household) with shadow wages and income estimated in the second stage of the analysis together with youth and household head demographic, asset information and other variables. Excluding some observations for which some data is missing, we end up with a total of 1015 observations on male youth members, and 1011 observations on female youth's members for the estimation at household level.

In computing our measure of youth labor supply in agriculture, we generally categorized time spent into: on-farm, off-farm and total (which is the sum of both on-farm and off-farm labor supply). In 2010/11 agricultural season, it was reported that 23% of households have experienced participation in off-farm wage employment either through the head, spouse or youth members and this figure has increased to 28% in 2014/15 agricultural season. As to the off-farm participation of male youth members, 8% and 10% of them have engaged in off-farm employment in 2010/11 and 2014/15 agricultural seasons, respectively. In 2010/11 and 2014/15 agricultural seasons, off-farm participation for female youth members of farm household were 16% and 17%, respectively.

The empirical representations of equation (19) for male and female youth members of farm household h in year t, are specified in log-linear form as follows[11]:

$$lnD_{my}^{*}(ht) = \gamma_{my0} + \gamma_{my} ln\widehat{W}_{my}^{*}(h,t) + \gamma_{mfy} ln\widehat{W}_{fy}^{*}(h,t) + \gamma_{mmm} ln\widehat{W}_{mm}^{*}(h,t) + \gamma_{mfm} ln\widehat{W}_{fm}^{*}(h,t) + \gamma_{myI} ln\hat{\mathrm{I}}(\mathrm{h},\mathrm{t}) + \delta_{my}\,\mathrm{T} + \gamma_{myx} Z(h,t) + \mu_i + \mu_{it} + \epsilon_{my}(h,t) \qquad (28)$$

10 Though our interest is the participation of youth in agriculture, we excluded labor allocated to animal production, domestic and non-farm labor allocations from the sample in labor supply estimation because of absence of data. Hence, our data is limited to crop production

11 If the shadow income is negative, a value of 1 is assigned so that the observations will not be lost after talking logs. In doing so, 146 observations out of 1051 observations on I was negative.

$$lnD^{*}_{fy}(ht) = \gamma_{fy0} + \gamma_{fy}ln\widehat{W}^{*}_{fy}(h,t) + \gamma_{fmy}ln\widehat{W}^{*}_{my}(h,t) + \gamma_{fmm}ln\widehat{W}^{*}_{mm}(h,t) + \gamma_{ffm}ln\widehat{W}^{*}_{fm}(h,t) + \gamma_{fyI}ln\hat{\Gamma}(\mathrm{h,t}) + \delta_{fy}\,\mathrm{T} + \gamma_{fyx}Z(j,h,t) + \mu_i + \mu_{it} + +\epsilon_{fy}(\,h,t) \quad (29)$$

where the $\gamma's \quad and\ \delta$ are parameters to be estimated, $D^{*}\ (ht)$, $\widehat{W}^{*}_{my}$ (h,t), $\widehat{W}^{*}_{fy}$ (h,t), $\widehat{W}^{*}_{mm}$ (h,t), $\widehat{W}^{*}_{mf}$ (h,t) and $\hat{\Gamma}(\mathrm{h,t})$ are as described above, $Z(h,t)$ denotes a vector of youth/individual and household specific observable characteristics in household h in year t presented in Table 6; μi is the standard time invariant unobserved characteristics, (μit) is unobserved time variant and $\epsilon_i(\,h,t)$ is error term representing unobservable factors. The coefficient (δ_i) of year dummy (T) is one of our interest as it indicates trend. For individual estimation, the outcome variables in the labor supply model is the average working days per the respective gender for the different labor categories.

The coefficients of the shadow wage provides estimates of own wage elasticities and cross-wage elasticities, whereas the coefficients of the shadow income provide the estimates of income elasticities for the respective gender category. Since, the shadow wage and shadow income depends on on-farm labor (Fi) which is part of the labor supply (Di) they will, therefore, be endogenous. As Murtazashvili and Wooldridge (2008) suggested, when endogenous explanatory variables are continuous and when we have endogeneity that arises from both time invariant unobservable characteristics (μi) and time variant unobservables (μit), the better way to estimate the parameters is to use the fixed effects instrumental variables (FE-IV) estimators. This sweep away individual specific time trends and enable us to control for the simultaneity between labor supply, and shadow wages and income. The relevant variables we used as instruments in shadow wage and income are discussed in the results section. To control for within correlation, we use cluster-robust covariance.

Table 7 summarizes the statistics of the variables used in the estimation of the labor supply functions.

Table 7.Definition, Mean and standard deviation of variables used in the estimation of labor supply

Variable name	Description of key variables used in labor supply models	2010/11		2014/15	
		Mean	Standard deviation	Mean	Standard deviation
$\hat{I}$	Shadow income estimated for the household	4,708	5,743	6,760	8,872
W_{my}	Shadow wage estimated for male youth members	8.268	8.761	21.61	40.67
W_{fy}	Shadow wage estimated for female youth members	20.764	25.14	40.804	24.32
W_{mm}	Shadow wage estimated for male mature members	7.134	6.556	24.86	25.91
W_{fm}	Shadow wage estimated for female mature members	26.38	31.86	34.00	33.54
Wm	Market wage earned by male youth	16.82	4.041	39.27	12.73
Wf	Market wage earned by female youth	14.09	3.085	20.95	16.36
ToT_On	Total on-farm family labor days(AELD)	114.38	101.26	106.96	102.5
off_MYL_ha	Total off-farm male youth labor days(AELD)	6.73	54.12	10.70	101.38
off_MYL_ha	Total off-farm female youth labor days(AELD)	6.42	43.44	7.01	51.23
ToT_Off	Total off-farm labor days (in AELD)	11.17	36.51		28.37
ToT_Lss	Total supply of household labor (in AELD)	130.5	99.04	119.6	125.8
MYL	Total male youth members labor contribution (AELD, on-farm)	57.10	58.57	52.38	84.78
FYL	Total female youth members labor contribution (AELD,on-farm)	20.69	31.17	16.71	27.77
MML	Total male mature members labor days (in AELD, on-farm)	30.58	43.35	23.40	39.45
MFL	Total female mature labor days (in AELD, on-farm)	10.55	16.39	17.04	25.68
CHL	Child labor (in AELD, on-farm)	5.759	14.05	5.249	11.21
THL	Total hired labor days (in AELD)	6.130	21.02	14.43	78.91
Farm_Dist	Farm distance from the household home(in minutes)	0.207	0.295	0.198	0.283
Childern_tot	# of children under 14 years	1.427	1.122	1.362	1.159
Student_m	# of male student youth 13-34 years	0.733	0.942	0.703	0.925
Student_f	# of female student youth 13-34 years	0.702	0.932	0.717	0.922
Full_timeyou_m	# of full-time male youth 13-34 years	0.722	0.701	0.730	0.716
Full_timeyou_f	# of full-time female youth 13-34 years	0.310	0.548	0.262	0.482
TLU	Number of livestock owned in TLU	8.204	8.530	8.523	8.733
Educ_male	Average education of male youth (years)	2.844	2.976	2.895	3.061
Age_male	Average age of male youth members (years)	17.60	9.893	17.99	10.01
Educ_female	Average education of female youth members (years)	2.558	3.279	2.365	3.008
Age_female	Average age of female youth members (years)	18.12	9.403	19.16	9.026
Headtype	Head type(1=youth headed, 0 otherwise)	0.34		0.39	
Land_quality	Land quality (1=Teuf, 2-lem-teuf, 3-lem)	2.441	0.673	2.347	0.733
Durables	Total durable and consumable asset values(in 2011 ETB)	5,385	38,571	7,577	66,499
Sex_head	Sex of household head (1=female, 0 otherwise)	0.28		0.30	
Educ_head	Education of the household head(years)	1.640	2.66	1.94	2.9
Marit_head	Marital status of the household head(1=married, 0 otherwise)	0.72	0.44	0.71	0.45
Assetprod	Value of assets for agricultural production (in 2011 prices)	5,363	3849	7518	5420
Youth_male	# of male youth in the household 13-34 years	1.22		1.15	
Youth_female	# of male youth in the household 13-34 years	1.17		1.08	
Mature_male	# of male mature in the household >35 years	1.0		0.86	
Mature_fem	# of female mature in the household >35 years	0.70		0.54	
	Number of observations(households)	511		506	

Source: Survey results

In the next sections we present the results of the regression models described earlier.

6. Results and discussions

Table 8 presents the OLS, random-effects (RE) and fixed-effects (FE) estimates of the coefficients of the production technology specified in equation (22). The Hausman test of the random versus fixed-effects specification fail to reject the random-effects specification at the 5% significance level. However, we use also fixed-effects for comparison as it controls for the correlation of the unobservable farmer-specific effects with the observed inputs. The use of random effects estimates indicate that use of family labors such as male youth , female youth , male matures, female matures and child labor have larger significant effects on output than the use of hired labors. In addition, the results of both FE and RE estimates indicate that the use of family male youth members seem to have bigger effect on output compared to family female youth members, though care should be taken in interpreting the results as we pooled the resources of the household in estimating the labor productivities of family members. We also note that the use of family female mature members have higher effects on output compared to other family members. Furthermore, the RE estimates show that child labor has a positive and significant effect on output, suggesting the economic contribution of child labor in the production of crops.

There are mainly three issues in investigating labor supply- the need to control for sample selection bias, unobserved heterogeneity, and endogeneity of shadow wages and shadow income. Selection process driving the decision to work and where to work is only observable for the youth who are only present in the off-farm employment. Applying OLS under such condition results in biased estimates. Our panel data make it possible to correct for selection bias and as well as unobservable heterogeneity. Nijman and Verbeek (1992) propose simple tests for sample selection in the presence of panel data: to include variables measuring whether the individual is observed in previous period (P1), individual is observed in both period (P2) and total number of periods the individual is observed (P3). The null hypothesis is that P1, P2, P3 should not be significant in our model if there is selection problem. Accordingly, the results rejected the null for the off-farm labor equations for both male and female youth labor. The Hausman type test also rejected the null hypothesis of no selection problem for the off-farm models. Following Kyriazidou (1997) method we estimated the selection equation to get consistent estimates.

Table 8: Cobb-Douglass agricultural production function: OLS, FE and RE estimates

	Dependent variable: Log(total value of output)		
	(1)	(2)	(3)
Variables	OLS	Fixed Effects	Random Effects
Sex_head	-0.168*	-	-0.1518*
	(0.0925)	-	0.0935
Age_head	0.0215*	0.0254	0.0234**
	(0.0120)	(0.0200)	(0.0116)
Age_head (squared)	-0.0002*	-0.0002	-0.0002*
	(0.0002)	(0.0002)	(0.0002)
Educ_head	0.0018	-0.0088	0.0016
	(0.0130)	(0.0352)	(0.0120)
Marit_head	0.0671	-	(0.0352)
	(0.0707)	-	0.0316
Log(MYL)	0.0590***	0.0463*	0.0579***
	(0.0224)	(0.0214)	(0.0224)
Log(FYL)	0.00786	0.0234	0.00740
	(0.0370)	(0.0482)**	(0.0383)*
Log(MML)	0.0333	0.0284	0.0214*
	(0.0285)	(0.0325)	(0.0302)
Log(MFL)	0.0693**	0.0661**	0.0653**
	(0.0271)	(0.0306)	(0.0260)
Log(CHL)	0.0441	0.0382	0.0492*
	(0.0271)	(0.108)	(0.0281)
Log(HL)	0.0256	0.0119	0.0239
	(0.0242)	(0.0314)	(0.0241)
Log(OXEN)	0.254***	0.173**	0.254***
	(0.0456)	(0.0734)	(0.0459)
Log(land)	0.446***	0.347***	0.432***
	(0.0736)	(0.0740)	(0.0698)
Log(FERRVAL)	0.0356***	-0.0286	0.0335***
	(0.0109)	(0.0303)	(0.0110)
Log(SEEDVAL)	-0.0034	-0.146	-0.0032
	(0.0115)	(0.732)	(0.0116)
Log(WEEDVAL)	-0.0745***	-0.0591	-0.0762***
	(0.0180)	(0.757)	(0.0182)
Educ_male	-0.0057	-0.0131	-0.0058
	(0.0126)	(0.0221)	(0.0129)
Age_male	0.0045	0.0041	0.0050
	(0.0045)	(0.0075)	(0.0048)
Educ_female	-0.00342	-0.0030	-0.0038
	(0.0098)	(0.0161)	(0.0097)
Age_female	-0.0028	-0.0104*	-0.0035
	(0.0032)	(0.0055)	(0.0032)
Much_RAIN	-0.209***	-0.0770	-0.1812**
Constant	6.517***	8.106	6.523***
	(0.342)	(6.300)	(0.340)
Observations	1,022	1,022	1,022
Household FE	-	YES	YES
Year FE	Yes	Yes	Yes
R-squared	0.46	0.20	0.46
Fixed vs Random Hausman	Probn>chi2	=	0.2378

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: Survey results

Note: other additional regressors used in the model includes woreda dummies, shock dummies such as input prices, output prices, pests, livestock diseases, household production shifters which include total number of children in the household, total number of male and female youth members and total number of mature male and female members, farm assets, land certificate, plot characteristics-slope, soil quality, farm distance from residence place. Given the presence of zero values in some inputs, the logarithmic transformation was carried out by adding one to all input levels (i.e., $InX_i = \ln (X_i+1)$)[12]. This is a common practice in literature to keep the estimation manageable and under such condition the use of CD production function is plausible (McCurdy and Pencavel, 1986; Jacoby, 1993); hence the labor supply estimates will be robust to the choice of constant. For example, some households have only male or female youth labor; labor is hired by about 30 percent of the households, and about 35 and 40 percent of the households do not use any chemical fertilizer and improved seed, respectively. Fifty nine percent of households report zero labor inputs for child labor.

To control for individual heterogeneity, sample selection and instrumenting for possible endogeneity of shadow wages and shadow income, we estimated the labor supply functions in equations 28 and 29 using the fixed effects and fixed effects instrumental variables (FE-IV) methods. FE-IV involves two stage regressions. First, shadow wage rates and shadow income for the different gender and age groups are regressed on the complete set of instruments presented below. Using the predicted values from these first stage regressions as regressors, we estimated the labor supply functions by using fixed effects. We also estimated the models using OLS but not reported here. In this estimation, as discussed earlier, we assume that all youth farm labors are of equal quality within the same sex and the same age category but different between sexes and age categories.

Based on the random-effects estimates in column (3) of Table 8 used to derive the shadow wage rates of male and female youth members' (using the expressions in equations (25) to (27)), the effect of shadow wages and shadow income on the different types of youth labor supply is presented in Table 9. Most of our discussion will concentrate on the estimated effects of shadow wages and incomes (mainly the results of FE estimates) on labor supply of youth members. The first column, third, fifth, seventh, ninth and eleventh reports the FE estimates of male and female youth members on-farm and off-farm labor supply, while the results from the IV counterpart of this model (FE-IV) is given in column two, column four, column six, column eight, column ten and column twelve.

[12] As to other inputs, such as fertilizer, the baseline study show that mature headed and male headed households applied more fertilizer compared to youth and female headed households (up to 10% more fertilizer). Though the utilization of improved seeds is low among households (about 40%), the application rate of improved seeds among users was significantly large (about 17.5 kg/ha). Slightly households with mature heads applied more improved seeds. As to irrigation and soil conservation measures, male heads and mature households used irrigation and soil conservation measures more than their counterparts. Extension services is one of the most widely used and government promoted type of services practiced in the country. Interestingly, young heads were visited more by an extension agent than mature household heads.

Table 9: Determinants of on-farm and off-farm male and female youth members' labor supply (FE and FE-IV estimation result): at household level

(Dependent variable: Log (total working days of male or female members'))												
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	On-farm				Off-farm				Total			
	Male FE	Male FE-IV	Female FE	Female FE-IV	Male FE	Male FE-IV	Female FE	Female FE-IV	Male FE	Male FE-IV	Female FE	Female FE-IV
$\ln(\widehat{W_{my}})$	0.399***	1.639***	-0.0850*	0.0737	0.105**	0.147**	-0.0266	-0.0760	0.404***	1.575***	-0.122***	-0.0295
	(0.0666)	(0.0740)	(0.0451)	(0.0634)	(0.0469)	(0.0703)	(0.0427)	(0.0835)	(0.0669)	(0.0784)	(0.0450)	(0.0699)
$\ln(\widehat{W_{fy}})$	-0.208***	0.133	-0.293***	1.535***	0.0178	-0.00685	0.0503	0.237**	-0.211***	0.0573	-0.264***	1.162***
	(0.0564)	(0.109)	(0.0595)	(0.105)	(0.0487)	(0.133)	(0.0477)	(0.107)	(0.0566)	(0.111)	(0.0585)	(0.110)
$\ln(\widehat{W_{mm}})$	-0.227***	-0.921***	-0.0195	-0.714***	0.0283	-0.0184	0.0341	-0.118	-0.208***	-0.840***	0.0188	-0.502***
	(0.0519)	(0.158)	(0.0453)	(0.154)	(0.0452)	(0.166)	(0.0413)	(0.143)	(0.0515)	(0.159)	(0.0461)	(0.165)
$\ln(\widehat{W_{fm}})$	0.133***	0.927***	0.0310	0.527**	0.0273	-0.190	0.0366	-0.144	0.130***	0.836***	0.0269	0.450*
	(0.0422)	(0.236)	(0.0400)	(0.227)	(0.0399)	(0.265)	(0.0424)	(0.216)	(0.0429)	(0.248)	(0.0430)	(0.239)
$\ln(\widehat{W_{ch}})$	-0.0925*	-0.136	-0.0170	0.149	-0.0674	-0.273*	-0.00835	-0.0394	-0.110*	-0.165	-0.00525	0.00749
	(0.0550)	(0.111)	(0.0591)	(0.109)	(0.0634)	(0.144)	(0.0565)	(0.135)	(0.0568)	(0.121)	(0.0567)	(0.122)
$\ln(\widehat{I})$	-0.0436	-0.129	-0.0158	-0.0915	0.0198	0.132	0.0639**	0.256**	-0.0415	-0.0828	0.00165	0.0656
	(0.0294)	(0.0896)	(0.0220)	(0.0980)	(0.0267)	(0.125)	(0.0265)	(0.125)	(0.0306)	(0.0956)	(0.0222)	(0.105)
Trend	-0.0676	-0.226*	0.0175	-0.0579	0.0283	0.160	-0.104	0.101	-0.0310	-0.175	-0.0761	-0.175
	(0.127)	(0.117)	(0.120)	(0.127)	(0.117)	(0.153)	(0.104)	(0.144)	(0.126)	(0.129)	(0.119)	(0.137)
Educ_male	0.0375	0.0339	0.0553	0.0983	-0.0913	-0.101	-0.0503	-0.0600	-0.0206	-0.0258	-0.0351	-0.00406
	(0.0864)	(0.0595)	(0.0739)	(0.0598)	(0.0697)	(0.0693)	(0.0666)	(0.0679)	(0.0877)	(0.0658)	(0.0743)	(0.0672)
$(\text{Edu\_male})^2$	-0.0003	-0.0032	-0.0089	-0.0129**	0.0080	0.0082	0.0029	0.0035	0.0041	0.0013	-0.0006	-0.0040
	-0.0090	-0.0066	-0.0066	-0.0054	-0.0076	-0.0079	-0.0054	-0.0062	-0.0095	-0.0075	-0.0062	-0.0061
Age_male	-0.0019	-0.0085	0.0202	-0.0129	0.0281	0.0384*	-0.0074	-0.0049	0.0116	0.0073	0.0230	-0.0037
	-0.0291	-0.0198	-0.0241	-0.0210	-0.0218	-0.0217	-0.0240	-0.0247	-0.0296	-0.0205	-0.0239	-0.0225
$(\text{Age\_male})^2$	0.0006	0.0005	0.0000	0.0005	-0.0004	-0.0007	0.0006	0.0006	0.0003	0.0002	0.0000	0.0004
	-0.0008	-0.0006	-0.0007	-0.0007	-0.0006	-0.0006	-0.0007	-0.0007	-0.0008	-0.0006	-0.0007	-0.0007
Educ_female	-0.1280	-0.0332	-0.129**	-0.172***	-0.0678	-0.0649	-0.0727	-0.0830	-0.141*	-0.0503	-0.141**	-0.189***
	-0.0794	-0.0555	-0.0646	-0.0499	-0.0506	-0.0495	-0.0530	-0.0553	-0.0797	-0.0565	-0.0607	-0.0535
$(\text{Edu\_femal})^2$	0.0039	-0.0004	0.0057	0.0188***	0.0024	0.0024	0.0024	0.0033	0.0047	0.0006	0.00621*	0.0194***
	-0.0066	-0.0042	-0.0039	-0.0032	-0.0036	-0.0034	-0.0039	-0.0039	-0.0066	-0.0043	-0.0037	-0.0034
Age_female	0.077***	0.0187	0.0547	0.0386*	0.0327	0.0239	0.0560**	0.0514**	0.0836***	0.0273	0.0522*	0.0440**
	-0.0271	-0.0192	-0.0333	-0.0201	-0.0229	-0.0216	-0.0236	-0.0238	-0.0255	-0.0194	-0.0307	-0.0221
$(\text{Age\_female})^2$	-0.0024***	-0.0007	-0.0012	-0.00121*	-0.0008	-0.0005	-0.00127*	-0.0011	-0.003***	-0.0010*	-0.0012	-0.0013*

	-0.0008	-0.0006	-0.0009	-0.0006	-0.0006	-0.0006	-0.0007	-0.0007	-0.0008	-0.0006	-0.0009	-0.0007
Childern_tot	-0.0051	-0.0304	0.0840	0.0588	-0.0700	-0.0735	-0.0290	-0.0277	-0.0014	-0.0212	0.1120	0.0989
	-0.0772	-0.0545	-0.0657	-0.0578	-0.0607	-0.0621	-0.0546	-0.0547	-0.0786	-0.0564	-0.0683	-0.0658
Student_m	0.1220	0.0442	0.0716	0.0302	0.130**	0.125**	0.108*	0.118**	0.1100	0.0334	0.1100	0.0726
	-0.0984	-0.0695	-0.0787	-0.0645	-0.0611	-0.0608	-0.0598	-0.0598	-0.0935	-0.0702	-0.0765	-0.0696
Student_f	-0.0515	-0.112*	-0.0583	-0.0906	-0.0568	-0.0652	-0.0368	-0.0441	-0.0523	-0.111*	-0.1250	-0.156**
	-0.1050	-0.0658	-0.0817	-0.0647	-0.0664	-0.0673	-0.0660	-0.0653	-0.1050	-0.0659	-0.0814	-0.0702
Full_timeyou_m	0.0605	0.0761	0.0786	0.154**	0.1020	0.0946	0.0779	0.0867	0.0461	0.0605	0.0838	0.156*
	-0.1080	-0.0788	-0.0924	-0.0785	-0.0973	-0.0997	-0.0813	-0.0793	-0.1100	-0.0845	-0.0907	-0.0831
Full_timeyou_f	0.0478	-0.0301	0.1020	0.0607	-0.0280	-0.0064	-0.0324	-0.0354	0.0850	0.0152	0.0956	0.0668
	-0.1260	-0.0848	-0.0926	-0.1060	-0.0919	-0.0949	-0.0984	-0.0985	-0.1220	-0.0884	-0.0992	-0.1110
Mature_male	-0.576***	-0.407***	-0.0107	0.00677	-0.0943	-0.0352	-0.0197	-0.00731	-0.592***	-0.424***	-0.0361	-0.0292
	(0.106)	(0.0732)	(0.0845)	(0.0838)	(0.0827)	(0.0825)	(0.0751)	(0.0747)	(0.104)	(0.0745)	(0.0866)	(0.0883)
Mature_fem	-0.0340	0.0364	-0.478***	-0.278***	-0.0322	-0.0276	-0.163**	-0.109	0.00347	0.0645	-0.399***	-0.248***
	(0.109)	(0.0756)	(0.0931)	(0.0727)	(0.0816)	(0.0749)	(0.0760)	(0.0727)	(0.110)	(0.0785)	(0.0989)	(0.0826)
Age_head	0.00421	0.0129	-0.0508*	-0.0324	-0.00991	-0.00630	-0.0332	-0.0226	0.0111	0.0193	-0.0476	-0.0305
	(0.0354)	(0.0208)	(0.0307)	(0.0235)	(0.0218)	(0.0223)	(0.0236)	(0.0233)	(0.0347)	(0.0214)	(0.0313)	(0.0290)
Educhead	0.0143	0.0171	0.0990**	0.0459	-0.081**	-0.0907**	-0.098***	-0.116***	-0.0003	0.00489	0.0509	0.00846
	(0.0525)	(0.0358)	(0.0428)	(0.0498)	(0.0348)	(0.0362)	(0.0355)	(0.0374)	(0.0498)	(0.0359)	(0.0417)	(0.0473)
Constant	3.020***	0.651	3.378***	1.121	0.669	0.595	1.322	0.0693	2.930***	0.555	4.177***	1.508
	(0.996)	(0.921)	(0.921)	(1.146)	(0.773)	(1.409)	(0.803)	(1.313)	(1.003)	(1.020)	(0.920)	(1.228)
Observations	1,015	1,011	1,015	1,011	1,015	1,011	1,015	1,011	1,015	1,011	1,015	1,011
R-squared	0.267	0.643	0.198	0.389	0.168	0.169	0.184	0.188	0.273	0.606	0.185	0.277

Source: survey results   Robust standard errors in parentheses   *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Note: other additional regressors used in the model include sex of household head, woreda dummies, livestock diseases, farm assets, land certificate.

After controlling for unobserved heterogeneity (FE estimates in column 1, column 5 and column 9), we find positive and significant shadow wage elasticities (0.40, 0.11 and 0.40 for on-farm, off-farm and total labor supply of male youth members, respectively); suggesting an upward sloping youth male labor supply. The magnitude of the estimates (own shadow wage elasticity and shadow income) for male youth members in this study are similar to the pervious empirical findings of Skoufias (1994), Jacoby (1993) and Kien (2009), though on-farm wage elasticity is a bit higher in this study. An important notable difference observed by comparing the coefficients for male youth members working on-farm with that of male youth members participating in the labor market is the effect of shadow wages on both types of labor supply. The effect of shadow wage is higher in an on-farm labor supply compared to off-farm (0.40 vs 0.11). This suggests that family members have stronger work incentives of working on-farm compared to off-farm work.

The negative effect of female youth members shadow wage on male youth members labor supply suggest that, male and female youth labors are gross substitutes. The significance of this cross-wage effect is "consistent with family utility maximization and it suggests that studies that strict such cross-wage effects to be zero may yield estimates that are subject to specification error"(Skoufias, 1994: 224). However, the positive effect of female mature members shadow wage on male youth members labor supply indicates gross complementarity (or less substitutability) between the two labor categories. The less substitutability of labor between male youth members and mature female members, given the agricultural production system in Ethiopia, is as expected. Activities such as planting, ploughing, harvesting and threshing of some crops [eg. teff, wheat, barley, and pulses] are mainly done by men.

The coefficients on year dummies describe how average time spent in agricultural activities has changed over time for the different groups, controlling for changes in key demographics; trend indicator. Using the 2010/11 main agricultural production season as a base year, male youth members' on-farm labor supply is decreasing whereas the off-farm labor supply is increasing. There is a decreasing trend in total labor supply since the on-farm labor supply decrease is greater than the off-farm labor increment. However, none of them are statistically significant, an indicator that youth are not disengaging in agriculture, rather working less number of days on family or own farm and working more hours on others farm for wage (to some extent changing farm work locations for migrant youth) as revealed in off-farm increment. The conclusion of the main result remain unchanged after controlling for some variables such as part-time workers, the age of youngest or oldest son-there is no significant reduction in the labor supply of male youth members.

The effect of male member's education, age and their squares which is an indicator of experience and life-cycle effects on labor supply is insignificant, interestingly education has a positive effect, though. Education could impact labor supply indirectly through its effect on marginal productivity and profitability in farm production. The effect of age of female youth members on on-farm male youth labor supply is positive and significant. As female youth members in the household gets older, the labor supply of male youth members increases. This is mainly because of the fact that at an early age there is substitutability while at the later ages the two labor categories play some complementarity. In addition, as female members get older, they leave the household because of marriage. This in turn creates labor shortage in the household. To fill that gap, the household increases the allocation of male youth members' labor. As to the family composition variables, the number of male mature household members are the only significant variables affecting labor supply of youth male members. Off-farm labor supply of male youth members increases with number of male student members in the household. On the other hand, on-farm labor supply of youth male members' decreases significantly with the number of mature labors in the household since the two labor types are substitutes.

The effect of female shadow wages on youth female members labor supply is negative and strongly significant at 1% level, suggesting that female youth agricultural labor supply is backward bending. The effect of shadow income on female youth labor supply is partly realized through the reallocation of labor from on-farm to other activities such as schooling and domestic work. This is reflected in backward sloping labor supply and a recent increasing trend in school participation of female youth, which is also consistent with the marginal role female youth play in agricultural production. This effect is more pronounced via the effect of female youth members' education on total labor supply. As the sign of wage elasticities is theoretically unpredictable, this result is not unusual considering the agricultural production system of farm households in rural Ethiopia. It should be noted, however, that it could be possible that the estimated marginal productivity for female youth members is a biased estimate of the shadow value of time of female youth members that work mainly on domestic activities and not in crop production (26 % of households reported zero working days of female youth members in either in an on-farm or off-farm). Since we pooled a household resource in the estimation of male and female youth members labor supply, it also may bias the estimates. Furthermore, measurement errors would be an avoidable that may impact the magnitude and direction of the estimate. The positive effect of female shadow wages on female youth labor supply, after instrumenting shadow wages, suggest this line of thinking. Female youth members' on-farm and off-farm labor supply is decreasing over time though none of them are statistically significant, an indicator also that cast doubt on the presumption that youth are exiting agriculture. An important difference observed is the effect of shadow income on on-farm and off-farm female labor supply: an increase in shadow income induces a decrease in an on-farm female labor supply where as it induces an increase in off-farm female labor supply.

Similar to the findings of Skoufias (1994) female youth members' labor supply appears to exhibit the usual concave pattern in age with adult female members working less. The family composition variables that appear to have significant effect on female youth members labor supply (off-farm) include number of male youth students and number of mature female members. Off-farm female youth labor supply increases with the total number of male youth students in the household. The supply (on-farm and off-farm) of female youth members' decreases with total number of female mature members. Unlike the case for male youth members, the effect of education of the household head on on-farm female youth members labor supply is positive and significant at 5% level where as the effect is negative on off-farm labor supply.

So far we have focused on results of the fixed effects estimators without instrumenting the endogeneity of key variables of interest such as shadow wages and shadow income. In columns 2, 4, 6, 8, 10 and 12, we present FE-IV estimators of the different labor supply models. As stated earlier, the fixed effects estimation enables to remove the time invariant unobservable characteristics (μi) but not the time variant unobservables (μit) that are potentially correlated with the error term$\epsilon_i(h, t)$. The difficult exercise here is to find appropriate and good instruments for shadow wages and shadow income. For an instrument to be valid, two conditions need to fulfil (Sargan, 1958; Stock et al., 2002). First, the instrumental variables should strongly correlate with the endogenous variables; and second, the instruments must influence the outcome variables through the endogenous variables (i.e. exogeneity of the instruments -the exclusion restriction criteria). Accordingly and in line with the previous studies who have used similar approaches (Tassew, 2000; Awudu and Punya, 2000; Jacoby, 1993), we propose to use the following instruments for the shadow wages and shadow income: housing facilities (roof type, floor type, bed type), ownership of mobile phones and radios, jewellery, ownership of cart and youth population density. In addition to the above instruments, ownership of stove, sources of drinking water during rainy and dry seasons are used in female youth members. Though debatable, these variables are assumed to affect shadow wages and shadow income but not number of working days. Accordingly, the validity of these instruments are tested.

Higher youth population density[13] causes more available infrastructure per youth worker which enhances labor productivity, facilitate the availability of fertilizer and other inputs (Glover and Simon, 1975). Ownership of mobile and carts increase labor productivity-they channel the effect of capital investment through wages on labor supply. Housing facilities, ownership of stoves, and source of drinking water improve health and thereby raise shadow wages (or labor productivity of individuals); hence impact number of working days through shadow wages and income. In this respect, these variables can be qualified as good instruments that captures variations in shadow wages and shadow income. One the other hand, it's unlikely that these variables directly determine number of working days. The statistical evidence on the exclusion restrictions [using the Sargan and Basmann test of overidentifying restrictions shows that the identified instruments explain number of working

[13]Youth population density explains about 12-13 percent of the total variations in the shadow wages of male and female but none of them are significant in explaining labor supply.

days indirectly only via its correlation with shadow wages and shadow income. The results of the tests for the validity of the instruments are presented in appendix Table B. The first stage regressions in appendix Table B show that the coefficients of almost all instruments are statistically significant in explaining the endogenous shadow wages and shadow income to a larger extent; except for Jewellery. As stated above, the exogeneity of the instruments is tested using the Sargan and Basmann test of overidentifying restrictions. There are concerns that radio and stove may be a direct cause of labor supply, if these variables are another determinants of number of working days. In this case, these variables may not serve as exogenous instruments (appendix Table B).

Focusing on the total labor supply FE-IV estimators, we find that the effect of shadow wage elasticities are higher and strongly significant in all the models than that reported by the FE estimators. In the male youth members' labor supply model, there are no dramatic changes in the sign of the estimated coefficients. However, there are dramatic changes in the size and significance of some of the estimated coefficients. For instance variables such as education of female, shadow wage for female youth, and age of female become insignificant and the only variable that become significant is number of female youth students in the household. In the female youth members' labor supply model, there are not only dramatic changes in the sign but also in the magnitude of the coefficients estimated. For instance, the negative value of female youth agricultural labor products (or shadow wage) of female youth members disappear, and turns to positive while its magnitude has increased dramatically (from 0.26 to 1.16). The effect of male mature members' productivity on female youth members' labor supply becomes significant, with change of sign from positive to negative. Though decreasing trend is observed in both male and female members total labor supply in agriculture, none of them are significant. These findings suggest again that youth are not disengaging from agriculture. Other explanatory variables in the female youth members' total labor supply model that show increase in magnitude and significance include female mature shadow wage, education of female, age of female, total number of female youth students and total number of male full-time youth in the household. The negative effect of female education on female youth labor supply remains negative and strongly significant. In general, all the results indicate that the trends and patterns of youth involvement in agriculture vary across gender and farm work locations; so do the values of their agricultural labor products.

For comparison, the labor supply functions in equations 28 and 29 were re-estimated for the sub-sample at individual level. Over all similar trend, pattern and magnitude in the estimated coefficients has been observed.

7. Testing for separability: equality of shadow wages and market wages

In order to test whether the labor market functions efficiently, we examined the relationship between the estimated shadow wages (the value of marginal products) and market wages (Jacoby, 1993). Assuming that farm households maximize utility, the marginal productivity of work on the family farm should be equal to the market wage received by family members working on the off-farm, if separability exists. This means that the estimated $\hat{\beta} = 1\ and\ \hat{\propto}= 0$), when there is separability. In this context, individual's allocation of time between farm and market is made purely on efficiency grounds, and there is an efficient labor market. We report the results of the test in Table 10 which is obtained from the regression of the form:

$$lnW_{it}^{*} = \propto + \beta lnW_{it} + \varepsilon_{it} \quad (30)$$

Where $W_{it}^{*}$is the estimated shadow wage of labor type i = male youth members, female youth members in year t (i.e. the estimated marginal product of labor i derived from the production function stated in equation (22)); W_{it} is the wage received by working in the off-farm labor market in year t and ε_{it} is a random term. The observed market wage are instrumented for possible measurement errors using the variables age, education and their squares. As one can see in Table 10, the results strongly rejected the existence of separability; suggesting that the use of non-separability approach best predicts the agricultural labor supply of youth members and likely to produce more reliable policy conclusions.

Table 10: Test for separability

Variables	Jacoby Test (Ho:β=1 & ∝=0)	Benjamin Test
Log (predicted Wm)	2.117***	2.106***
	(0.198)	(0.555)
Constant	-1.757***	-4.584***
	(0.616)	(1.396)
Observations	1,220	1192
F-test for joint significance:	0.000	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: survey results

8. Conclusions and policy implications

The dichotomy often exists in the literature of agricultural household members allocation of their labor is its inadequacy to distinguish whether market and non-market labor is spent on-farm or off-farm and for which household member and age category is the phenomenon refers to. Second and most importantly, if we want to understand the behaviour of youth career choices, we need to understand how youth labor is allocated within or among households that involves both market and non-market economy. In doing so, we investigate the trends, patterns and analyse the effect of shadow wages on youth labor supply in agriculture, disaggregated by gender using household and youth sample survey data collected during 2010/11 and 2014/15 agricultural seasons. We find that trends and patterns of youth involvement in agriculture vary across gender and farm work locations; so do the values of their agricultural labor products. Whilst the participation of youth in on-farm for both sex is declining across time (though insignificant), the participation in off-farm is increasing for both. The total agricultural labor supply (sum of on-farm and off-farm) of both male and female youth are decreasing but none of them are significant. The effect of male youth shadow wage on male youth members labor supply is positive and significant, suggesting an upward sloping male youth labor supply. However, FE estimation results indicate that the effect of female shadow wage on female youth labor supply is negative and strongly significant at 1% level, suggesting that female youth agricultural labor supply is backward bending. Our estimation results also indicate that the magnitude of shadow wage elasticities and shadow income depends on the estimators chosen. The shadow wage elasticities are especially higher when instrumenting for shadow wages, a higher result than what is reported in some other studies. Furthermore, our results suggest that aggregating heterogeneous labor productivities in the computation of shadow wages is likely to mislead policy conclusions.

Taking into account intensity of youth involvement on family farm or own farm, off-farm as well as their farm work at destination for youth migrating to other rural and per-urban areas, the results challenge the presumption that youth are exiting agriculture, at least in agricultural potential areas of Ethiopia. Instead youth's labor make an important economic contribution to the operation of their family or own farm. Based on descriptive and econometric results, we conclude that the myths of youth participation in agriculture over the last decade does not necessarily emanated from the trend and evolution of participation in agriculture but also from the methodological drawbacks. For instance, the comparison of youth responses regarding their intentions (plan) to work in agriculture and the farm level actual time spent by household members (including youth members) between 2010/11 and 2014/15 agricultural seasons, indicate that actual youth engagement in agriculture and the intention to engage in the sector vary greatly. Limitation of data regarding youth labor allocation in agricultural production has also contributed to this inconclusive findings in the literature, especially the absence of panel data. Thus, analyses that uses intensions alone to examine youth labor market outcomes would likely produce misleading policy implications.

Our estimation approach tests the existence of separability-the hypothesis strongly rejected in the estimation in favour of a non-separation model. A policy implications of the results reported here would be that changes in economic incentives such as marginal productivities (shadow wages) matter for youth involvement in agriculture, but the impact of it induces different outcomes for male and female youth members labor supply. In addition, increasing trend of farm employment opportunities suggest that governments need to give proper attention to agricultural development since improving agricultural labor productivity both at on-farm and off-farm level would help to provide employment for the youth that helps to reduce unemployment and underemployment. Moreover, attributes related to youth female members such as education of female and age of female youth members, composition of family structures and education of the household head also matters for youth labor supply in agriculture.

Furthermore, structural transformation that addresses the imperfections and rigidities in labor and other input markets (especially land, fertilizer, seed, etc) as well as poor infrastructure and social impediments that condition access to markets, services and productive assets in rural areas need to be addressed to make agriculture more attractive to the youth.

References

Agricultural Growth Program (AGP) of Ethiopia: Baseline Report 2011. *Ethiopia Strategy Support Program II. Addis Ababa: IFPRI*.

Aguiar, M. and Hurst, E., 2006. Measuring Trends in Leisure: The Allocation of Time over Five Decades." Federal Reserve Bank of Boston Working Paper.

Agwu, N.M., Nwankwo, E.E. and Anyanwu, C.I., 2014. Determinants of Agricultural Labor Participation among Youth in Abia State, Nigeria. *International Journal of Food and Agricultural Economics*, *2*(1), p.157-164.

Ahearn, M.C., El-Osta, H. and Dewbre, J., 2006. The impact of coupled and decoupled government subsidies on off-farm labor participation of US farm operators. *American Journal of Agricultural Economics*, *88*(2), pp.393-408.

Bachewe, Fantu Nisrane; Berhane, Guush; Minten, Bart; and Taffesse, Alemayehu Seyoum. 2016. Non-farm income and labor markets in rural Ethiopia. ESSP II Working Paper 90. Washington, D.C. and Addis Ababa, Ethiopia: International Food Policy Research Institute (IFPRI) and Ethiopian Development Research Institute (EDRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/130375

Barnum, H.N. and Squire, L., 1979. *A model of an agricultural household: theory and evidence [Malaysia]*. Published for the World Bank [by] Johns Hopkins University Press.

Becker, G.S., 1965. A Theory of the Allocation of Time. *The economic journal*, *75*(299), pp.493-517.

Bedemo, A., Getnet, K. and Kassa, B., 2013. Determinants of household demand for and supply of farm labor in rural Ethiopia. *Australian Journal of Labor Economics*, *16*(3), p.351.

Benjamin, D., 1992. Household composition, labor markets, and labor demand: testing for separation in agricultural household models. *Econometrica: Journal of the Econometric Society*, pp.287-322.

Benjamin, C. and Kimhi, A., 2006. Farm work, off-farm work, and hired farm labor: estimating a discrete-choice model of French farm couples' labor decisions. *European review of agricultural economics*, *33*(2), pp.149-171.

Bezu S, Holden S., 2014. Are rural youth in Ethiopia abandoning agriculture? World Development. 2014 Dec 31; 64:259-72.

Bezu, S., Barrett, C.B. and Holden, S.T., 2012. Does the nonfarm economy offer pathways for upward mobility? Evidence from a panel data study in Ethiopia. *World Development*, *40*(8), pp.1634-1646.

C.S.A. 2013. Statistical Report on the 1999 National Labor Force Survey (Statistical Bulletin No.225), Addis Ababa, Ethiopia.

Calvès, A.E. and Schoumaker, B., 2004. Deteriorating economic context and changing patterns of youth employment in urban Burkina Faso: 1980–2000.*World Development*, *32*(8), pp.1341-1354.

Chang, Y.M., Huang, B.W. and Chen, Y.J., 2012. Labor supply, income, and welfare of the farm household. *Labor Economics*, *19*(3), pp.427-437.

de Brauw, A., 2014. Migration, youth, and agricultural productivity in Ethiopia, International Food Policy Research Institute, Washington, DC.

Deolalikar, A.B., *Vijverberg*, W.P., *1983*. The test for heterogeneity of family and hired labor in agricultural production: A test using direct-level data from India, *Journal of Development Economics*, 8(2), pp. 45-89.

Deolalikar, A.B., *Vijverberg*, W.P., *1987*. TS test of heterogeneity of family labor and hired labor in Asian agriculture. Oxford Bulletin of Economics and Statistics, 49(3), pp.291-305.

Dessing, M., 2002. Labor supply, the family and poverty: the S-shaped labor supply curve. *Journal of Economic Behavior & Organization*, *49*(4), pp.433-458.

Dupraz, P. and Latruffe, L., 2015. Trends in family labor, hired labor and contract work on French field crop farms: The role of the Common Agricultural Policy. *Food Policy*, *51*, pp.104-118.

FAO (2014), General and equity implications of land-related investments for access to land, employment and other income opportunities: Selected studies in Sierra Leone FAO (2014), Youth and agriculture: Key challenges and concrete solutions. Rome.

Gronau, R. 1977. Leisure, Home Production, and Work-the Theory of the Allocation of Time Revisited. *Journal of Political Economy*, 85, pp. 1099-1123.

ILO (2013) Global employment trends for youth 2013: a generation at risk. International Labor Office (ILO), Geneva

Jacoby, H.G., 1991. Productivity of men and women and the sexual division of labor in peasant agriculture of the Peruvian Sierra. *Journal of Development Economics*, *37*(1-2), pp.265-287.

Jacoby, H.G., 1993. Shadow wages and peasant family labor supply: an econometric application to the Peruvian Sierra. *The Review of Economic Studies*, *60*(4), pp.903-921.

Juhn, C. and Murphy, K.M., 1996. *Wage inequality and family labor supply* (No. w5459). National Bureau of Economic Research.

Kien.T., 2009. Shadow wages and shadow income in farmers' labor supply functions. *American Journal of Agricultural Economics*, *91*(3), pp.685-696.

Kyriazidou, E., 1997. Estimation of a panel data sample selection model. *Econometrica: Journal of the Econometric Society*, pp.1335-1364.

Lopez, R.E.1984. Estimating labor supply and production decisions of self-employed farm producers. *European Economic Review*, 24(1), pp.61-82.

Macurdy, T. E. and Pencavel, J. H. (1986), Testing between Competing Models of Wage and Employment Determination in Unionized Markets*, Journal of Political Economy*, 94, S3-39

Manser, M. and Brown, M., 1980. Marriage and household decision-making: A bargaining analysis. *International economic review*, pp.31-44.

Murtazashvili, I. and Wooldridge, J.M., 2008. Fixed effects instrumental variables estimation in correlated random coefficient panel data models. *Journal of Econometrics*, *142*(1), pp.539-552.

Nijman, T. and Verbeek, M., 1992. Nonresponse in panel data: The impact on estimates of a life cycle consumption function. *Journal of Applied Econometrics*, *7*(3), pp.243-257.

Omoti, J. 2012. Synthesis report on current and emerging youth policies and initiatives with links to agriculture: the case of Malawi, Mauritius, South Africa, Swaziland, Tanzania and Zimbabwe. Pretoria: FANRPAN

Rosenzweig, M.R., 1980. Neoclassical theory and the optimizing peasant: An econometric analysis of market family labor supply in a developing country. *The Quarterly Journal of Economics*, pp.31-55.

Schultz, T.P., 1999. *Women's Role in the Agricultural Household: Bargaining and Human Capital* (No. 803). Economic Growth Centre, Yale University.

Semykina, A. and Wooldridge, J.M., 2010. Estimating panel data models in the presence of endogeneity and selection. *Journal of Econometrics*, *157*(2), pp.375-380.

Singh, I., Squire, L. and Strauss, J., 1986. *Agricultural household models: Extensions, applications, and policy*. The World Bank.

Skoufias, E., 1994. Using shadow wages to estimate labor supply of agricultural households. *American Journal of Agricultural Economics*, *76*(2), pp.215-227.

Stock J, Yogo M, Wright J. 2002. A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments. Journal of Business and Economic Statistics, 20:518 – 529.

Sargan, J. D. 1958. The estimation of economic relationships using instrumental Variables. *Econometric*a 26: 393-415.

Tassew W. 2000. *Economic Analysis and Policy Implications of Farm and Off-farm Employment*: A Case Study in the Tigray Region of Northern Ethiopia. *Doctoral Dissertation*. Wageningen University, Wageningen.

Glover, D. R and Simon, J. L. 1975. The Effect of Population Density on Infrastructure: The Case of Road Building, *Economic Development and Cultural Change* 23 (3): 453-468. DOI: 10.1086/450808

Appendices

Table A. Migrants and non-migrants (who are still working in farming) characteristics

Variables		Migrants	Non-migrants
Gender (%)			
	Male	55	62
	Female	45	38
Age of migrant(years)		22.76	21.64
Average education (years)		2.80	2.4
Work at destination (main) %)			
	Farming	31.46	53.33
	Domestic	16.85	13.00
	Student	16.85	33.67

Source: Own computation from household and youth survey data in 2010/11 and 2014/15

Table B1. First stage regressions

VARIABLES	(1) Male shadow wage	(2) Female shadow wage	(3) Male mature shadow wage	(4) Female mature shadow wage	(5) Child shadow wage	(6) Shadow income
youthdensity	0.267***	0.391***	0.184**	0.026	0.449***	0.354**
	-0.071	-0.078	-0.073	-0.104	-0.126	-0.163
roof_corrug	0.028	-0.101	-	0.165	0.200	-0.248
	-0.071	-0.076		-0.102	-0.128	-0.169
floor_conc	1.332*	0.374	-0.902	-1.221	-	-
	-0.800	-0.379	-0.871	-1.144		
woodstove	-	0.280**	0.162	0.259	-0.715***	0.571*
		-0.128	-0.134	-0.171	-0.220	-0.292
mosvolbed	0.137**	0.000	-0.025	-0.069	0.119	-0.226
	-0.065	-0.070	-0.068	-0.093	-0.115	-0.152
mobile	0.133**	0.093	-0.003	-0.047	-0.029	-
	-0.060	-0.064	-0.065	-0.086	-0.106	
radioo	0.022	0.127*	-	-0.070	0.080	0.021
	-0.066	-0.070		-0.094	-0.117	-0.155
jewlery	-0.019	0.006	-	0.0892*	-0.069	-0.021
	-0.034	-0.036		-0.048	-0.060	-0.080
cart	0.081	0.414***	0.222	-	-0.432*	-0.237
	-0.137	-0.146	-0.146		-0.245	-0.320
water_riv_rain		-0.054	-0.026	-	0.193	0.029
		-0.074	-0.072		-0.123	-0.163
water_pip_dry		0.062		0.213	0.147	0.637**
		-0.123		-0.160	-0.204	-0.267
Constant	-1.871**	-0.176	0.720	1.770	-0.732	7.095***
	(0.902)	(0.577)	(0.984)	(1.290)	(0.786)	(1.482)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,011	1,011	1,011	1,011	1,011	1,011
R-squared	0.316	0.275	0.363	0.271	0.248	0.131

	B. Test for exclusion criteria				
VARIABLES	(1) On-farm male SS	(2) On-farm female youth SS	(3) On-farm male mature SS	(4) On-farm female mature SS	(5) On-farm child labor SS
youthdensity	-0.038	-0.034	-0.101	-0.060	0.050
	-0.091	-0.080	-0.079	-0.075	-0.064
roof_corrug	-0.064	0.044	-0.033	0.104	0.049
	-0.091	-0.078	-0.078	-0.074	-0.063
floor_conc	0.643	-0.353	-0.198	-0.178	-
	-1.019	-0.389	-0.880	-0.823	
woodstove	-	-0.272**	0.011	0.095	-0.354***
		-0.132	-0.135	-0.123	-0.109
mosvolbed	0.016	0.045	0.016	0.072	-0.069
	-0.083	-0.072	-0.070	-0.067	-0.057
mobile	-0.121	-0.156**	-0.018	-0.071	-0.077
	-0.076	-0.066	-0.066	-0.062	-0.053
radioo	0.030	-0.119*		-0.053	0.031
	-0.083	-0.072		-0.067	-0.058
jewlery	-0.037	-0.013		0.005	-0.0548*
	-0.043	-0.037		-0.035	-0.030
cart	0.172	-0.287*	-0.378**		-0.116
	-0.174	-0.151	-0.150		-0.121
water_riv_rain		0.057	0.159**		0.164***
		-0.076	-0.074		-0.061
water_pip_dry		-0.180		0.326***	0.146
		-0.127		-0.115	-0.102
inputprice1		-0.014		-0.044	
		-0.089		-0.079	
Constant	0.165	1.258**	0.390	1.053	1.422***
	(1.148)	(0.593)	(0.996)	(0.928)	(0.476)
Other controls	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Observations	1,011	1,011	1,011	1,011	1,011
R-squared	0.381	0.317	0.340	0.225	0.194

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note: SS denotes labor supply