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Rural Income Diversification in Ethiopia

Patterns, Trends, and Welfare Impacts

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Abstract

Increased diversification of rural households into the rural non-farm economy is an important driver of economic growth and structural transformation in countries like Ethiopia where the vast majority of people live in rural areas and are largely dependent on seasonal agriculture. Some of the benefits of diversification include efficient utilization of asset endowments (e.g., labor during dry season) and reduction of risks. In this study we explore the: (i) patterns and trends of diversification, (ii) drivers of diversification including the association between rainfall risk/shocks and diversification, and (iii) welfare effects of diversification during the recent decade using three rounds of representative household data from the four main regions of Ethiopia. We used Cragg's double-hurdle model, a method that considers the two-step decision making process in diversification (i.e., participation and extent of participation), to identify the determinants of diversification and a fixed-effect and instrumental variable (IV) approaches to understand the links between diversification and household welfare. The descriptive results show that rural households generally adopt a livelihood strategy dominated by farming and that the level of diversification has been stagnant over the period of analysis considered. More importantly, the vast majority of households continue to draw a substantial share of their income from crop production, followed by livestock. The income from non-farm activities accounts only between 17 percent and 23 percent of the total income. The econometrics results show that diversification is positively associated with credit access, membership in social insurance, ownership of mobile phone, relative measure of household wealth, and population density. Conversely, access to relatively large, fertile, and irrigable land discourages diversification into non-farm activities. The analysis on the association between rainfall risks and diversification indicates that rural households use income diversification both as risk mitigation and shock coping strategy. The results on the link between income diversification and household welfare indicate a positive association between diversification and household total consumption expenditure, dietary diversity score, and housing/roof quality. In sum, the results imply the need for a deliberate effort to expand the non-farm economy so as to tap its full potential for employment generation, income growth, and welfare improvements. A starting point could be for agricultural and rural development policies and investments to go beyond promotion of cereal crop production and facilitate participation in high value crop, livestock, aquaculture production. Incentivizing investments in value addition activities that can create and enrich upward and downward linkages in the midstream segment of agricultural value chains is another potential avenue to boost rural non-farm economy.

Keywords: Ethiopia, Income diversification, welfare

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1. Introduction

Rural areas in Sub-Saharan Africa (SSA) are characterized with less economic dynamism relative to their urban counterparts. Product and labor markets, financial, communication, and other service infrastructure are underdeveloped in rural areas and as a result rural households and communities have less diversified sources of incomes. They generate most of their income from crop and livestock production and extraction of natural resources. However, there is growing evidence that households' participation in the non-farm economy, and the importance of non-farm incomes has been increasing in the last few decades. This increase in diversification of rural households into the rural non-farm economy is an important contributor for poverty alleviation, income growth, and resilience to shocks while it also contributes for agricultural and macroeconomic transformation and vice versa (von Braun and Feder 2007; Reardon et al. 2007; Barrett et al. 2001a, 2001b, 2001c; Ellis 1998).

A successful transformation of economies from predominantly agrarian to modern economies is viewed to involve increased specialization, whereby diversification is considered transitory and associated with adverse factors that push households to adopt nonspecialized income sources. However, the fact that economic transformation involves, among others, a declining share of agriculture in gross domestic product and total employment implies increased diversification of households, including those in rural areas, into non-agricultural economic activities. Therefore, these two views are not mutually exclusive. Individuals with increasingly specialized economic activities could inhabit increasingly diversified households and communities. Moreover, increasingly diverse goods and services consumption, which is concomitant with economic transformation, necessitates engagement in diverse economic activities. Furthermore, the growing literature in this area indicates that the rural non-farm economy is widespread, non-transient, and is prevalent in communities and among households in poor economic conditions and/or with little factor endowments, incomes, assets, and skills as well as among those in better economic conditions and/or with more resources. Perhaps more importantly, households' voluntary decision to participate and extent of participation in different income generation activities reflects their rational behavior or choices based on optimization of their welfare given the resource and other constraints they face. Diversification within agriculture and non-farm economic activities is also crucial in the face of increased climate change and transformation in agri-food systems needed to reduce malnutrition. In fact, research on diversification behavior

provides insights on its crucial role in poverty reduction and facilitating economic growth as well as in addressing new and emerging issues faced by households, rural communities, and ecosystems such as malnutrition and climate change (Asfaw et al. 2019; Wan et al. 2016; Mathenge and Tschirley 2015; Roe et al. 2010; Timmer and Akkus 2008; Breisinger and Diao 2008; Barrett et al. 2001a, 2001b, 2001c; Ellis 1998; Bryceson 1996; Hayami and Ruttan 1985).

This paper studies rural income diversification in Ethiopia during 2012-2019, a period marked with rapid economic growth in the country. The Ethiopian economy grew rapidly during 2004/05-2017/18 in which GDP grew at 10.4 percent and per capita GDP at 7.6 percent per year. Over 80 percent of the population resided in rural areas and most rural residents were engaged in agriculture. Agriculture, on average, accounted for 44 percent of GDP and was a major contributor to GDP growth. Within agriculture, crop production is the most important subsector. The share of crop production in agricultural GDP increased throughout the period (World Bank 2015; National Bank of Ethiopia (NBE) 2019). The period also saw an increase in per capita quantity consumed, real expenditure, and share in total consumption expenditure, particularly in urban areas, of animal products, fruits, and vegetables. Despite these changes, the share of livestock in agricultural output declined, livestock productivity was stagnant, and yields of high-value crops, particularly vegetables declined. These may imply limited change in income diversification (Bachewe and Minten 2021; Worku et al. 2017; Bachewe and Taddesse 2019).

Specifically, our analysis focuses on assessing the patterns and trends of income diversification and participation in and share of different income sources in total income of rural households in Ethiopia. We also study the relationship between income diversification and household factor endowments (household wealth, income streams, and household head characteristics), the effects of exposure to production risk (e.g., long-term rainfall variability) and shocks on diversification, and the association between diversification and welfare outcomes at the household level.

The results show that households generally adopt agrarian-dominated livelihood strategy, and this has changed little over the period of analysis, and the vast majority of households continue to draw a substantial share of their income from crop production, followed by livestock. The income from non-farm activities accounts only between 17 and 23 percent of the total income over the period considered and shows a downward trend. Interestingly, the highest share of non-farm income (23 percent) was in 2016 when El Niño caused droughts, which reduced crop

income in most parts of the country and presumably pushed households to augment their farming income from other sources.

The results on the determinants of income diversification shows that interhousehold differences in asset endowment (i.e., land, including quality and access to irrigation, labor, experience, access to capital and information, etc.), proximity to small towns, and natural conditions (e.g., rainfall pattern) play a crucial role in driving household's choice of diversification strategies. For instance, while income diversification is positively associated with access to credit, mobile ownership, and asset/wealth, it is negatively associated with access to large, fertile, and irrigable land, which make crop production more profitable. Consistent with prior studies, the results on the link between income diversification and household welfare indicate a significantly higher consumption expenditure, a more diverse diet, and better housing (as measured by roof quality) among households with diversified income sources.

The paper contributes to the growing literature on rural income diversification in developing countries and its potential for poverty reduction and improving wellbeing. First, it provides useful insights on patterns and trends of livelihood diversification during a period of rapid economic growth in Ethiopia based on a rich dataset with indicators on income generation activities and household and community characteristics that we also merge with geo-referenced weather data. Second, it explores the potential of diversification to address underemployment and unemployment in rural areas, especially among women and youth with limited access to agricultural lands. Similar to other countries in SSA, the youth account for a large proportion of the population in Ethiopia, with nearly 70 percent of the population in 2020 under the age of 30, and unemployment is relatively higher among the youth. Our analysis shows lower reliance of youth on agricultural, particularly crop, income and the role of other sources of incomes. Third, the period covered in this study straddles the El Niño caused drought in Ethiopia in 2015/16. Our investigation of the importance of income diversification as a risk-management and shock-coping mechanism provide important insights for efforts to improve the resilience and adaptive ability of rural households in the face of more frequent climate change driven shocks. Fourth, our examination of the impact of income diversification on household welfare is important to understand the pathways through which household economic activities improve household welfare, particularly nutritional outcomes. Furthermore, diversification into non-farm economic activities is considered an important component of the food system transformation required to

improve nutritional outcomes in rural areas of Ethiopia and SSA (WDI 2021; Minten et al. 2020, Alonso et al. 2020; Gebru et al. 2018).

This remainder of the paper is organized as follows. The following section discusses concepts, data, and methods used in the study. Section 3 presents results of the descriptive analyses, which is followed by Section 4 that presents the results and discussions of the econometric analyses. The last section concludes with policy implications.

2. Concepts, data, and methodology

In this section we define concepts and aggregations used in the study and review some of the motives for household income diversification. The section also briefly describes the data used and the empirical estimation strategies.

2.1 Concepts and definitions

Unit of analyses

This study uses households as the unit of analyses, although we will be using variables representing household members in some of our descriptions. According to the data collection manual used, a household can be defined as either a) a one-person household, that is a person who makes provisions for his own living without combining with any other person to form part of a multi-person household or b) a multi-person household, that is, a group of two or more persons who live together and make common provisions for food and other essentials of living. The persons in the group or members of the household may pool their incomes and have a common budget to a greater or lesser extent. They may be related or unrelated persons or a combination of both.

Income generation activities

Different studies identify different number of income sources or economic activities. We use the most common classification that includes crop, livestock, wage, enterprise/business, and remittance. Some studies divide income sources into more categories while others group them

into fewer categories.[1] Income sources can also be grouped into two broad sectoral (farm/non-farm) and locational (on-farm/off-farm) categories. In this study non-farm activities encompass all income generating activities other than production of primary agricultural outputs. This includes business enterprises, non-agricultural wage labor, remittances, and other activities. Farming activities, on the other hand, include income from own farming (crop and livestock) production plus agricultural wage labor. Off-farm incomes/activities include all incomes excluding income generated from own farming (crop and livestock). Note also that non-agricultural wage income includes income earned by working in business enterprises owned by others (Asfaw et al. 2019; Wan et al. 2016; Mathenge and Tschirley 2015; Barrett et al. 2001a).

Income diversification

Different studies provide different, implicit or explicit, definitions of income diversification. The definitions and methods used to quantify income diversification can be divided into three broad categories. The first measure of income diversification is a simple count of the number of economic activities households participate (Minot et al. 2006). The second measure of income diversification mainly considers the contribution of one source (such as non-farm income) or the top four sources (the concentration ratio) (Reardon 1997). The third and most common measure of income diversification considers both the number and importance of income sources across all sources (Joshi et al., 2003; Minot et al., 2006).

Consistent with the third approach we measure diversification using an index that considers the number of income sources and income shares, assigning an equal value to both components of the index. While this approach is preferred to the previous two (Dimova and Sen 2010) and most used method, we also use the other two measures of diversification to highlight/triangulate some aspects of our main findings.

Motives for diversification

The income diversification literature is mostly consistent on the motives about why households diversify their economic activities. These motives are often divided into two groups: push and pull factors. Push factors are those that pressure households into diversification to overcome

[1] In some parts of our analyses, we divide wage income into agricultural and nonagricultural wage income and add another income category, which comprises incomes earned from other sources (rental incomes, returns on investments, and incomes from sources not included in the remaining categories).

potential income variability and declines. Income diversification decisions due to such factors can be made before or after the occurrence of the factors. Pull factors, on the other hand, are those that incentivize households to participate in economic activities they were not participating hitherto. Such diversification is often pursued for the purpose of accumulation and improving living standards by economically better-off households and/or those with more factor endowments and higher income streams. While households diversify after factors that pull them into diversification occurred, they may begin diversification before if they anticipate the occurrence of such factors. While we provide below a partial list of these factors, in practice diversification decisions of individuals, households, and communities may be influenced by multitudes of factors. Heterogeneity in factor endowments, assets, and income streams of households means that different factors influence their diversification decisions differently and interventions addressing shocks, supporting livelihoods, and improving asset endowments need to consider such differences.

Seasonality: Agriculture is characterized by the paucity in its production process, which implies returns to factor inputs and assets could vary across periods. Typically, household members supply services of their labor and productive assets to the market during off-agricultural seasons to smooth their consumption. However, such diversifications can occur even under conditions of agricultural income that is sufficient to cover consumption needs across seasons (Barrett et al. 2001b; Ellis 1998; Alderman and Paxson, 1992).

Differentiated labor markets: Labor markets could be differentiated across locations (e.g., urban-rural), time (e.g., seasons), skills, gender, castes, and cultural proscriptions. Females are frowned upon or even prohibited from doing certain jobs in some cultures while in other cultures all members of a given caste cannot participate in some economic activities, both of which effectively narrow the set of opportunities available for those individuals and households. Households could invest on education or to learn skills to diversify income sources in the long-term by migrating to urban areas or participating in skilled wage labor (Ellis 1998).

Imperfect or non-existent land, credit, and labor markets: Households that are endowed with non-optimal factor ratios are forced to engage in income diversification by weak or nonexistent factor (land, labor, and/or credit) markets. A household with more labor than needed in its crop production could diversify into other activities if land markets are weak or do not exist. Conversely, a household that owns land but fully engaged in non-agricultural activities may be

forced into crop production in the face of weak/non-existent labor markets. Liquidity constrains force households engaged in wage labor to raise funds needed for investment in other economic activities (Barrett et al. 2001b; Ellis 1998).

Intertemporal savings and investment strategies: Diversification serves the purpose of intertemporal savings and investment strategies for households in better economic conditions and/or endowed with better factor inputs. Typically, such households are attracted/pulled into economic activities with higher returns and for purposes of accumulating wealth and/or achieving higher standards of living (Barrett et al. 2001a; Ellis 1998)

Risk management and shock-coping: Crop and livestock farmers in SSA face several kinds of risks given both production processes rely heavily on rainfall, use low levels of modern inputs, and early warning systems and preparedness to address emergencies are weak. With the absence or imperfect insurance markets against such/perceived risks, households self-insure their income streams by diversifying into different income generation activities. Diversification as a risk management strategy occurs ex ante, before the occurrence of the risky event, and involves a trade-off between a higher total income with greater probability of income failure and a lower total income involving smaller probability of income failure. While such diversification could lead to lower total income its main objective is selection of activities with no or low covariate risk. A related but distinct motive of income diversification is to cope with shocks. Shocks could be idiosyncratic, such as sickness or death of a household member and the associated loss of income or cost, or they could be covariate, such as policy changes or low rainfall in a given area affecting a large number of households. Diversification as a shock-coping mechanism occurs ex post, after or during the occurrence of the shocks. This motive, which is an unplanned reaction to unexpected livelihood failure not addressed by risk management strategy, differs from planned or voluntary ex-ante diversification strategies (Abid et al. 2020; Asfaw et al. 2019; Arslan et al. 2018; Ersado 2006; Barrett et al. 2001a, 2001b; Bryceson 1996; Delgado and Siamwalla 1999; Ellis 1998; Murdoch, 1995; Davies, 1993).

Adaptation: Households may pursue diverse economic activities due to inadvertent changes in their endowments, assets, and income generation potential at the wake of shocks. Such [negative] adaptations occur when households can no longer go back to their previous income generation potential and fail to reduce their vulnerability. Households may continue to participate in the new economic activity pursued as a shock-coping mechanism after the shocks recede even when no

lasting damages have been suffered. Such adaptations are by choice, are reversible, and mostly lead to increased income security (Davies and Hossain 1997; Ellis 1998).

Imperfect or nonexistent product markets: Households in rural area could also diversify within agriculture by cultivating different crops and engaging in livestock and fishery production and extraction of other natural resources. In addition to the reasons listed above such diversifications could be motivated by the distance, fewness, and infrequency of rural product markets.

2.2 Data

This study relies mainly on data collected in three rounds of household surveys conducted by the International Food Policy Research Institute (IFPRI) for the Agricultural Transformation Agency (ATA) of Ethiopia. The surveys were conducted in 2012, 2016, and 2019 and included 3,000, 4,991, and 5,311 sample households, respectively. These surveys were conducted to systematically assess the impact of the Agricultural Commercialization Clusters (ACC), a flagship project initiated by the ATA and implemented by the Ministry of Agriculture (MoA) and Regional Bureaus of Agriculture (RBoA). While the descriptive analyses section of the study includes all households with data in the relevant sections, the econometric analyses is based on 1,899 panel households that were interviewed in all three rounds.

Comprehensive survey instruments were used to collect household level data on crop production for a complete agricultural year that includes two cropping seasons (i.e., meher and belg), and livestock production[2], agricultural and non-agricultural wage income, enterprise income, remittances, and all other incomes for the 12 months preceding the time of the survey. For the purpose of this study total household income is defined as the sum of net crop, net livestock, total wages earned from agricultural and non-agricultural labor, enterprise income, remittance income, and other incomes. Net crop income is computed as the total value of crop output minus variable costs of production. Variable costs of crop production include money spent on purchased inputs such as fertilizer and improved seeds; rental of farm machinery and draft animals; and other crop production-related costs. Similarly, livestock income is computed as the value of livestock sold and slaughtered and the value of livestock products, such as milk, honey,

[2] Detailed data on livestock production were not collected in the 2019 survey. Therefore, we impute livestock net income for 2019 based on a regression model estimating livestock net income as a function of herd size and herd size squared from 2016 survey data.

butter, and other less variable costs of livestock production. Variable costs of production include costs of buying animals, labor hired to care for animals, veterinary services, and other livestock related costs. In each round of surveys, price data collected from sales transactions are used to compute the value of crop and livestock production. Similarly, net enterprise income is computed as the difference between gross enterprise income and total costs incurred for purposes of running the business.

Table 1 provides a summary of sample households' sociodemographic, economic, and location characteristics. During the first year of survey in 2012, the average household head was about 48 years old and without formal education. The average household had about six family members, owns 1.75 hectares of farmland and a livestock herd of about five tropical livestock units (TLU). Access to credit and social insurance was limited. A large share of households do not own mobile phones and need to travel more than 1 hour to reach the nearest weekly market. Furthermore, only 6 percent of households had irrigable land. In terms of household gender composition, the share of female-headed households, at 16 percent, is about one-third of the share of females in total working age population. The values in the second and third columns indicate that there is no significant change in these values of over time.

Table 1 Summary statistics of sample household (and location) characteristics

	2012	2016	2019
	(mean)	(mean)	(mean)
Gender of HH head (*1=female*)	0.16	0.16	0.16
Proportion of females in working age	0.53	0.54	0.53
Age of the HH head	46.01	48.93	50.84
Education level attained by the HH head	0.43	0.41	0.45
Education level attained by the spouse	0.19	0.20	0.21
Household size	5.50	5.72	5.56
Dependency ratio	1.50	1.51	1.47
Access to credit (*1=yes*)	0.29	0.28	0.16
Farmland owned (*hectare*)	1.75	1.77	1.79
HH has irrigable land (*1=yes*)	0.06	0.08	0.08
Social insurance (1=member in idir/equb)[a]	0.08	0.79	0.74
Membership in Agri cooperative (*1=yes*)	0.43	0.52	0.45
HH owns mobile phone (*1=yes*)	0.33	0.56	0.64
Livestock ownership (*TLU*)	5.20	5.89	5.42
Time to weekly market (*minutes*)	82.38	67.80	64.79
Time to Woreda Admin center (*minutes*)	165.84	137.44	132.21
Number of obs.	1891	1877	1865

Source: Authors' analysis using the ACC Surveys of 2012, 2016, and 2019.Note: a=The number for 2012 pertains only to membership in equb. Iddir and equb are an associations of people in the Ethiopian culture that have the objective of providing social and economic insurance in the events of death, accident, damages to property and mobilization of resources, especially finance, and distributing them on a rotating basis, respectively.

The income diversification literature has been growing for quite some time given the important insights derived from this body of works for policymakers and others engaged in poverty reduction and improving livelihoods and resilience of households and communities. However, most studies do not use data collected to purposefully study income diversification, motivations of households to diversify, and other information that directly address the process of household income generation. As indicated above the dataset used in this study is richer than those used in most studies reviewed. However, we take the fact that the data was not purposefully collected for the purpose being used as a caveat of this study.

2.3 Methods

Indicators

This study uses two related indicators of diversification. The first set of indicators are the share of income, net of variable costs, from different economic activities out of total household income. This includes the shares of incomes from crop production; livestock production;

agricultural wage labor; non-agricultural wage labor; enterprise income; remittance/transfer income; and other incomes. The share of each economic activity j out of total income of household h is given as:

$$S_{hj} = \frac{Y_{hj}}{\sum_{j=1}^{J} Y_{hj}} \text{ where } j = 1, 2, \ldots, J$$

where Y_{hj} is income of household h from source j and S_{hj} is the share in total income of source j for household h.

The second indicator is the Herfindahl–Hirschman diversification index (Rhoades, 1993), developed by Herfindahl (1950) and Hirschman (1964). We use the income shares for each activity to first calculate the normalized Herfindahl-Hirschman index (nHHI) of concentration[3] as follows: $nHHI_h = \frac{\sum_{j=1}^{J} {S_{hj}}^2 - (1/J)}{1-(1/J)}$

where J is the total number of income sources. Because we are interested in diversity rather than concentration, our index is one minus the nHHI of concentration:

$$HDI_h = 1 - nHHI_h$$

Measured in this manner the HDI_h ranges between zero and one. A diversification index of zero ($HDI_h = 0$) occurs when a household generates all of its income from just one income generating activity. If the household decides to participate in more than one activity, then $HDI_h > 0$ and its magnitude depends on the number of activities participated and the importance (share) of the activities in total income. A diversification index of one ($HDI_h = 1$) occurs when a household earns an equal share of its income from all sources.

The foregoing discussion on diversification implies that households' income generation decision is a two-part process. First, households decide whether or not to participate in the activity, such as crop production, and second, they decide on the importance of the income generation activity as a proportion of total income. However, unlike the decision to participate and share of income

[3] The (non-normalized) Herfindahl-Hirschman index (HHI) of concentration is calculated as Σs^2 and ranges from 1/J to 1, where J is the number of elements (sources of income in our example). The normalized Herfindahl-Hirschman index subtracts 1/J and divides by (1-1/J) so that the range of the index is between 0 and 1. The Simpson index of diversity (used widely in ecology as a measure of biodiversity) is 1-HHI.

generated from one or more of the activities, which are decided upon directly, the decision to diversify and extent of diversification is decided indirectly.

As indicated above, one of the questions this study aims to address is assessing the impact of diversification on household welfare (i.e., the relationship between diversification and welfare outcomes). The study uses three indicators of household welfare: (i) households consumption expenditure per capita; (ii) household diet diversity score (HDDS); (iii) and roof quality (as proxy measure of household assets).

Estimation strategy

The econometric analyses on factors associated with such two-phased decision process is conducted using Cragg's (1971) model, often known as the double-hurdle model. Relative to alternative empirical models the double-hurdle model is particularly useful in cases such as ours where the decision to participate in an economic activity is generated by a process that may differ from the process generating the income shares of each activity (Goodwin et al. 1993).

The intuitions for modeling participation and extent of participation as a two-step decision making process are as follows. Households participate in an economic activity if a) the net benefits from participating in the activity is positive ($B_{hj}^{*} > 0$) and b) they can (have access to) participate in the economic activity ($A_{hj}^{*} > 0$). Both variables (net benefits of participation and access to participation) are unobservable (latent) variables. We only observe households that participate ($P_{hj} = 1$). For each income generation activity *j*, the participation (first-hurdle) equation of household *h* is given as:

$$P_h = \propto_{p0} + \boldsymbol{\beta_p} X_h + \boldsymbol{\gamma_p} Y_h + \boldsymbol{\delta_p} C_h + \boldsymbol{\theta_p} T_h + u_h \text{ if and only if } (B_h^{*} > 0 \text{ and } A_h^{*} > 0) \quad (1)$$

$P_h = 0$ if $(B_h^{*} \leq 0)$ or $(B_h^{*} > 0$ and $A_h^{*} \leq 0)$

Where $u_h \sim N(0,1)$. The second hurdle is the equation that determines the extent of participation, which we measure here as a share of total income (S_h). This is given as:

$$S_h = \propto_{s0} + \boldsymbol{\beta_s} X_h + \boldsymbol{\gamma_s} Y_h + \boldsymbol{\delta_s} C_h + \boldsymbol{\theta_s} T_h + v_h \quad (2)$$

Where $v_h \sim N(0, \sigma^2)$. Equations pertaining to HDI equivalent to (1) and (2) obtain subsequent to decisions regarding other activities. Vectors *X, Y, C,* and *T* in the right-hand side of equations (1)

and (2) above contain household characteristics. More specifically, *X* is a vector of six household demographic variables: gender, age, and education of household head, and education of spouse, household size, and proportion of females in working age household members (the ratio of number of female household members between ages of 15 and 65 years to total number of household members in that age bracket). *Y* is a vector of ten variables that represent farm/farmer characteristics and household endowment: total cultivated area, land quality index[4], share of high-value crops in crop income, and tropical livestock units (TLUs), which normalizes the number of livestock households own in cattle units. Included in *Y* is also household asset index[5] and dummy variables that take a value of 1 if the household irrigated land, had access to credit, owned a mobile phone, is a member of social insurance, and is a member of agricultural cooperatives.

Vector *C* stands for administrative zone dummy variables as well as six variables that represent the characteristics of their communities: travel time to all weather roads, population density, average real wages, long-term meher rainfall, coefficient of variation of meher rainfall, and a dummy variable that takes a value of 1 if the woreda/district was selected for the Productive Safety Net Program interventions. *T* stands for year dummies.

The vectors of parameters β, γ, δ, and θ, which are identified by the subscript 'p' in the participation equation and 's' in the share equation, are estimated using a user-written Stata code, craggit (Burke 2009). Although these parameters are estimated simultaneously using craggit, estimates of the participation equation are the same as those obtained from a probit model and estimates of the share equation are the same as those obtained from a truncated normal tobit model. The real advantage of the double-hurdle model implemented via the craggit approach is it enables us to estimate the partial effect of an explanatory variable on the unconditional expected value of S_h, whether the explanatory variable is in equation 1, 2, or both (Burke 2009).

As indicated above, this study also aims to assess the impact of diversification on household welfare. For this purpose, the study uses three indicators of household welfare: (i) household

[4] Land quality index is computed by multiplying perceived soil fertility (1=infertile, 2=semi-fertile, 3=fertile) and slope of land (1=steep, 2=gentle, 3=flat). The index, therefore, ranges from the poorest land quality (1) to the best (9).

[5] Household wealth index is constructed using principal components method and includes all durable production implements and durable household assets while it does not include landholdings of households.

consumption expenditure per capita; (ii) household diet diversity score (HDDS); (iii) and roof quality (as proxy measure of housing quality). Household consumption expenditure per capita is the sum of consumer purchases and the value of own-produced food divided by the size of the household. The household diet diversity score is the number of food categories consumed out of ten categories in the previous week. The roof quality index is 1 if the roof is corrugated metal and 0 if the roof is mud, sand, stone, thatch, grass, or plastic.

To understand the effect of income diversification on household welfare, the outcome indicators ($\mathrm{W_{ht}}$) of household h at time t are modelled as a function of income diversification index at time t (HDI_{ht}). The basic empirical model is estimated as:

$$W_{ht} = \alpha + \delta HDI_{ht} + \rho Z_{ht} + \varepsilon_{ht} \quad (3)$$

where Z_{ht} is a vector of household, community, and location characteristics that may affect both household welfare and income diversification. The variables include age, gender, and education level of the household head, household size, dependency ratio, the value of durable assets, TLU, size of land owned, access to credit, ownership of mobile phone, travel time to a weekly market, and travel time to the woreda administrative centres. Household fixed effects are included in all the estimations as observed and unobserved household, agro-ecological and other location characteristics might influence the welfare outcomes. The last term in the equation, ε_{it}, is the random error term clustered at the village (kebele) level.

In equation (3), δ captures the main relationships of interest. It represents the impact of HDI on the three household welfare indicators. Based on prior studies and theoretical insights, our hypothesis is that δ is positive. In other words, households with more diversified income source will have better welfare outcomes (e.g., Dercon and Christiaensen 2011; Reardon et al. 2006). One main estimation concern of equation (3) is that HDI is likely to be endogenous, making the consistency of δ estimated using OLS questionable (Wooldridge 2013).[6] To address this concern, we apply a panel fixed effect and an instrumental variable (IV) approach. Three instruments are used to identify household income diversification. One of the instruments, the degree of income diversification in the kebele (community), is used as a proxy for social norms and economic opportunities. It captures the attitude regarding the possibility and the potential

[6] HDI could be endogenous due to non-random distribution of diversification index, omitted variables bias or measurement error (e.g., income is measured in monetary terms).

benefit of diversification in the community. We measure income diversification in the kebele by the average kebele level diversification score excluding the household under consideration. This directly affects the diversification level of the particular household but does not affect welfare outcomes of the household in consideration directly.

The second and third instruments are the mean and the standard deviation of the amount of rainfall during the previous harvest season. In highly rainfall-reliant rural economies, the amount and variation of rainfall during the previous harvest periods are powerful predictors of the pattern of income diversification in the subsequent periods, as it can determine production decisions (and thereby share of agricultural income) and migration patterns (Barrett et al. 2001a). However, while amount and variation of rainfall are exogenous to the household, their lagged values are less likely to affect the welfare outcomes directly during the current period.

The validity of the IV approach rests on two criteria. First, the *relevance* criterion demands that the instruments be good predictors of the diversification indicator. To formally test for this criterion, HDI is estimated as a function of the instruments and other relevant household and community characteristics, including several household wealth measures. Table A3 in the Online Appendix accompanying this paper shows the first-stage regression results. From this result, it is evident that the instruments are relevant (i.e., good predictors of income diversification at household level). The partial F-statistic for the model is above 10, the minimum threshold value of the "rule of thumb" for valid instruments (Staiger and Stock 1997). Moreover, the additional IV diagnostic tests presented at the bottom of the Table 7 affirm the validity of the instruments. The critical values of the Cragg-Donald test statistic reject the null hypothesis that the endogenous regressor is weakly identified. The Kleibergen-Paap test also rejects the hypothesis of under-identification, i.e., the minimal canonical correlation between the endogenous variable and the instruments is statistically different from zero. Furthermore, the Sargan-Hansen test (Hansen J test) could not reject the joint null hypothesis that the instruments are valid (i.e., that the instruments are uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation).

3. Descriptive results

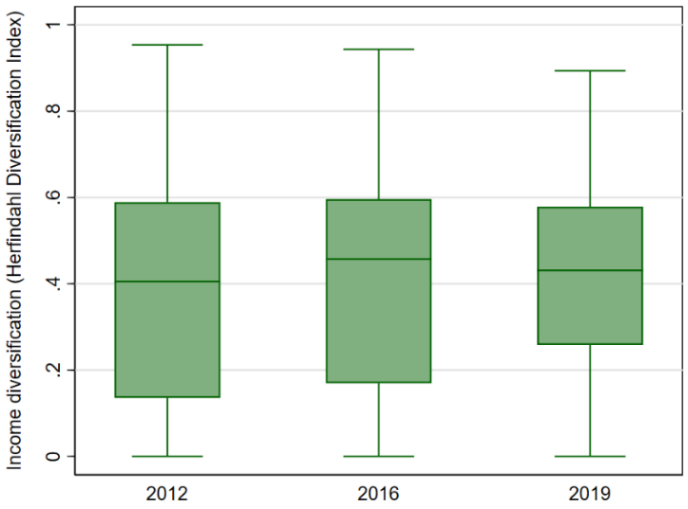
In this section we present the descriptive results on the patterns and trends in income diversification across rural households; the correlation between income diversification and

income sources with variables that capture household wealth, assets, and income streams (third subsection); risk and shock (fourth subsection); and a brief description of the aforementioned household welfare measures.

3.1 Patterns and trends of rural income diversification

Figure 1 summarizes the HDI for all households. Two main observations can be made. First, diversification of income generating activities, measured on a scale of 0 to 1, averaged less than 0.5 in all three years indicating that income diversification is generally low. Indeed, average HDI was below 0.5 across different household categories (Figures 2 and 3). The level of HDI calculated from this dataset is also comparable with that obtained from other datasets (see Bachewe et al. 2020). Secondly, despite the slight increase in HDI in 2019, there is little change in diversification of income sources of rural households in Ethiopia. HDI averaged 0.38 in 2012 and 0.39 in 2016 but increased to 0.41 in 2019. That is, HDI increased by seven percent during 2012–2019 or by an average of one percent per year during the period. The median diversification index is above 0.4 across the three years (Figure 1).

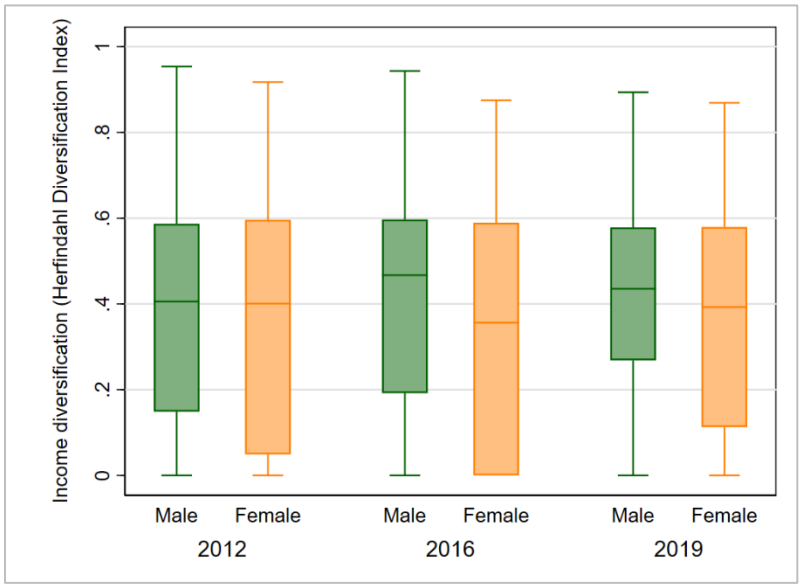
Figure 1 Income diversification (Herfindahl Diversification Index), by year



Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Figure 2 presents the HDI by gender of the household head and indicates that households with female heads have slightly lower levels of diversification and their HDI stagnated during the period. In contrast, the HDI of male-headed households dominated the pattern observed in the overall sample.

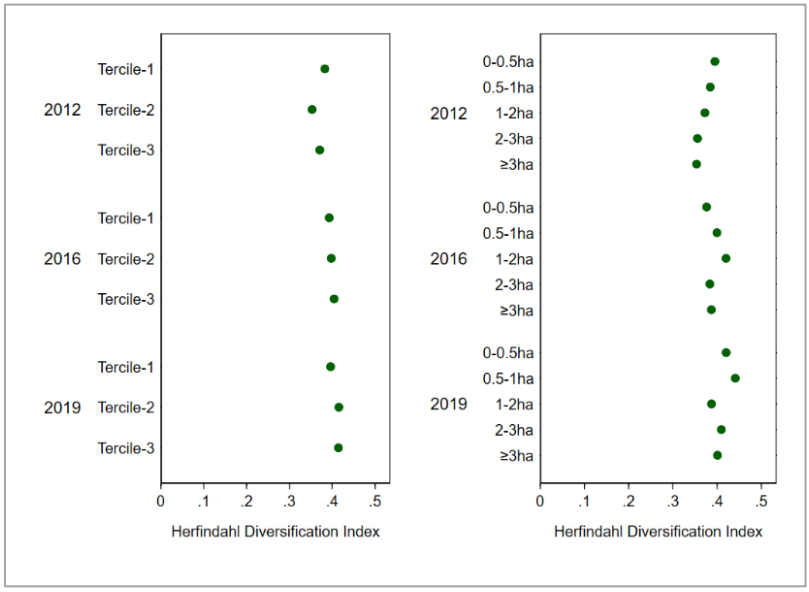
Figure 2 Income diversification (Herfindahl Diversification Index), by gender of the household head



Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Figure 3 presents the HDI by remoteness (as measured by distance tercile to the closest small city) and by farm-size category. Diversification of households in all three terciles of remoteness appears to clearly increase over time, although differences in diversification among households in different remoteness terciles are marginal. Households with smaller farms appear to have higher levels of diversification although the pattern is unclear in 2016, when drought affected most of the country adversely, implying that farm size may be linked with diversification only loosely during periods of crop failure.

Figure 3 Income diversification (Herfindahl Diversification Index), by remoteness and farm size



Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Table 2 presents participation rates of households in the different income generation activities, shares of the income sources in total household income, and household average income. Several observations can be made regarding these results. First, a large proportion of rural households participate in crop production, and crop income accounts for the majority of rural household income. However, both participation in and the share of crop income are slowly declining. Second, both participation in and the share of livestock income are increasing. Moreover, both of these observations are consistent with what was observed in other large household survey data in the country like the Feed-the-Future survey data (Bachewe et al. 2020). Participation in and share of crop income is more important for male- than female-headed households (Appendix Table A1).

Third, female-headed households participate twice as often in remittance income compared to male-headed households, and the share of remittances in their income is even higher. Relative to male-headed households, the proportion of female-headed households participating in "Other income sources" and its share in their total income was considerably higher (Appendix Table A1).

Table 2 Participation in different income generating activities and contribution of each source of income to overall income

	Percent participated			Share of income		
	2012	2016	2019	2012	2016	2019
Net crop income	93.7	87.9	89.6	63.3	54.1	60.4
Net livestock income	78.1	78.5	91.0	17.2	21.4	22.4
Agri wage income	7.8	4.7	2.4	2.0	1.5	0.5
Non-agri wage income	9.0	12.2	9.11	2.8	4.2	3.2
Enterprise income	30.9	29.5	21.5	7.4	9.0	6.5
Remittance (transfer)	9.32	9.32	7.27	2.3	2.9	2.1
Other incomes	21.5	24.6	15.9	5.1	6.9	4.8
Total (income)	-	-	-	100.0	100.0	100.0
Agricultural income	*98.5*	*97.8*	*98.4*	*82*	*77*	*83*
Non-farm income	*50.2*	*60.2*	*46.4*	*18*	*23*	*17*
Obs.	1,891	1,877	1,865	1,891	1,877	1,865

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.
Note: The share of income includes households without income from that source.

Fourth, based on participation and the share in total income, business (enterprise) activities are the third most important source of income after crop and livestock production. Moreover, enterprise income is even more important than wage income for female-headed households. Participation and share of agricultural and non-agricultural wage as well as enterprise income is the highest in 2016, indicating the influence of the drought caused by El Niño that reduced crop income and pushed households to augment their income from other sources.

Fifth, excluding its decline in 2016, agriculture's importance remained about the same in terms of participation and slightly increased in terms of its share of total income while non-farm activities declined in importance by both counts over the period considered.[7] Over 98.4 percent of the households participated in agricultural (i.e., crop, livestock, and/or agricultural wage) in 2012 and 2019 and only slightly lower (97.8 percent) in 2016. Consequently, the share of income from farming activities in total income was about the same in 2012 and 2019 and lower in 2016. In contrast, the proportion of rural households that participated in non-farming activities (i.e., non-agricultural wage, enterprise, remittance, and/or other) was 59 percent in 2012 and 60 percent in 2016, though it was considerably lower at 46.4 percent in 2019. The share of non-farming activities in total income was 18, 23, and 17 percent in 2012, 2016, and 2019,

[7] Non-farm activities include business enterprises, non-agricultural wage labor, and remittances. Farming activities, on the other hand, involve the production of primary agricultural outputs and include incomes from own farming (crop and livestock) activities plus agricultural wage labor.

respectively. This is considerably lower than the average share of non-farm income in rural areas of selected countries in Latin America (47 percent), Asia (51 percent), and Africa (37 percent) (Haggblade et al. 2007).

Overall, diversification of income sources among households in our dataset has changed marginally over the period considered, even if these data pertain to the same set of households with previously young household members joining the labor force. This indicates that an increasing proportion of the income was generated in agriculture and the new workers did not lead to a meaningful diversification in income sources.

One could argue that specialization in income generation activities, rather than diversification, is concomitant with the transformation in agriculture, the overall economy, and increased urbanization that was observed in Ethiopia during the period studied. However, the ACC data do not imply specialization either. Furthermore, the premise for that argument would imply diversification increase at some level of aggregation. We assess this by conducting the analyses at community/kebele and district/woreda level. The results indicate that kebele (woreda) level HDI averaged 0.56 (0.56), 0.64 (0.65), and 0.53 (0.54) in 2012, 2016, and 2019, respectively. Two observations can be made about these results. First, although community and district income sources are more diversified than that of households', which is expected, the difference is not substantial. More importantly, with HDI in 2019 lower than in 2012, there was no overall change in community/district level income diversification that can be presented as evidence supporting the argument above. Secondly, HDI in 2016 was about 15 percent higher compared to 2012 and 2019, presumably the El Niño caused droughts in 2016 has forced households and communities to diversify out of crop production indicating that push factors are important drivers for diversification.

3.2 Outcome measures

Table 3 indicates that the rapid growth in gross domestic product observed in Ethiopia between 2004 and 2019 appears to have translated into improved welfare of rural households. Total consumption expenditure increased at average annual rate of 22.2 percent per year. Household food and non-food consumption expenditure grew by a total of 173.1 and 37.3 percent during 2012-2019 or at average annual rate of 28.8 and 6.2 percent, respectively. The share of food out of total expenditure has been increasing, despite the rapid increase in income observed in this

dataset. Although this is not in line with the predictions of Engel's law, such a positive relationship between income and food expenditure in Ethiopia has also been observed in other datasets (Dereje et al. 2014).

Table 3 Household welfare measures

	2012	2016	2019
Household dietary diversity score (HDDS)	5.83	6.02	5.98
Consumption expenditure per capita (*birr, 2016 prices*)			
Food expenditure	3,118.6	5,080.4	8,515.6
Non-food expenditure	1,307.7	1,764.6	1,796.0
Total expenditure	4,426.2	6,845.0	10,311.5
Share of food in total expenditure	70.5	74.2	82.6
Roof quality (*1= corrugated metal*)	0.51	0.65	0.73

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Welfare, measured also in terms of household dietary diversity, is higher in 2019 than in 2012. More importantly, dietary diversity was the highest in 2016, which again goes back to the 2015/16 drought caused by El Niño when households may have depended on markets which normally have more diversified food than own harvest. The data also indicates that nearly three quarters of the households have corrugated metal roofs in 2019 compared to about half in 2012, a proxy indicator we used to measure housing quality.

3.3 Income diversification and household factor endowments (wealth, incomes, and head characteristics)

This section focuses on showing the relation between the importance of different income sources and income diversification with household factor endowments, wealth, income streams, and other household characteristics. We examined this relationship in a bivariate setting in this subsection (the results from a multivariate analysis are presented in the next subsection). Table 4 below and Tables A6 and A7 in the Appendix summarize our findings. In both Tables 4 and A6, HDI, land, wealth, income, and age quintiles have been calculated across each of the survey rounds, while the summary in the tables contain values in all rounds. For each variable, quintile I represents the group with lower values and quintile V the highest. A number of observations can be made about the results in the tables.

First, household land endowment is positively correlated with household wealth and income streams (Tables 4, A6, and A7). As expected, households with increasingly larger landholdings

generate more income from crop production. Livestock income is positively correlated with wealth and land size and negatively with total income, indicating the importance of livestock income for lower income households. Relative to households in the highest land quintile those in the lowest land quintile generate at least twice as much income from agricultural and non-agricultural wages, enterprise, remittance, and other incomes. This is the same when considering the households across income and wealth quintiles, except that the difference is lower for enterprise income, indicating that wealthier households and those earning higher incomes generate a considerable income from business enterprises. Indeed, absolute incomes (in real birr) of wealthier and high-income households is over twice and 11 times higher than the corresponding incomes of poorest and low-income households, respectively.

Second, households that are more diversified in terms of both number of activities and HDI generate lower income from crop production (Tables 4) or number of activities and HDI are negatively correlated with the magnitude of crop income (Table A7). Crop income shares of households in the highest HDI quintile or participating in 5 or 6 income sources is about half of those in the lowest HDI quintile and income sources, respectively. The importance of livestock income increases (is positively correlated) with HDI and appears to decline (is negatively correlated) with number of income sources. HDI and number of income sources participated considerably increase (are positively correlated) with the remaining income sources, except for other incomes, which is negatively correlated with HDI. The data also imply that out of households that participated in only one income source, 63 percent generated their income from crop production, 19 percent from livestock, and 9 percent from other sources. Furthermore, out of households that participated in two or more income sources at least 93 percent participated in crop production and at least 85 percent participated in livestock production, and the proportion of farmers that generate income from agriculture increases with number of income sources. The same pattern is observed when looking at households across HDI. Table A7 also indicates that HDI and farm size are uncorrelated, number of income sources and farm size are negatively correlated, while real income is negatively (positively) correlated with HDI (number of income sources).

The observations above appear to imply the following: land size (or landlessness) is an important push factor for households to diversify; even as households diversify more into other activities

agriculture is an important component of their portfolio; households generating incomes from more sources appear to earn relatively higher incomes even if they have smaller landholdings.

Third, households with younger heads (younger households) own smaller land, even in per capita terms. Household head age is positively correlated with wealth, seemingly because wealth accumulates over years. However, total income is negatively correlated with age (i.e., younger households generate more income). Consistent with other studies younger households generate more income from all non-farm income sources other than remittance and other incomes. However, unlike other studies, the dataset used here indicates younger households' participation levels and share of income generated from crop production is similar with households in other age categories, excluding those in the oldest age category, which has the lowest numbers. This may be reflecting findings in other studies that agricultural input use intensification is higher among younger farmers, who are more educated as is corroborated in this data. Age of household head is positively correlated with livestock income, which involves livestock assets accumulated over the years as is also observed in the positive correlation of livestock assets and household head age.

Table 4 Importance of income sources across household wealth, income, assets, head characteristics, and rainfall patterns

Quintiles/ groups	Farm size (ha)	Real income (000 birr)	Crop (%)	Livestock (%)	Agricultural wage (%)	Non-agricultural wage (%)	Enterprise (%)	Remittance (%)	Others (%)
HDI									
I	1.6	23.9	69.9	12.5	0.1	1.4	5.7	1.6	8.7
II	2.0	31.5	77.7	11.7	0.7	2.2	4.2	0.8	2.7
III	1.9	25.7	62.8	22.0	1.1	2.1	6.3	1.4	4.3
IV	1.9	21.2	49.3	32.1	1.3	3.1	7.0	2.5	4.7
V	1.5	24.5	40.0	24.0	3.3	8.3	15.0	5.4	4.0
Income sources									
1	1.6	14.1	70.3	17.9	0.0	1.0	8.5	2.3	0.0
2	2.0	25.5	67.3	22.1	0.8	1.5	3.9	1.2	3.2
3	1.7	27.8	53.4	20.0	1.5	4.4	11.2	2.9	6.6
4	1.4	24.3	40.6	16.8	3.6	10.1	12.9	5.7	10.3
5 or 6	1.3	26.0	29.9	15.7	4.3	14.5	13.7	8.8	13.2
Land									
I	0.3	16.9	50.3	16.7	2.8	6.1	11.3	4.0	8.7
II	0.8	20.2	57.1	20.5	1.4	3.7	8.3	2.9	6.1
III	1.2	23.5	61.2	20.2	1.1	3.2	7.7	2.0	4.7
IV	1.9	27.1	63.7	21.5	0.9	2.7	6.0	2.1	3.2
V	4.4	38.7	66.7	23.4	0.3	1.7	5.1	1.0	1.9
Wealth									
I	1.0	11.8	48.3	18.7	3.3	5.6	11.3	4.2	8.5
II	1.3	17.5	59.5	20.2	1.6	3.0	8.1	2.0	5.5
III	1.6	23.3	62.6	19.8	1.2	3.3	6.2	2.2	4.5
IV	2.0	28.1	62.2	22.2	0.4	3.2	6.1	2.0	3.9
V	2.7	43.0	64.5	21.2	0.3	2.4	7.2	1.7	2.8
Total income									
I	1.2	4.1	43.9	23.3	2.4	2.8	9.8	4.2	13.6
II	1.3	10.8	54.5	22.6	2.4	4.3	7.4	3.1	5.7
III	1.7	18.0	60.5	21.5	1.0	4.5	7.0	2.3	3.1
IV	1.9	29.1	66.2	19.3	0.5	3.9	7.1	1.5	1.4
V	2.9	65.4	74.0	15.9	0.1	1.6	7.1	0.7	0.7
Head age									
I	1.3	24.2	61.1	17.5	1.5	4.0	10.1	1.4	4.5
II	1.6	26.8	62.4	19.4	1.3	3.8	8.6	0.7	3.8
III	1.8	29.0	60.0	20.5	1.6	3.6	8.2	1.7	4.4
IV	2.1	26.3	60.5	20.7	1.3	3.3	6.5	2.7	5.0
V	2.0	20.9	55.2	24.6	0.7	2.5	4.9	5.4	6.8
Education									
Illiterate	1.8	22.4	58.8	21.4	1.5	2.9	6.7	3.1	5.6
Elementary	1.7	29.3	61.8	19.3	1.0	3.7	9.2	1.3	3.8
Secondary	1.9	36.5	59.4	18.0	0.9	6.7	10.2	1.1	3.7
Tertiary	1.7	39.5	53.6	14.0	1.8	19.0	7.4	0.2	4.0
Head sex									
Male	1.8	27.1	62.4	20.4	1.2	3.3	6.9	1.7	4.0
Female	1.4	15.7	45.5	20.9	1.8	4.1	11.7	6.0	10.0
Meher RF									
I	1.4	23.2	44.6	22.7	0.7	5.3	9.1	4.6	13.0
II	1.6	23.1	56.6	21.4	0.9	3.3	8.4	1.7	7.8
III	1.9	23.5	60.1	20.5	1.3	4.3	7.8	3.4	2.5
IV	1.7	30.4	70.5	17.7	1.4	1.9	6.1	1.4	0.9
V	2.2	25.9	66.1	20.5	2.0	2.5	7.1	0.8	0.9
CV meher RF									
I	2.0	28.2	69.7	18.2	2.4	2.2	6.1	0.7	0.8
II	1.8	26.5	67.5	17.7	1.4	2.4	8.0	1.8	1.3
III	1.9	26.1	59.2	21.8	1.0	3.9	8.5	2.4	3.3
IV	1.9	25.6	52.6	21.6	0.7	5.2	8.2	3.1	8.5
V	1.1	18.8	44.6	24.0	0.6	4.0	7.3	4.7	14.8

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Fourth, female-headed households are generally endowed with less factor inputs, are less wealthy, and generate a considerably low income. Particularly, the proportion of female-headed households in the poorest wealth quintile is three times higher than the proportion of male-headed households in that wealth quintile while the reverse is the case for households in the richest wealth quintile. Furthermore, households with female heads own slightly smaller lands but their household size is considerably smaller (by about 2 persons); consequently, they are endowed by about as much land per capita as households with male heads. However, female-headed households own considerably less livestock assets; nearly 86 percent of female heads are illiterate relative to about 50 percent of male heads that are literate; and a considerably lower proportion of female headed households participate in crop production because female heads take full responsibility of the activity late in life after separating from or widowed with male heads. Consequently, female heads generate considerably less income from crop production, as much income from livestock production, and more income from the remining (off-farm) income sources. While about the same proportion (55.5 percent) of female- and male-headed households generated income from one or two sources, the proportion of female-headed households that generated income from four or more sources is higher than the proportion of male headed households. Furthermore, excluding households in the lowest income quintile, households with female heads have a relatively higher HDI (or gender of head, which equals 1 if head is female, and HDI are positively correlated). These observations may imply that female headed households, who are endowed with less resources, could be more diversified and generate more income through schemes that build their household and productive assets and through policies that reduce labor and land market imperfections.

Finally, education and skills play an important role in income generation capacity and diversification of households, even under rural settings. The data indicate that about 34 percent of household heads had elementary (0–6 grades) education and 4.6 percent had secondary or tertiary education. The summary in Tables 4, A6, and A7 indicate that head education is uncorrelated with landholding size it is positively correlated with crop income. The share of livestock income is negatively correlated with household head education. Participation in and share of incomes generated from non-agricultural wages, remittance, and other incomes declines with education. Participation in and share of incomes generated from enterprise income increases with head education. Relative to households with illiterate heads, those with secondary or more

education are at least twice more likely to participate in non-agricultural wage income and the share of non-agricultural wage income is at least twice higher in their total income. Consequently, households with better educated heads are wealthier, generate higher incomes, and are more diversified in terms of both HDI and number of income sources.

3.4 Income diversification as a risk-management and shock-coping mechanism

This study includes the 2015/16 agricultural season, during which the second round ACC survey was conducted, and El Niño-caused droughts affected agricultural production in Ethiopia adversely, as described above. In this subsection, we examine livelihood patterns across different rainfall gradients and changes/responses in these patterns during periods of rainfall shock. For this purpose, we use the ACC survey datasets together with geo-referenced rainfall data from Climate Hazards Group InfraRed Precipitation with Station (CHIRPS), which is a database of rainfall covering 40 years and spanning the area between 50° S and 50° N. We summarize the data in Tables 5 and 6 and Figure 4 below, and Figures A1–A3 in the Appendix, in addition to the lower parts of Tables 4, A6, and A7 that summarize the statistics across long-term meher rainfall and coefficient of variation (CV) quintiles.

Diversification as a risk-management strategy

In Figure A1 in the Appendix, we provide maps showing spatial dispersion of average long-term meher rainfall spanning 1980-2021, CV of rainfall, importance of crop income, and income diversification. Areas with lower values are depicted by light green and the colors deepen to darker green as the values increase.

The first (top-left) map shows that woredas located in the northwest, center-west, and southwest of the country receive relatively more rainfall and, as shown in the map in the top-right, these areas generally have lower variability in rainfall. Woredas to the north, east, and southeast of the areas referred above generally have lower rainfall and higher CV. The two maps in the middle of Figure A1 indicate that a relatively higher proportion of households in the relatively wet and more rainfall-reliable areas derive a considerably higher proportion of their income from crop production while the reverse holds in areas with low and less reliable rainfall. The number of economic activities (bottom-left map) is similar with the map showing CV of rainfall, i.e., compared with households in more reliable rainfall, those in areas with low and less-reliable

rainfall are likely to pursue more economic activities. The last (bottom-right) map shows a mix of dark and light green colors in both areas. In summary, Figure A1 shows that households in high- and more rainfall-reliable areas derive much of their income from crop production. On the other hand, in low- and less rainfall-reliable areas, the proportion of households that participate in and the share of income generated from crop production is lower and more households diversify into other income sources ex ante to cope with the risk of low income.

Table 5 provides numerical interpretation of the observations made above. CV of meher rainfall declines across increasing quintiles of long-term mean rainfall; number of economic activities and HDI decline (increase) with mean (CV) of long-term rainfall; the proportion participating in crop income and importance of crop income increases across rainfall quintiles and generally the reverse holds for livestock production. The lower panel of Table 5 shows that the correlations pointed above are statistically significant. The bottom parts of Tables 4, A6, and A7 are consistent with the observations above and further indicate total household income, farm size, and agricultural wage income increase with long-term rainfall, which is expected given that cultivated areas and agricultural labor demand is higher in areas more productive in crop production. Although long-term rainfall and household wealth are uncorrelated, households in areas with less reliable rainfall are less wealthy. Non-agricultural wage, enterprise, remittance, and other incomes are less important in areas with higher long-term rainfall.

While Figure A2 in the appendix corroborates observations made above, it shows a slightly more nuanced relationship between income diversification and long-term average precipitation. Accordingly, the share of crop income first increases with long-term mean rainfall and then declines. Similarly, HDI first increases (declines) with CV (mean of rainfall) and then declines (increases). This may indicate that there exists a nonlinear relationship between the magnitude of precipitation and crop income while it may also be indicating that households in high-potential crop production areas, who are wealthier, endowed with more productive assets, and generate higher incomes, may diversify into other income generating activities to improve their living standards.

Table 5 Correlation between long-term meher rainfall, crop income, and income diversification

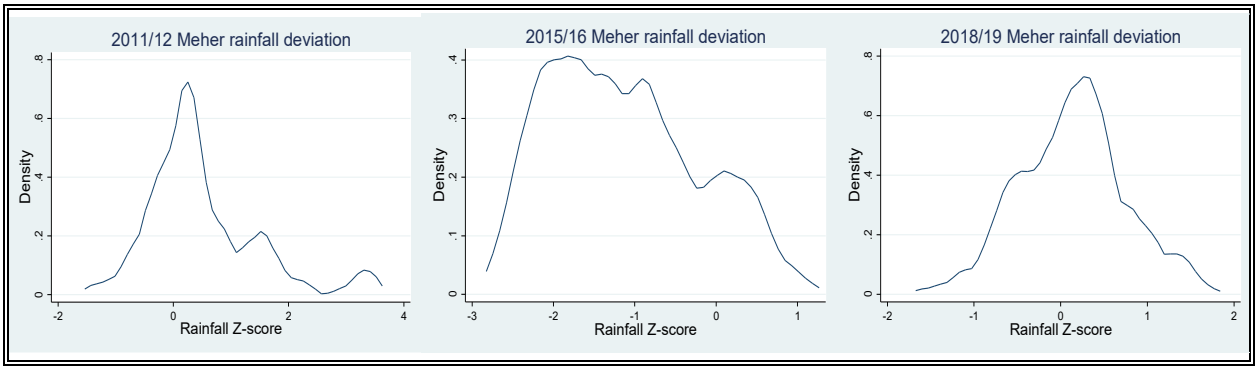
	Mean meher RF	CV meher rainfall	Number of activities	HDI	Crop income (%)	Crop producers (%)	Livestock income (%)	Livestock producers (%)
Quintiles of long-term meher rainfall								
I	583	0.18	2.79	0.41	44.6	84.6	22.7	85.3
II	791	0.14	2.59	0.42	56.6	93.6	21.4	85.5
III	950	0.13	2.42	0.40	60.1	93.1	20.5	81.3
IV	1,092	0.11	2.35	0.37	70.5	96.3	17.7	85.1
V	1,364	0.10	2.34	0.40	66.1	95.4	20.5	85.3
Correlation coefficients								
CV meher rainfall	-0.7782*							
Number of activities	-0.1952*	0.1910*						
HDI	-0.0324*	0.0430*	0.6147*					
Crop income (%)	0.2553*	-0.2751*	-0.3095*	-0.3969*				
Crop producers (%)	0.1389*	-0.1562*	0.1929*	0.2418*	0.5546*			
Livestock income (%)	-0.0347*	0.0916*	-0.0492*	0.2865*	-0.4946*	-0.2175*		
Livestock producers (%)	0.0133	0.0137	0.3632*	0.3410*	-0.0419*	0.0826*	0.4023*	

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019, and CHIRPS rainfall data.

Diversification as a shock-coping strategy

Figure 5 below depicts deviations (Z-values) of rainfalls in the 2011/12, 2015/16, and 2018/19 meher seasons, calculated using the total meher rainfall in respective agricultural seasons and the long term mean and standard deviations of meher rainfall spanning the 1980–2021 period. The figure clearly shows that the meher rainfalls observed in 2011/12 and 2018/19 are higher than zero in most areas while most areas have a considerably lower rainfall in 2015/16, which corroborates with the drought that occurred in that year.

Figure 5. Deviation of rainfalls in 2011/12, 2015/16, and 2018/18 meher seasons from long-term meher rainfall



Source: Authors' analysis using CHIRPS rainfall data.

In Table 6 we provide a summary of the three measures of income diversification across years and severity of rainfall shocks suffered during 2015/16. To group households across the three categories of shocks we use meher 2015 rainfall quintiles and the "Hotspot Woreda" categorization (HRD 2016).[8] Accordingly, the numbers in the table enable us to compare livelihood patterns and responses to shocks across categories of households and periods. Several observations can be made from the summary in Table 6.

The first observation is that the areas severely affected by the 2015/16 El Niño-caused drought were areas characterized by low mean and highly variable rainfall, as implied by their long-term mean and CV of rainfall. Furthermore, the areas severely affected by the drought had the highest decline and those that did not suffer shocks suffered the least rainfall decline. However, even those in the latter category suffered rainfall declines exceeding 10 percent in 2015/16, relative to 2011/12.

Second, areas that suffered shock and which have historically low and volatile rainfall rely less on crop production even in years of "normal rainfall", which as indicated above is an ex-ante risk-mitigation strategy, but also, they diverse away from crop production the largest when they suffer rainfall shocks, both in terms of participation and shares of income from crop production. Crop income of households in the severely affected category is on average the lowest relative to households in the other categories and the average of those not affected was the highest. The share of crop income in 2016 declined by a third in the severely affected category while it declined by less than 7 percent in the least affected category; and participation in crop production declined significantly in the worst affected areas.

Third, as indicate above, livestock income has been increasing in importance during the period studied, and this is apparent also in Table 6. However, the importance of livestock income

[8] In 2016 the Ethiopian government and its partners classified the woredas in the country into hotspot categories 1 to 3, whereby woredas severely affected by the drought are categorized as hotspot 1 and those with decreasing severity of drought as categories 2 and 3. Woredas that did not suffer shock (uncategorized) were assigned 4 (HRD 2016). Given that the latter categories were created for administrative ease and since there could be households in a given hotspot category that may not have been affected by the drought, we overlay the meher rainfall quintiles on the woreda hotspot categorization to create three categories of households according to shocks suffered. We categorize households in the first two 2015/16 meher rainfall quintiles and are in hotspot 1 woredas as "Suffered severe shock", those in quintiles two and three and hotspots 2 and 3 as "Suffered moderate shock" and those in the last two rainfall quintiles and hotspot 4 as "Did not suffer shock". This classification includes 70 percent of the households surveyed in all rounds.

increased considerably in the severely drought-affected areas in 2016, despite the decline in the proportion that participated in livestock income. This may have been caused by distress sales of animals by those households in that area in that year, as was documented by Bachewe et al (2020). Fourth, agricultural wage income is least (most) important in areas where crop production is least (most) important. The observation here is that agricultural wage is not dependable as a shock-mitigation strategy during periods of rain shortfall.

Table 6 Differences in livelihoods patterns and responses to shocks across rainfall gradients and severity of shocks

	Suffered severe shock			Suffered moderate shock			Did not suffer shock		
	2012	2016	2019	2012	2016	2019	2012	2016	2019
Rainfall patterns									
Long run mean meher rainfall		599			841			1,235	
CV of meher rainfall		0.183			0.137			0.100	
Meher rainfall	607	446	623	878	683	883	1,364	1,172	1,228
Income diversification									
Number of income sources	2.72	2.76	2.63	2.58	2.55	2.38	2.33	2.23	2.17
HDI	0.380	0.355	0.406	0.405	0.445	0.406	0.323	0.376	0.354
Share of income source (%)									
Crop	48.5	32.5	47.1	59.9	51.4	58.6	73.9	69.1	70.2
Livestock	19.3	25.0	22.0	19.6	23.6	23.9	14.5	18.7	21.7
Agricultural wage	1.1	0.7	0.6	1.2	1.6	0.2	2.4	1.4	0.6
Non-agricultural wage	3.9	4.8	4.4	3.2	3.1	3.5	1.1	2.7	1.2
Enterprise	7.9	9.3	7.8	7.9	11.2	6.2	5.5	5.8	4.8
Remittance	4.0	4.8	2.7	2.0	2.7	3.2	1.3	1.1	0.6
Others	15.3	23.0	15.4	6.3	6.5	4.3	1.3	1.2	1.0
Participation in income sources (%)									
Crop	86.4	74.1	82.0	94.5	90.4	89.6	96.7	95.7	96.1
Livestock	78.5	75.6	87.4	79.0	80.8	92.3	79.8	82.4	94.4
Agricultural wage	4.0	2.6	2.6	6.8	4.4	1.9	9.8	5.1	2.7
Non-agricultural wage	9.6	12.2	13.7	12.6	11.0	11.0	4.7	8.2	3.8
Enterprise	21.8	24.7	21.4	29.8	36.3	22.8	31.1	23.0	19.7
Remittance	12.1	14.8	11.4	7.9	8.5	6.3	6.5	5.0	3.0

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019, and CHIRPS rainfall data.

Fifth, non-farm income sources generally increase in importance during periods of rainfall shock. This is particularly the case in areas severely affected by drought where income shares and the proportion participating in non-agricultural wage, enterprise, and remittance income all increased in importance between 2012 and 2016 while the importance and participation in at least one of the income sources declined in the other areas.

Sixth, other incomes are most important in areas severely affected by the drought and became even more important in 2016 than in both 2012 and 2019. These income sources are relatively less important in areas less affected by the drought and remained about the same in importance in these areas during the period.

Finally, income diversification, measured in terms of number of economic activities participated, increased during 2012–2016 in areas severely affected by the drought. However, HDI declined in these areas in 2016, which may be because of the considerable decrease in the proportion that generate crop and agricultural wage income and slight decline in the proportion participating in livestock income in those areas. Income diversification measured in HDI was the highest in 2016 in the less shock affected areas while the number of income sources participated slightly declined in 2012–2016.

Figure A3 in the appendix provides the fractional-polynomial prediction plots of three measures of diversification (crop income share, number of income sources, and HDI) against z-score of meher 2015/16 rainfall and hotspot woreda codes. The graphs are consistent with what was observed above.

The graphs in the upper row indicate that the share of crop income generally declines with the severity of the drought in 2015/16. Furthermore, relative to the share of crop income in 2012 and 2019, crop income declined higher in areas where there was severe rain shortfall; increases were the highest in areas where there were little changes in rainfall. Finally, change in crop income (measured in standardized values) show the same positive relationship with woreda hotspot assignment, whereby crop income declined significantly in hotspot 1 (severely affected).

The graphs in the second and third row indicate that income diversification, measured in terms of both number of income sources and HDI are negatively associated with rainfall z-score in 2015/16. The same held when considering changes in number of income sources and HDI. The two bottom graphs in the last column are also consistent with what was noted above. Number of income sources increased in areas severely affected by the drought while they declined slightly in areas less affected, while HDI increased in the less affected areas.

In conclusion, the above analysis indicate that rural households generally use income diversification as an ex-ante risk mitigation strategy, an ex-post shock-coping strategy, and as a

source of upward mobility. In high- and more rainfall-reliable areas, most households participate in and generate most of their income from crop production. In low- and less rainfall-reliable areas, however, households diversify away from crops into other income sources ex ante to cope with the risk of low crop income. During and immediately after large agricultural shocks, such as the El Niño-caused drought, rural households diversify their income, ex-post, into non-farm sectors to augment the loss income from farming. Finally, the non-linear relationship we uncovered between precipitation and income diversification suggests that the agricultural sector has the potential to break liquidity-induced poverty trap in rural areas of developing countries. A well performing agricultural sector can serve as a source of start-up capital for a more productive rural non-farm sectors, leading to ownership of more productive assets to further improve their living standards.

4. Econometric results

In this section we present and discuss the results obtained from our econometric analyses. The first subsection presents the results from our fixed effect and IV estimates on the link between income diversification and welfare outcomes at household level. The subsequent subsection presents the household and community level push and pull factors associated with income diversification based on the results from Cragg's double-hurdle model.

4.1 Impact of rural income diversification on household welfare

A sizable share of households chooses to allocate their assets and efforts across a variety of activities, presumably to broaden economic opportunities and cope/manage risk exposures. Since diversification itself is not the end goal, in this subsection, we examine whether diversification strategies eventually lead to an increase in income and welfare at household level. Table 7 presents the results on the link between diversification strategies and welfare outcomes from the household fixed effect and IV[9] estimates.

The result show that income diversification has a strong positive effect on consumption expenditure per capita, household dietary diversity, and roof quality (a proxy indicators for housing quality/asset building). For instance, the estimates from the fixed effects model show that a one standard deviation increase in income diversification index leads to 13 percent growth

[9] Instrumental variables (IV) regression estimates are equivalent to two-stage least squares (2SLS) regression estimates when there is one dependent variable and one instrument for the endogenous explanatory variable.

in consumption per capita; 0.24 increase in number of food groups consumed; and a 4.8 percentage point increase in housing quality. It is also interesting to see that the result of the FE and IV-2SLS estimations are consistent, although the coefficient is slightly larger in the case of the IV model. Such differences between FE and IV methods could be due to potential measurement errors. We know that while measurement errors can lead to an attenuation bias towards zero in the linear model coefficients, instrumental variable approaches often mitigate such problems (Gujarati 2003; Angrist and Pischke 2009).

Table 7 also reveals that welfare outcomes are significantly correlated with many other covariates. Consistent with other empirical studies, diet quality (HDDI) is strongly correlated to membership in social insurance (i.e., iddir and equb) and standard wealth indicators— size of land owned ownerships of livestock and durable assets.[10] On the other hand, consumption expenditure and housing quality are positively correlated with age of the household head and mobile ownership.

[10] Iddir is an association of people in Ethiopian culture that have the objective of providing social and economic insurance for the members in the events of death, accident, damages to property, among others. Equb is an association of people in Ethiopian culture with the aim of mobilizing resources, especially finance, and distributing them on a rotating basis.

Table 7 Rural income diversification and household welfare

	Consumption expenditure per capita		HDDS		Roof quality	
	FE	IV (2SLS)	FE	IV (2SLS)	FE	IV (2SLS)
Income diversification index	0.131**	2.210**	0.240**	1.746	0.048*	0.647**
	(0.059)	(1.112)	(0.109)	(1.317)	(0.025)	(0.297)
Gender of HH head (*1=female*)	0.153*	0.150	-0.011	-0.013	0.089**	0.088**
	(0.086)	(0.099)	(0.106)	(0.112)	(0.041)	(0.043)
Proportion of females in working age	0.053	0.001	0.049	0.012	0.021	0.006
	(0.086)	(0.095)	(0.121)	(0.135)	(0.030)	(0.032)
Age of the HH head	0.015***	0.013***	-0.010***	-0.011***	0.004***	0.003***
	(0.002)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)
Education level attained by the HH head	0.078*	0.068	-0.024	-0.031	-0.001	-0.003
	(0.042)	(0.049)	(0.075)	(0.077)	(0.017)	(0.018)
Education level attained by the spouse	0.073*	0.009	0.111	0.064	0.009	-0.009
	(0.041)	(0.064)	(0.082)	(0.091)	(0.020)	(0.023)
Household size	-0.137***	-0.155***	-0.008	-0.021	0.011***	0.006
	(0.011)	(0.016)	(0.020)	(0.023)	(0.004)	(0.005)
Dependency ratio	-0.002	0.006	0.064**	0.069**	-0.008	-0.006
	(0.017)	(0.020)	(0.031)	(0.033)	(0.007)	(0.008)
Access to credit (*1=yes*)	-0.133***	-0.181***	0.130**	0.095	-0.030**	-0.044**
	(0.033)	(0.048)	(0.056)	(0.071)	(0.015)	(0.019)
Farmland owned (*hectare*)	0.005	0.008	0.040**	0.042**	0.004	0.004*
	(0.008)	(0.009)	(0.019)	(0.019)	(0.002)	(0.002)
HH has irrigable land (*1=yes*)	0.193**	0.215**	0.160	0.175	0.018	0.024
	(0.078)	(0.084)	(0.121)	(0.125)	(0.027)	(0.028)
Social insurance (1=member in idir/iqub)	0.902***	0.850***	0.294***	0.255***	0.101***	0.086***
	(0.045)	(0.052)	(0.067)	(0.081)	(0.014)	(0.017)
Membership in Agri cooperative (*1=yes*)	-0.024	-0.012	0.038	0.047	0.018	0.022
	(0.037)	(0.043)	(0.054)	(0.055)	(0.015)	(0.016)
HH owns mobile phone (*1=yes*)	0.358***	0.329***	0.006	-0.015	0.093***	0.085***
	(0.036)	(0.042)	(0.058)	(0.061)	(0.016)	(0.016)
Livestock ownership (*TLU*)	0.002	-0.001	0.025**	0.022**	-0.000	-0.001
	(0.002)	(0.003)	(0.012)	(0.010)	(0.001)	(0.002)
Household asset index (PCA)	0.014	0.003	0.110***	0.103***	0.014***	0.011**
	(0.013)	(0.017)	(0.020)	(0.022)	(0.004)	(0.005)
Time to weekly market (*minutes*)	-0.001***	-0.001***	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Time to Woreda Admin center (*minutes*)	-0.000	-0.000	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	7.894***		5.845***		0.255***	
	(0.123)		(0.220)		(0.052)	
Number of observations	5,428	5,376	5,428	5,376	5,428	5,376
R2	0.420	0.197	0.059	-0.009	0.102	-0.065
Adjusted R2	0.418	-0.225	0.055	-0.540	0.099	-0.625
Cragg-Donald test		13.48		13.48		13.48
Kleibergen-Paap rk LM statistic		16.56		16.56		16.56
P-value		0.000		0.000		0.000
Hansen J statistic		2.142		1.045		2.525
P-value		0.343		0.593		0.283

Note: Estimation based on three-round balanced panel data. ***p<0.01, **p<0.05 *p<0.1.
Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

4.2 Determinants of rural income diversification

As indicated in section 2.2 we obtain three sets of estimates from Cragg's double-hurdle model. We provide estimates of parameters of equation (1), the participation or first hurdle, and equation (2), income share or second-hurdle equation in Table A.8 in the appendix. In Table 8 we provide the third set of estimates: the average partial effects of the explanatory variables on HDI and income shares, obtained using the method described in Burke (2009). Several observations can be made about the results in Table 8.

First, demographic factors play important role in income diversification. Female-headed households are more diversified. This is likely because female heads have smaller farms and have less experience in agriculture and consequently, generate more income from diverse—non-farming—activities. Increase in number of household members serves as an impetus for greater income diversification not only to provide for the members but also because there likely is ample labor in the household. Households with a higher proportion of working females generate relatively more income from livestock production and a lower share from crop production and wage income. This may be because female members, particularly younger girls, are generally discouraged from working as hired labor and spend more time on household chores. Education levels of either the household head or the spouse are positively associated with wage and enterprise income and negatively with crop and remittance income.

Table 4 Average partial effects of the Double-Hurdle model

Variables	HDI		Crop		Livestock		Wage		Enterprise		Remittance	
	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Gender of HH head, =1 if female	2.374**	1.007	-4.31***	1.136	0.844	0.837	0.685*	0.387	1.037*	0.610	1.374***	0.136
Proportion of females in working age	1.607	1.545	-3.902**	1.720	3.609***	1.257	-4.245***	0.648	0.977	1.006	1.009***	0.190
Age of the head, in years	-0.027	0.026	-0.001	0.029	0.059**	0.022	-0.009	0.011	-0.062***	0.017	0.057***	0.004
Education level attained by the head	0.406	0.620	-1.223*	0.687	-0.076	0.525	1.038***	0.229	0.546	0.364	-0.137	0.097
Education level attained by the spouse	0.71	0.777	-1.316	0.871	-0.404	0.666	0.538*	0.282	1.12**	0.441	-0.569***	0.142
Household size	0.351**	0.162	-0.054	0.180	0.552***	0.137	0.104	0.067	-0.052	0.101	-0.289***	0.027
Household had access to credit, yes=1	3.216***	0.719	-2.681***	0.809	-0.108	0.608	1.035***	0.269	1.055**	0.420	0.58***	0.110
Farmland owned (ha)	-0.504***	0.162	0.537***	0.136	-0.014	0.126	-0.631***	0.115	-0.434***	0.141	-0.405***	0.047
Index of land quality	-0.102	0.165	0.543***	0.185	-0.429***	0.141	0.046	0.063	-0.125	0.100	0.026	0.024
Livestock, in tlu	0.412***	0.060	-0.002	0.065	0.687***	0.044	-0.707***	0.048	-0.448***	0.065	-0.093***	0.015
Household asset index, PCA	0.403*	0.222	0.771***	0.243	-0.241	0.184	-0.263***	0.092	0.208	0.138	0.213***	0.034
High-value crops in crop output, %	-0.113***	0.012	0.171***	0.013	-0.119***	0.013	-0.031***	0.005	-0.011	0.007	-0.012***	0.002
HH owns mobile phone, yes=1	1.565**	0.729	-3.157***	0.814	-1.055*	0.599	1.296***	0.287	1.792***	0.467	0.835***	0.112
Member of social insurance	3.144***	0.929	-3.734***	1.044	-0.308	0.754	0.315	0.362	3.38***	0.613	-0.421***	0.132
Agri cooperative member	-0.817	0.706	0.282	0.788	0.688	0.582	-0.195	0.285	-0.363	0.426	-0.341***	0.103
HH has irrigable land, yes=1	-2.961**	1.212	11.657	10.568	-4.912***	1.199	0.009	0.468	-0.268	0.713	-1.031***	0.218
Time to all-weather road, in min	-0.004	0.003	0.002	0.003	0.002	0.002	-0.007***	0.002	0.001	0.002	0.001**	0.000
Population density, persons/sq KM	0.022***	0.006	-0.01	0.006	0.01*	0.005	0.004	0.002	-0.002	0.004	0.001	0.001
Real wage of casual labor (in 2016 birr)	0.103***	0.036	0.013	0.041	0.01	0.029	0.014	0.014	0.011	0.022	0.021***	0.005
PSNP in woreda (=1 if yes)	2.006	2.457	3.277	2.741	-0.533	2.216	0.896	1.016	0.709	1.491	-2.022***	0.360
Long-term average meher rainfall (RF)	0.006*	0.003	0.002	0.004	0.003	0.003	-0.001	0.001	0.001	0.002	-0.002***	0.001
Coefficient of variation of meher RF	52.029*	31.223	-105.46***	36.319	61.655**	23.757	12.458	11.657	-19.76	19.854	24.464***	3.853
2016 dummy	-1.776	1.208	-4.276***	1.377	4.36***	0.997	-0.398	0.457	-1.205*	0.718	0.48***	0.171
2019 dummy	-1.359	1.685	2.335	1.880	4.733***	1.398	-2.969***	0.660	-4.031***	1.047	-1.716***	0.274
Number of observations	5,172		5,172		5,172		5,172		5,172		5,172	

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.
Note: Estimation based on three-round balanced panel data. ***p<0.01, **p<0.05 *p<0.1.

Second, interhousehold differences in asset endowment are important in income diversification. Households that own larger farms with higher quality soils and some irrigations are likely to generate a higher share of their income from crop production and less likely to diversify their income. The share of high-value crops in crop output has a similar relationship with income diversification. The econometric results corroborate the descriptive results whereby wealth index is correlated positively with crop income and HDI while it is negatively correlated with wage income. Household access to credits and ownership of mobile phones serve as pull factors for household income diversification. These factors are negatively associated with crop and livestock income share and mostly positively associated with the remaining income sources. Similarly, the size of livestock owned is positively associated with income diversification and livestock income and it is negatively associated with wage, enterprise, and remittance incomes. Households that are members in social insurance (i.e., iqqub and/or iddir) have higher income diversification and enterprise income while such households have lower crop and remittance incomes.

Thirdly, local factors affect diversification and the importance of different sources. A higher population density leads to higher income diversification perhaps because large population puts pressure on farming while also increased demand for non-agricultural products may pull/attract households towards other income generation activities. Proximity to all-weather road increases the importance of wage income as availability of wage employment (pull) increases with connectivity. Similarly, households' remittance income and HDI are positively correlated with manual laborers' wages, which serves as a pull factor for households to diversify. The presence of the Productive Safety Net Program (PSNP) in the area is negatively correlated with remittance income, which may reflect substitution of communal safety net by state-run safety net.

The importance of rainfall in the livelihoods of these households shows strongly in the econometric results. Variation of rainfall reduces the importance of crop income, as most of the crop production in Ethiopia is rainfed (only 8 percent of the households own irrigated land in 2019). Rainfall variation is positively associated with livestock income, implying the role of livestock as insurance against crop failure. Households in areas with such unreliable rainfall generate more remittance income and are more diversified. The estimates of mean long-term rainfall indicate that households in high-rainfall areas earn relatively less in the form of

remittance. This rainfall-crop-livestock incomes nexus is also shown in the 2016 dummy, which is associated negatively with crop income and positively with livestock and remittance incomes.

5. Conclusions and policy implications

Non-farm economic activities have traditionally been important in the transformation of developing economies of Asia, Latin America, and Africa. Such activities are crucial not only from poverty reduction point of view but also to accelerated growth in income, output, and employment in rural areas. In this study, we use data collected in 2012, 2016, and 2019 by IFPRI and the ATA of Ethiopia to study income diversification and the importance of non-farm income sources. We use descriptive analyses to elucidate the patterns and trends of income diversification, the importance of different economic activities in total income, the association between rainfall risks/shocks and income come diversification, and the welfare effect of diversified income sources among rural households in Ethiopia. We deploy the data on Cragg's (1971) double-hurdle model to study the pull and push factors associated with income diversification and importance of income sources and a fixed-effect and instrumental variable approaches to study the links between income diversification and household welfare.

We find that income diversification changed only marginally over the years considered. Female-headed households have relatively lower and stagnant income diversification. A large majority of households participate in and derive their livelihood from crop production. Although both participation in and share of crop income are slowly declining, these appear to be more than compensated by rising participation in and the share of livestock income. Consequently, the total share of income from farming has increased, while non-farm activities declined in importance by both counts during the period. Crop production is more important for male-headed households, while a higher proportion of female-headed households participate in and generate a higher income from other activities. We also find that participation in and the share of non-farming activities was highest in 2016, when droughts caused by El Niño reduced crop income in most parts of the country and seemingly pushed households to augment their income with other sources. In addition to stagnancy of household level income diversification, we find little change in community and district level income diversification. This makes the argument that suggests an increase in spatially aggregated income diversification during economic transformation less universal.

Results of the econometric analyses indicate that income diversification has a strong positive effect on consumption expenditure per capita, household dietary diversity, and roof/housing quality. Analyses of push and pull factors associated with income diversification reveal that large households and female-headed households have more diversified incomes. Income diversification is negatively associated with farm size, good quality soil, and irrigable land as well as with increased production of high-value crops. In contrast, income diversification is positively associated with access to credits, ownership of mobile phones, and relative measure of household asset/wealth, factors which are generally negatively associated with crop and livestock income share. Similarly, the number of tropical livestock units owned, membership in social insurance schemes, and population density are positively associated with income diversification. The analysis on the association between rainfall risks/shocks and income diversification indicates that households generally use diversification both as an ex-ante risk-management strategy and as an ex-post shock-coping strategy.

These results have important policy implication. First, as is observed in the ACC data, income diversification among rural households is stagnant, with most of the rural population continuing to depend on agriculture. However, the rapid growth in crop agriculture observed in the last decade and half, whereby almost half of the growth came from expansion in area and labor (Bachewe et al. 2018) is unsustainable. This is due to two related reasons. First, cropland is limited. Second, rural population growth is fast, particularly among working age adults (15-64 years old). Consequently, landholdings are declining, particularly among young farmers (Minten et al. 2020). Therefore, policymakers, while they need to reemphasize the importance of agriculture, they also need to reimagine agricultural policies to address current and future problems given policies implemented in the last two decades were meant to mainly address food insecurity. In particular, these policies need to relax land markets, increase agricultural intensification (through targeted efforts that can increase land and labor as well as total factor productivity), catalyze commercialization and value-addition activities, and thereby increase rural household income.

Second, agricultural policies need to expand to crops other than cereals, as well as include livestock production. Increases in agricultural income will serve as a catalyst for non-farm employment and income growth as it increases the demand for personal services, health,

education, housing, processed non-agricultural products and foods, transport, and communication. This is in addition to employment and incomes generated in the marketing, transportation, and processing of agricultural outputs that serves as a bridge between growing agriculture and growing urban centers. More importantly, firms that provide services (non-tradable goods) face less competition compared to the competition that agro-processing firms can face.

Third, policymakers can improve/expand the rural non-farm economy by creating incentive systems that encourage large scale agro-processors operate in rural areas and thereby employ locals, enrich up-ward and down-ward linkages, and help in the transfer of technologies to small and medium scale firms in the areas.

Fourth, just as blanket policy recommendations are recently going through a rethink process in other sectors, we believe that the issue of non-farm economy development need solutions that fit local conditions. Different areas/communities/agro-ecologies and households within communities differ in their endowments, opportunities, problems, and beliefs. Therefore, policy makers attempting to facilitate non-farm employment and income should first realize the diversity of areas and households and that they could be suited for different non-farm activities. For instance, different areas could be suited for production, processing, and marketing of different agricultural produce. Moreover, in areas where the production and processing of agricultural outputs is infeasible other small and medium enterprises engaged in merchandise trade, services, or other activities could be feasible. Having identified the types of activities that suit the community/people, policy makers need also to choose interventions that are effective to facilitate growth in non-farm employment and income for that particular area.

Fifth, experiences of other developing countries indicate that expansion of roads, communication, electrification, and marketing and transportation infrastructure in rural areas will help in the creation or accelerating growth of rural non-farm economy (Haggblade et al. 2007).

Finally, expansion of employment opportunities in rural areas reduces the ills of urban areas, including urban unemployment and poverty because a majority of the population in major urban areas in Ethiopia are recent migrants from rural areas. Thus, government's efforts to address unemployment in urban areas should expand to rural areas. This includes expanding or tailoring

the technical, logistical, and financial support provided for small and medium scale enterprises in urban areas to start or expand non-farm employment and income in the rural environment.

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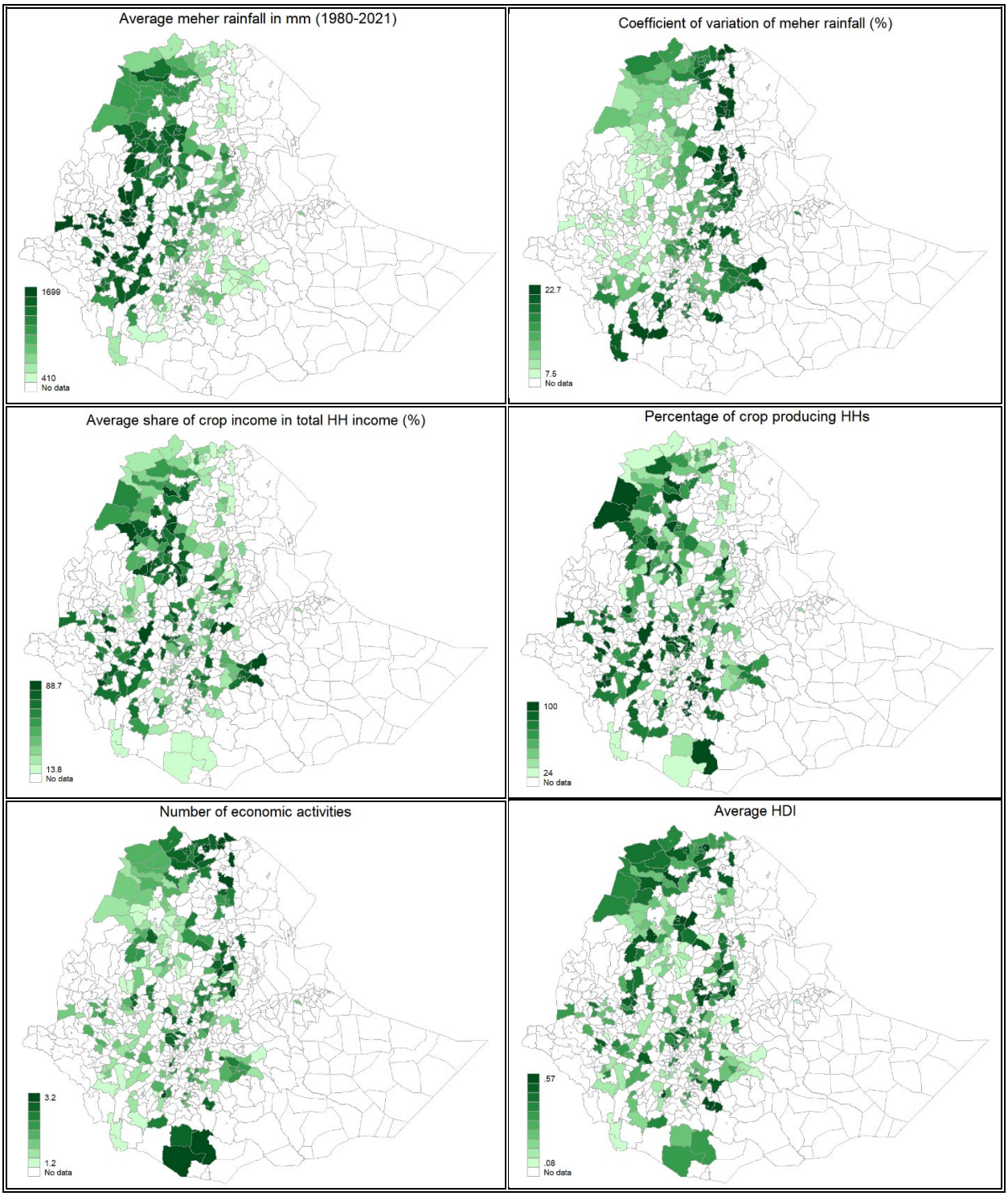
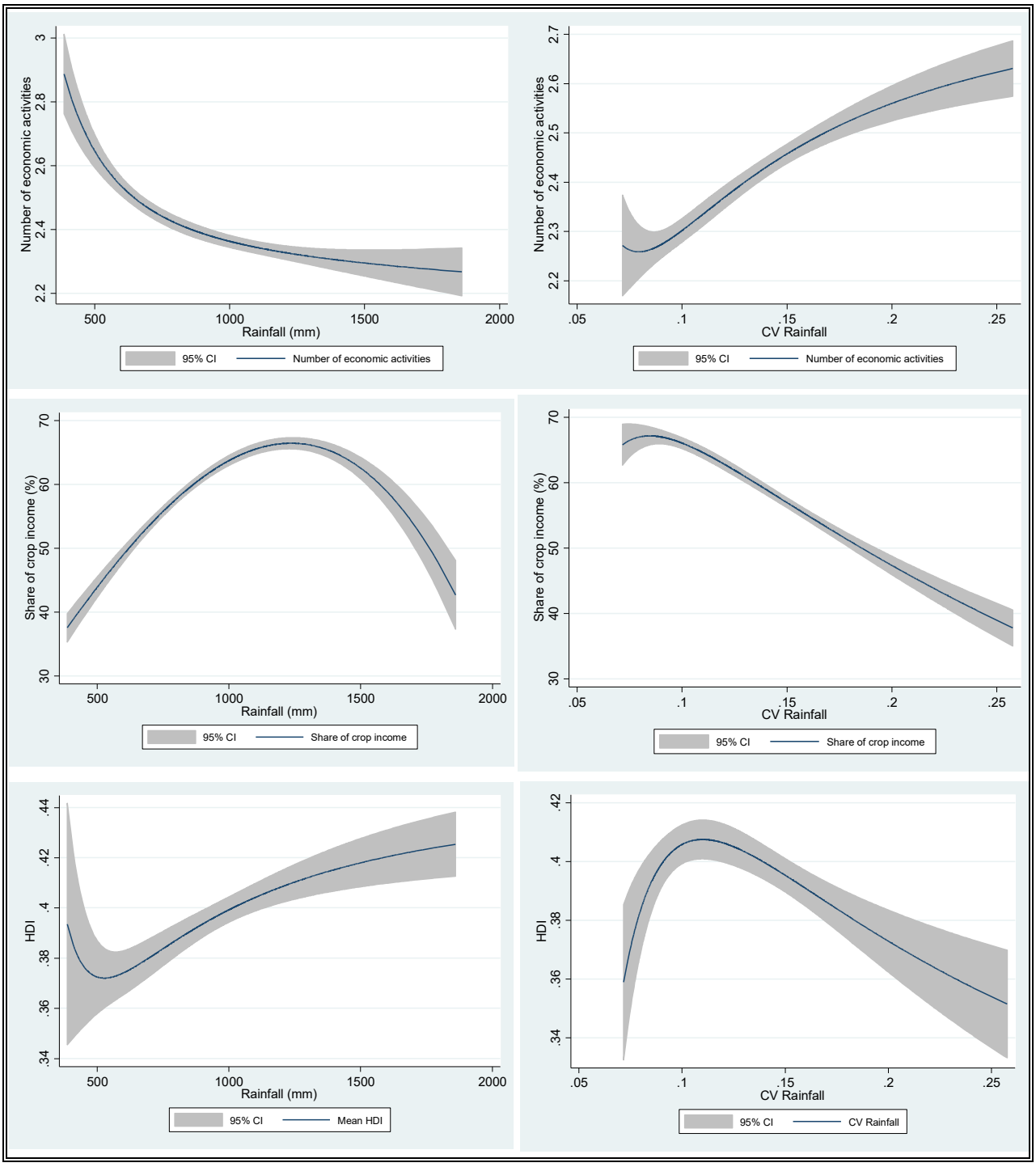
Appendix: Supplementary Tables and Figures

Figure A1. Long-term mean meher rainfall, coefficient of variation of meher rainfall, importance of crop income, and income diversification



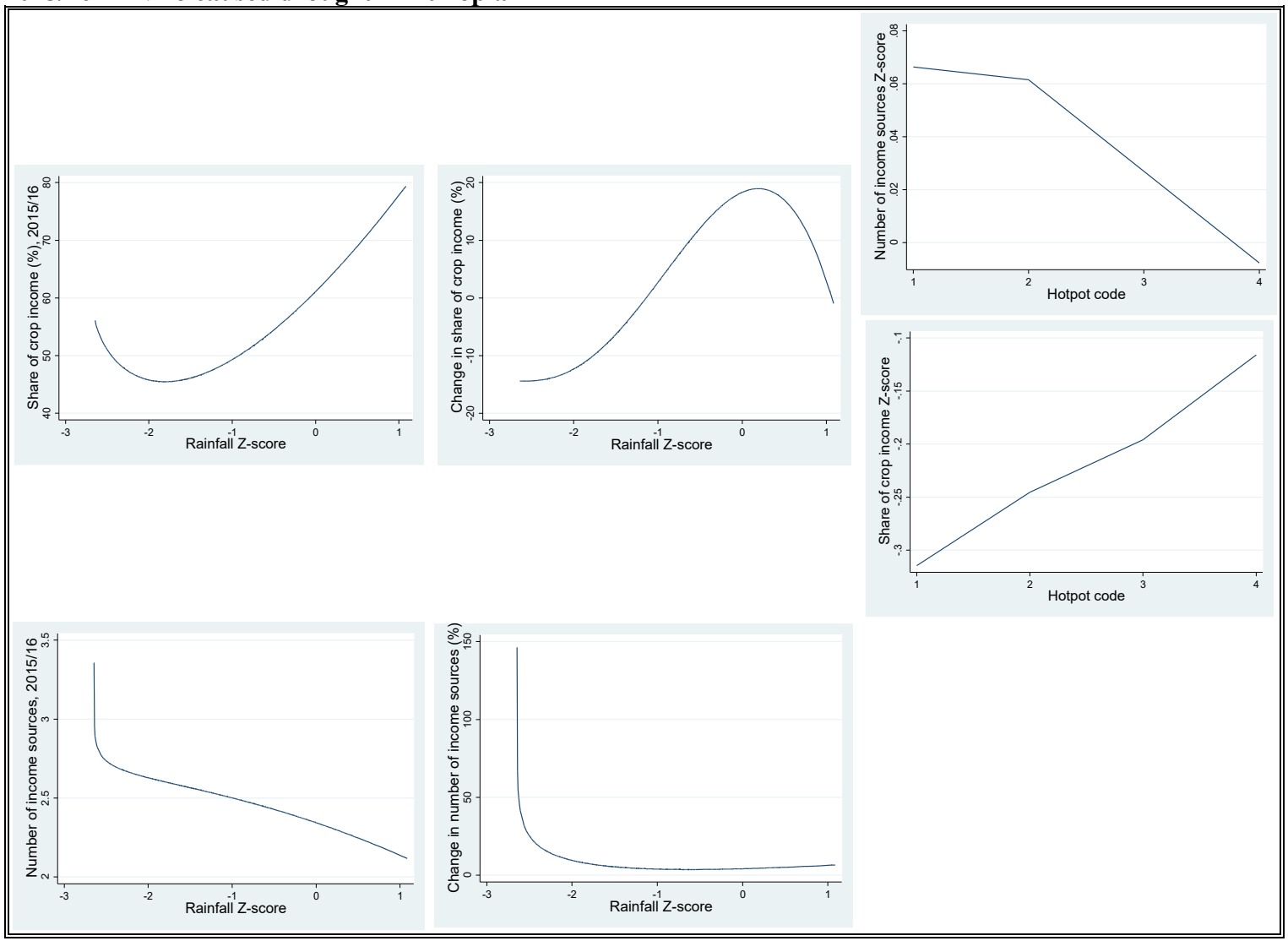
Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019, and CHIRPS rainfall data.

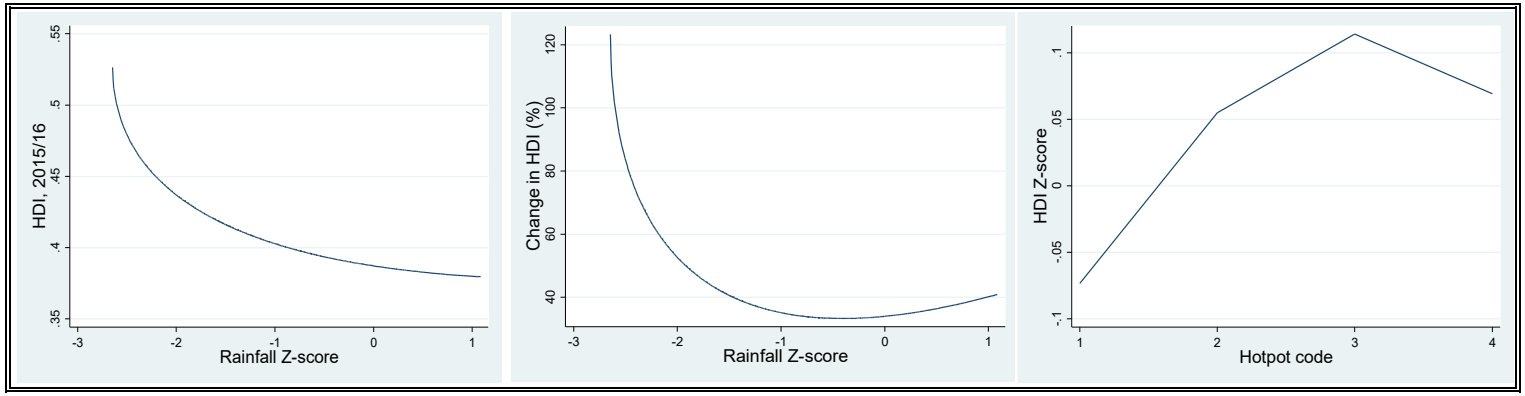
Figure A2 Relationship between long-term meher rainfall, crop income, and income diversification



Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019, and CHIRPS rainfall data.

Figure A3 Correlation between deviation of meher rainfall, importance of crop income, and income diversification during the 2015/16 El Niño caused drought in Ethiopia





Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019, and CHIRPS rainfall data.

Table A1 Participation in different income generating activities and contribution of each source of income to overall income, by gender of the household head

Income source	Female headed			Male headed		
	2012	2016	2019	2012	2016	2019
Panel A: Participation in different income generating activities						
Agriculture						
Crop	0.78	0.67	0.70	0.97	0.92	0.94
Livestock	0.69	0.62	0.78	0.80	0.82	0.94
Wage income						
Agricultural	0.09	0.04	0.03	0.08	0.05	0.02
Non-agricultural	0.08	0.10	0.09	0.09	0.13	0.09
Enterprise income	0.29	0.32	0.23	0.31	0.29	0.21
Remittance/transfer	0.22	0.16	0.11	0.07	0.08	0.06
Other income	0.35	0.37	0.27	0.19	0.22	0.14
Panel B: Contribution/share of each income source to overall income						
Agriculture						
Crop	0.48	0.39	0.43	0.66	0.57	0.64
Livestock	0.18	0.18	0.25	0.17	0.22	0.22
Wage income						
Agricultural	0.04	0.02	0.01	0.02	0.01	0.00
Non-agricultural	0.03	0.05	0.04	0.03	0.04	0.03
Enterprise income	0.11	0.14	0.10	0.07	0.08	0.06
Remittance/transfer	0.06	0.08	0.04	0.02	0.02	0.02
Other income	0.11	0.15	0.13	0.04	0.05	0.03
Number of obs.	305	311	321	1,594	1,588	1,578

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Table A2 Participation in different income generating activities and contribution of each source of income to overall income, by remoteness

Income source	Remoteness tercile		
	Tercile 1	Tercile 2	Tercile 3
Panel A: Participation in different income generating activities			
Agriculture			
Crop	0.91	0.92	0.90
Livestock	0.82	0.84	0.83
Wage income			
Agricultural	0.06	0.04	0.05
Non-agricultural	0.10	0.11	0.10
Enterprise income	0.29	0.24	0.27
Remittance/transfer	0.09	0.08	0.09
Other income	0.16	0.15	0.27
Panel B: Contribution/share of each income source to overall income			
Agriculture			
Crop	0.60	0.62	0.57
Livestock	0.21	0.20	0.20
Wage income			
Agricultural	0.01	0.01	0.01
Non-agricultural	0.03	0.04	0.03
Enterprise income	0.08	0.06	0.08
Remittance/transfer	0.02	0.02	0.03
Other income	0.04	0.04	0.08
Number of obs.	2,109	1,165	2,359

Note: remoteness is defined based on the distance of the sample household to the closest small city.
Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Table A3 Participation in different income generating activities and contribution of each source of income to overall income, by farm size category

Income source	Farm size categories				
	<0.5ha	0.5-1ha	1-2ha	2-3ha	>=3ha
Panel A: Participation in different income generating activities					
Agriculture					
Crop	0.85	0.89	0.92	0.92	0.94
Livestock	0.71	0.79	0.84	0.88	0.90
Wage income					
Agricultural	0.11	0.05	0.04	0.03	0.02
Non-agricultural	0.16	0.12	0.09	0.08	0.07
Enterprise income	0.33	0.28	0.27	0.24	0.26
Remittance/transfer	0.11	0.12	0.08	0.08	0.05
Other income	0.29	0.29	0.20	0.13	0.11
Panel B: Contribution/share of each income source to overall income					
Agriculture					
Crop	0.49	0.54	0.62	0.63	0.67
Livestock	0.16	0.20	0.21	0.22	0.23
Wage income					
Agricultural	0.03	0.02	0.01	0.01	0.00
Non-agricultural	0.07	0.04	0.03	0.03	0.02
Enterprise income	0.11	0.09	0.07	0.06	0.05
Remittance/transfer	0.04	0.03	0.02	0.02	0.01
Other income	0.10	0.09	0.05	0.03	0.02
Number of obs.	755	1324	1807	888	853

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Table A4 Participation in different income generating activities and contribution of each source of income to overall income, by per capita income quintile

Income source	Per capita income quintile				
	Poorest	Poorer	Middle	Richer	Richest
Panel A: Participation in different income generating activities					
Agriculture					
Crop	0.73	0.92	0.95	0.97	0.99
Livestock	0.66	0.84	0.86	0.89	0.90
Wage income	0.06	0.07	0.05	0.04	0.03
Agricultural	0.07	0.12	0.11	0.12	0.10
Non-agricultural	0.20	0.25	0.28	0.30	0.34
Enterprise income	0.08	0.08	0.09	0.10	0.08
Remittance/transfer	0.33	0.27	0.20	0.15	0.11
Other income	0.73	0.92	0.95	0.97	0.99
Panel B: Contribution/share of each income source to overall income					
Agriculture					
Crop	0.42	0.54	0.61	0.64	0.73
Livestock	0.23	0.23	0.21	0.20	0.15
Wage income	0.02	0.02	0.01	0.01	0.00
Agricultural	0.03	0.04	0.04	0.04	0.02
Non-agricultural	0.09	0.08	0.07	0.07	0.07
Enterprise income	0.03	0.02	0.03	0.03	0.01
Remittance/transfer	0.18	0.06	0.03	0.02	0.01
Other income	0.42	0.54	0.61	0.64	0.73
Number of obs.	1030	1107	1194	1143	1159

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Table A5 Participation in different income generating activities and contribution of each source of income to overall income, by region

	Tigray			Amhara			Oromia			SNNP		
	2012	2016	2019	2012	2016	2019	2012	2016	2019	2012	2016	2019
Panel A: Participation in different income generating activities												
Agriculture												
Crop	0.88	0.73	0.85	0.94	0.92	0.87	0.97	0.90	0.92	0.95	0.96	0.95
Livestock	0.86	0.79	0.88	0.80	0.81	0.93	0.78	0.78	0.93	0.95	0.75	0.88
Wage income												
Agricultural	0.05	0.03	0.03	0.10	0.04	0.01	0.07	0.08	0.03	0.95	0.03	0.02
Non-agricultural	0.14	0.17	0.17	0.03	0.08	0.05	0.10	0.11	0.07	0.95	0.15	0.09
Enterprise income	0.23	0.23	0.20	0.25	0.24	0.17	0.38	0.38	0.24	0.95	0.30	0.27
Remittance/transfer	0.13	0.14	0.15	0.03	0.04	0.06	0.09	0.08	0.03	0.95	0.13	0.08
Other income	0.59	0.64	0.47	0.10	0.16	0.12	0.09	0.14	0.05	0.95	0.09	0.05
Panel B: Contribution/share of each income source to overall income												
Agriculture												
Crop	0.44	0.31	0.47	0.72	0.65	0.67	0.69	0.57	0.62	0.63	0.61	0.63
Livestock	0.23	0.28	0.20	0.16	0.21	0.22	0.17	0.22	0.26	0.12	0.15	0.20
Wage income												
Agricultural	0.01	0.01	0.01	0.03	0.01	0.00	0.02	0.03	0.01	0.03	0.01	0.00
Non-agricultural	0.05	0.08	0.06	0.01	0.02	0.01	0.02	0.03	0.03	0.04	0.06	0.04
Enterprise income	0.08	0.09	0.08	0.05	0.06	0.04	0.08	0.10	0.06	0.10	0.11	0.09
Remittance/transfer	0.04	0.04	0.04	0.01	0.02	0.02	0.01	0.02	0.01	0.04	0.04	0.02
Other income	0.15	0.19	0.15	0.03	0.04	0.03	0.01	0.03	0.01	0.05	0.03	0.02
Number of obs.	419	419	419	495	495	495	627	627	627	358	358	358

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Table A6 Correlation between HDI and household wealth and with household income, assets, rainfall patterns, and head characteristics

Quintiles/groups	HDI					Wealth quintiles					Total
	I	II	III	IV	V	I	II	III	IV	V	
Wealth/HDI											
I	30.1	17.5	15.8	18.1	18.5	27.3	21.8	18.0	17.8	15.2	100.0
II	21.9	21.4	18.6	19.7	18.4	14.6	19.6	19.5	24.1	22.2	100.0
III	16.8	19.8	20.1	22.8	20.5	14.4	18.5	21.6	23.7	21.9	100.0
IV	15.7	23.1	20.9	19.9	20.4	15.4	18.3	22.9	21.1	22.3	100.0
V	13.8	21.8	19.8	21.6	22.9	15.9	17.3	20.9	21.9	24.0	100.0
Income sources											
1	100.0	0.0	0.0	0.0	0.0	33.3	23.6	19.0	15.9	8.2	100.0
2	22.1	29.2	22.3	23.9	2.6	18.1	19.5	20.2	21.7	20.6	100.0
3	4.2	17.6	21.2	22.2	34.7	14.0	18.0	21.2	22.8	24.0	100.0
4	1.0	7.9	11.8	13.8	65.5	14.4	17.7	22.3	22.9	22.7	100.0
5 or 6	0.0	0.0	6.4	9.0	84.6	20.5	18.0	15.4	20.5	25.6	100.0
Total income											
I	37.4	14.1	16.1	20.1	12.3	45.8	25.6	13.9	10.8	4.0	100.0
II	16.3	16.8	17.7	25.4	23.8	20.8	26.0	24.7	18.2	10.3	100.0
III	11.9	19.8	21.1	22.8	24.4	11.4	20.5	24.9	26.0	17.2	100.0
IV	11.2	25.1	21.9	19.8	22.1	6.5	14.9	23.2	28.6	26.7	100.0
V	20.5	28.3	18.9	14.3	18.0	3.9	8.5	15.7	24.3	47.6	100.0
Land											
I	21.0	17.2	18.2	19.3	24.3	35.0	24.4	18.0	14.1	8.5	100.0
II	19.7	18.3	17.7	21.1	23.3	19.4	22.2	23.4	20.9	14.1	100.0
III	18.0	22.6	18.8	18.9	21.7	15.4	21.0	20.3	22.9	20.5	100.0
IV	18.6	21.8	20.3	21.8	17.6	12.6	17.7	23.5	24.3	22.0	100.0
V	18.9	24.3	21.1	21.2	14.5	5.7	10.7	17.7	26.0	40.0	100.0
Head age											
I	19.7	23.0	18.1	19.7	19.6	23.5	24.4	20.0	18.4	13.6	100.0
II	15.5	22.8	21.0	19.3	21.3	17.5	19.5	20.8	21.5	20.8	100.0
III	16.3	22.3	20.5	19.6	21.3	14.4	17.2	19.9	24.1	24.4	100.0
IV	19.9	19.0	19.3	21.0	20.8	13.5	17.1	19.8	22.9	26.7	100.0
V	24.6	17.1	17.3	23.0	18.1	18.2	17.1	22.3	21.9	20.5	100.0
Education											
Illiterate	21.0	19.8	19.2	21.1	19.0	20.9	20.3	20.9	20.9	17.0	100.0
Elementary	16.6	22.7	19.4	19.8	21.5	12.5	17.8	20.1	23.0	26.7	100.0
Secondary	15.0	22.3	18.2	18.6	25.9	7.7	13.2	18.6	24.1	36.4	100.0
Tertiary	12.5	18.8	15.6	15.6	37.5	9.4	9.4	21.9	25.0	34.4	100.0
Head sex											
Male	17.8	21.4	19.9	20.8	20.2	13.0	18.6	21.7	23.3	23.5	100.0
Female	27.4	18.0	15.3	18.9	20.4	43.0	21.9	14.4	13.0	7.6	100.0
Meher RF											
I	20.8	15.6	17.3	22.2	24.1	14.7	19.5	20.6	23.0	22.1	100.0
II	19.1	16.6	19.5	22.0	22.8	16.3	17.9	21.0	21.4	23.4	100.0
III	20.0	20.4	15.8	22.7	21.1	20.2	20.5	19.8	21.7	17.9	100.0
IV	19.8	26.8	20.9	18.1	14.5	16.1	17.6	22.4	21.5	22.5	100.0
V	16.8	23.4	21.9	18.4	19.5	20.0	19.8	19.2	21.1	19.9	100.0
CV RF											
I	20.0	26.0	20.5	16.5	17.1	14.6	18.6	22.4	22.6	21.8	100.0
II	19.9	23.5	20.9	18.4	17.3	17.2	18.3	18.6	22.4	23.6	100.0
III	16.4	19.8	18.7	22.2	22.9	21.1	19.4	21.0	19.1	19.5	100.0
IV	20.4	17.4	19.3	20.9	22.1	14.5	18.1	18.5	25.7	23.2	100.0
V	21.4	15.6	16.2	25.2	21.5	17.9	21.1	21.8	20.9	18.2	100.0

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Table A7 Correlation coefficients of income shares and HDI and household wealth, income, assets, head characteristics, and rainfall patterns

	HDI	Income sources	Wealth	Real income	Farm size	Head age	Head Education	Head sex	Crop	Livestock	Agricultural wage	Non-agricultural wage	Enterprise	Remittance	Other income	Meher rainfall
Income sources	0.6136*															
Wealth	0.1102*	0.1068*														
Real income	-0.0354*	0.0705*	0.4613*													
Farm size	-0.0164	-0.0530*	0.2521*	0.2397*												
Head age	-0.0135	-0.0215	0.0727*	-0.0643*	0.0929*											
Head Educ	0.0454*	0.0624*	0.1701*	0.1600*	0.0033	-0.3720*										
Head sex	-0.0529*	0.0038	-0.2544*	-0.1578*	-0.0631*	0.0510*	-0.1998*									
Crop	-0.3969*	-0.3092*	0.1424*	0.2920*	0.1008*	-0.0866*	0.0284[a]	-0.1967*								
Livestock	0.2865*	-0.0495*	0.0432*	-0.1344*	0.0403*	0.1194*	-0.0551*	0.008	-0.4946*							
Agricultural wage	0.1344*	0.1215*	-0.1223*	-0.0938*	-0.0572*	-0.0475*	-0.0276[a]	0.0300[a]	-0.1456*	-0.0837*						
Non-agricultural wage	0.1573*	0.2106*	-0.0551*	-0.0529*	-0.0568*	-0.0365*	0.0799*	0.0201	-0.2851*	-0.1257*	-0.008					
Enterprise	0.1589*	0.1581*	-0.0693*	-0.0371*	-0.0602*	-0.0971*	0.0653*	0.0931*	-0.4090*	-0.1697*	-0.0240[a]	-0.0525*				
Remittance	0.1249*	0.1279*	-0.0673*	-0.0991*	-0.0539*	0.1581*	-0.0829*	0.1509*	-0.2460*	-0.0660*	-0.0213	-0.0390*	-0.0557*			
Other income	-0.0960*	0.2070*	-0.1307*	-0.2230*	-0.0875*	0.0763*	-0.0625*	0.1599*	-0.3840*	-0.0526*	-0.021	0.0016	-0.0401*	0.0357*		
Meher rainfall	-0.0324[a]	-0.1960*	-0.0132	0.0532*	0.1137*	-0.1608*	0.0182	-0.1024*	0.2553*	-0.0347[a]	0.0661*	-0.0757*	-0.0410*	-0.1287*	-0.3368*	
CV of rainfall	0.0430*	0.1918*	-0.0376*	-0.1073*	-0.1005*	0.1196*	-0.0413*	0.0868*	-0.2751*	0.0916*	-0.0682*	0.0639*	0.0132	0.1189*	0.3470*	-0.7782*

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Note: Correlation coefficients with superscripts of * are significant at 1% and those with superscripts of a at 10% level of significance.

Table A8 Estimates of Double-Hurdle model (Probit-Truncated models)

Variables	HDI		Crop		Livestock		Wage		Enterprise		Remittance	
	Partic.	Share	Partic.	Share	Partic.	Share	Partic.	Share	Partic.	Share	Partic.	Share
Gender of HH head, =1 if female	0.106	2.211**	-0.153	-4.209***	0.056	2.488	0.022	7.109	0.087	4.886	0.320***	11.493*
	(0.091)	(1.097)	(0.153)	(1.163)	(0.077)	(3.394)	(0.077)	(4.482)	(0.066)	(6.254)	(0.082)	(6.160)
Proportion of females in working age	0.335**	-0.227	0.545**	-5.365***	0.262**	10.227**	-0.480***	-17.009**	0.025	10.232	0.399***	-5.726
	(0.135)	(1.690)	(0.241)	(1.762)	(0.122)	(5.050)	(0.123)	(7.899)	(0.105)	(10.966)	(0.123)	(8.168)
Age of the head, in years	-0.009***	0.025	-0.002	0.003	-0.004*	0.306***	-0.006***	0.346***	-0.012***	0.414**	0.017***	0.167
	(0.002)	(0.028)	(0.004)	(0.029)	(0.002)	(0.088)	(0.002)	(0.134)	(0.002)	(0.182)	(0.002)	(0.186)
Education level attained by the head	0.078	-0.012	-0.029	-1.227*	0.020	-0.641	0.060	8.704***	0.033	3.792	0.014	-5.101
	(0.063)	(0.662)	(0.103)	(0.703)	(0.052)	(2.114)	(0.045)	(2.563)	(0.039)	(3.835)	(0.061)	(5.327)
Education level attained by the spouse	-0.040	1.132	-0.018	-1.350	-0.024	-1.237	0.065	1.810	0.096**	5.002	-0.094	-8.120
	(0.077)	(0.834)	(0.124)	(0.892)	(0.064)	(2.690)	(0.057)	(3.068)	(0.048)	(4.333)	(0.082)	(9.186)
Household size	0.054***	0.076	0.015	-0.092	0.050***	1.393**	0.035***	-1.412*	0.019*	-2.543**	-0.069***	-2.270*
	(0.016)	(0.174)	(0.027)	(0.184)	(0.014)	(0.542)	(0.013)	(0.852)	(0.011)	(1.117)	(0.015)	(1.243)
Household had access to credit, yes=1	0.211***	2.559***	-0.198*	-2.384***	0.133**	-2.667	0.226***	-4.480	0.222***	-8.314*	0.068	10.667*
	(0.069)	(0.775)	(0.110)	(0.828)	(0.058)	(2.461)	(0.052)	(3.127)	(0.045)	(4.339)	(0.070)	(5.563)
Farmland owned (ha)	-0.001	-0.608***	0.000	0.567***	0.030	-0.554	-0.068***	-2.773*	-0.021*	-3.517**	-0.044*	-7.769**
	(0.019)	(0.166)	(0.024)	(0.139)	(0.022)	(0.452)	(0.021)	(1.561)	(0.013)	(1.714)	(0.026)	(3.079)
Index of land quality	0.019	-0.252	0.027	0.513***	0.012	-1.938***	0.005	0.236	0.006	-2.211**	0.001	0.626
	(0.016)	(0.179)	(0.026)	(0.189)	(0.014)	(0.568)	(0.012)	(0.726)	(0.011)	(1.039)	(0.016)	(1.173)
Livestock, in tlu	0.061***	0.108**	0.053***	-0.122*	0.137***	0.495***	-0.076***	-3.136***	-0.021***	-3.745***	-0.018**	-1.110
	(0.010)	(0.052)	(0.017)	(0.066)	(0.010)	(0.106)	(0.008)	(0.614)	(0.005)	(0.731)	(0.009)	(0.979)
Household asset index, PCA	0.076***	-0.005	-0.023	0.867***	0.066***	-2.077***	0.008	-4.061***	0.068***	-4.036***	0.068***	0.173
	(0.025)	(0.232)	(0.038)	(0.249)	(0.021)	(0.730)	(0.018)	(1.159)	(0.014)	(1.553)	(0.020)	(1.801)
Share of high-value crops in crop output, %	-0.003***	-0.118***	0.007***	0.165***	-0.003***	-0.433***	-0.003***	-0.167***	0.001	-0.199***	-0.001	-0.265***
	(0.001)	(0.013)	(0.002)	(0.014)	(0.001)	(0.050)	(0.001)	(0.055)	(0.001)	(0.075)	(0.001)	(0.097)
HH owns mobile phone, yes=1	0.177**	0.758	-0.121	-3.063***	0.090	-5.785**	0.073	11.002***	0.167***	6.747	0.205***	6.071
	(0.071)	(0.784)	(0.121)	(0.834)	(0.061)	(2.407)	(0.056)	(3.414)	(0.048)	(4.801)	(0.069)	(5.379)
Member of social insurance (idir or iqqub)	0.255***	2.180**	0.174	-4.344***	0.015	-1.491	0.163**	-8.831**	0.352***	9.078	-0.144*	0.441
	(0.090)	(1.002)	(0.141)	(1.070)	(0.079)	(3.023)	(0.072)	(4.162)	(0.062)	(5.732)	(0.085)	(6.349)

Table A8 Estimates of Double-Hurdle model (Probit-Truncated models) …continued.

Variables	HDI		Crop		Livestock		Wage		Enterprise		Remittance	
	Partic.	Share	Partic.	Share	Partic.	Share	Partic.	Share	Partic.	Share	Partic.	Share
Agri cooperative member	-0.012	-0.921	0.049	0.186	0.023	2.409	-0.008	-1.886	-0.027	-2.023	0.022	-11.690**
	(0.067)	(0.763)	(0.117)	(0.807)	(0.058)	(2.341)	(0.055)	(3.548)	(0.046)	(4.476)	(0.067)	(5.160)
HH has irrigable land, yes=1	-0.156	-2.607**	4.075	3.066**	-0.101	-18.219***	0.054	-4.189	-0.015	-1.979	-0.067	-23.654*
	(0.111)	(1.317)	(143.17)	(1.345)	(0.100)	(4.846)	(0.090)	(5.873)	(0.077)	(7.528)	(0.126)	(14.088)
Time to all-weather road, in min	-0.000	-0.004	-0.001	0.003	0.000	0.004	-0.001***	0.014	-0.000	0.021	-0.000	0.043**
	(0.000)	(0.003)	(0.000)	(0.003)	(0.000)	(0.009)	(0.000)	(0.019)	(0.000)	(0.022)	(0.000)	(0.022)
Population density, persons/sq KM	0.001**	0.019***	0.002	-0.015**	0.001**	0.023	0.001	0.004	0.000	-0.056	0.001	-0.035
	(0.001)	(0.006)	(0.001)	(0.007)	(0.000)	(0.022)	(0.000)	(0.031)	(0.000)	(0.039)	(0.001)	(0.052)
Real wage of casual labor (in 2016 birr)	0.005	0.093**	0.000	0.013	0.008**	-0.096	0.001	0.074	0.002	-0.033	0.000	0.568**
	(0.004)	(0.038)	(0.006)	(0.042)	(0.004)	(0.115)	(0.003)	(0.169)	(0.002)	(0.225)	(0.004)	(0.281)
PSNP in woreda (=1 if yes)	0.214	1.058	0.378	2.605	0.211	-5.691	0.169	-1.773	0.294*	-19.978	-0.716***	4.254
	(0.234)	(2.653)	(0.446)	(2.807)	(0.197)	(9.025)	(0.191)	(13.294)	(0.165)	(15.032)	(0.231)	(15.659)
Long-term average meher rainfall (RF)	0.000	0.005	0.001**	-0.001	0.000	0.003	0.000	-0.030**	0.000	-0.013	-0.001**	0.012
	(0.000)	(0.004)	(0.001)	(0.004)	(0.000)	(0.012)	(0.000)	(0.014)	(0.000)	(0.020)	(0.000)	(0.028)
Coefficient of variation of meher RF	-2.372	79.288**	-4.470	-101.36***	1.721	220.993**	-0.073	167.250	-2.186	-40.134	5.020*	264.323*
	(3.066)	(33.548)	(4.311)	(37.200)	(2.760)	(93.616)	(2.324)	(131.556)	(2.150)	(205.821)	(2.565)	(141.85)
2016 dummy	-0.363***	0.204	-0.668***	-3.005**	-0.190*	20.850***	-0.269***	16.145***	-0.358***	19.906***	0.037	10.476
	(0.118)	(1.299)	(0.174)	(1.410)	(0.104)	(3.959)	(0.090)	(5.312)	(0.079)	(7.360)	(0.111)	(8.385)
2019 dummy	0.352**	-3.974**	-0.097	2.690	0.674***	7.898	-0.506***	1.588	-0.608***	7.868	-0.277	-25.037*
	(0.175)	(1.791)	(0.273)	(1.926)	(0.154)	(5.526)	(0.127)	(7.858)	(0.109)	(10.500)	(0.169)	(14.569)
Zonal dummies	Yes		Yes		Yes		Yes		Yes		Yes	
Constant	0.403	30.862***	0.140	65.294***	-1.128*	-31.139	-0.050	47.400	-0.319	82.692*	-1.768***	-68.789
	(0.712)	(7.790)	(1.109)	(8.488)	(0.628)	(24.090)	(0.541)	(31.814)	(0.482)	(45.669)	(0.651)	(49.686)
Log-Likelihood	-22,120		-23,565		-19,729		-5,035		-8,523		-2,898	
Number of observations	5,172		5,172		5,172		5,172		5,172		5,172	

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

Table A9. Relevance of instruments (first stage regressions)

	HDI at household level	
	(1)	(2)
HDI at the kebele level	0.407***	0.375***
	(0.062)	(0.060)
ln(Mean rainfall)	-0.029	0.017
	(0.042)	(0.038)
ln(Standard deviation of rainfall)	0.001	0.000
	(0.002)	(0.002)
Gender of HH head (*1=female*)		-0.003
		(0.024)
Proportion of females in working age		0.020
		(0.026)
Age of the HH head		0.001
		(0.001)
Education level attained by the HH head		0.003
		(0.012)
Education level attained by the spouse		0.029**
		(0.013)
Household size		0.008**
		(0.003)
Dependency ratio		-0.003
		(0.005)
Access to credit (*1=yes*)		0.022**
		(0.010)
Farmland owned (*hectare*)		-0.002
		(0.001)
HH has irrigable land (*1=yes*)		-0.012
		(0.016)
Membership in iddir (*1=yes*)		0.020**
		(0.008)
Membership in iqqub (*1=yes*)		-0.006
		(0.009)
HH owns mobile phone (*1=yes*)		0.013
		(0.008)
Livestock ownership (*TLU*)		0.002
		(0.001)
Household asset index (PCA)		0.006*
		(0.003)
Time to weekly market (*minutes*)		0.000
		(0.000)
Time to Woreda Admin center (*minutes*)		0.000
		(0.000)
Constant	0.333***	0.072
	(0.112)	(0.114)
Number of observations	5,589	5,428
R2	0.017	0.032
Adjusted R2	0.016	0.029

Source: Authors' analysis using ACC Surveys of 2012, 2016, and 2019.

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