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## Effect of migration on the food security of households left behind: Evidence from Ethiopia

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**Abstract:** In most countries, migration is a common phenomenon that can have both positive and negative effects on the living conditions of households in the locality of origin. This paper offers new evidence concerning the effect of migration on the food security of households left behind. The evidence is provided for Ethiopia, a country where internal migration is more predominant, and where food insecurity is still acute. The analysis is based on the 2013/2014 and 2015/2016 Ethiopian Socioeconomic Surveys (ESS), which are both nationally representative. In order to address the self-selection bias of migration, the estimation strategy used relies on the Heckman two-stage estimate and several robustness tests. The result indicates that migration negatively affects household per capita calorie intake while it leads to an improvement of their dietary diversity. However, the overall result is more inclined towards a negative effect of migration on the food security of migrant households in Ethiopia. Policies aimed at improving food security in Ethiopia should therefore consider those households among the priority targets.

**Keywords:** Migration; Food security; Households; Ethiopia

**JEL Codes:** I31, O15, O55, Q18, R23

## 1. Introduction

Migration has become a key component in the livelihood strategies of an increasing number of households across the developing countries. A large number of people migrate for better earning opportunities in more prosperous countries or more developed areas within their own country. According to *the new economics of labor migration*, the migration decision is made among households in order to minimize risks and overcome limitations imposed as a consequence of the failure of the national markets (Stark, 1991). Once migrated, migrants send remittances to the household members left behind. The money received relaxes the liquidity constraints of households which in turn allows them to invest in consumption, education, health, and housing.

However, in the development economics literature, there has been little attention to the direct effect of migration on households food security. In addition, the empirical studies that address the direct interface between migration and food security have found varying results. Some studies conclude that migration has a positive effect on per capita food expenditure, food consumption and food diversity (Adams Jr. & Cuecuecha, 2013; Nguyen & Winters, 2011; Sharma & Chandrasekhar, 2016), while others show the opposite (Karamba, Quiñones, and Winters (2011)). The fact that these studies yield divergent results shows that there is a continuing need for new evidence on the impact of migration on household food security. This paper aims to make a clarifying contribution to this unresolved question, based on new evidence. Its contribution to the literature compared to previous studies is twofold. First, it compares the impact of migration in general to that of labour migration alone. Second, it discusses the impact of migration on five quantiles of the distribution of the food security indicators used in the analysis.

The evidence is provided for Ethiopia. The rationale of choosing this country is that, despite its economic progress, food insecurity remains ubiquitous in many regions of the country. In 2015, 28.8 % of Ethiopians was undernourished (FAO). The country was also ranked 104<sup>th</sup> out of 119 in the 2017 Global Hunger Index (GHI). Food insecurity is thus a major concern in Ethiopia. Besides, the empirical studies that have addressed the relationship between migration and food security in Ethiopia have mainly looked to the latter as a determinant of the former (Berhanu & White, 2000; Ezra & Kiros, 2001). For these studies, food insecurity is one of the major causes of migration in many regions of Ethiopia. It is therefore worth looking at the opposite effect as well.

Data used in the analysis are from the second and third Ethiopian Socioeconomic Survey (ESS) from 2013/2014 and 2015/2016. Three household food security indicators were used to conduct the analysis. The first indicator is the per capita calorie intake (PCCI) which measures household access to sufficient nutritious food that meets their dietary needs. The two other indicators, the Simpson and Shannon indexes, measure household dietary diversity. The empirical methodology used to address the effect of migration is first a two-stage instrumental variables approach based on the Heckman model, which addresses the self-selection bias of migration. In order to test the robustness of the Heckman estimate, the second empirical methodology consists of estimating a quantile treatment effect following the approach proposed by Abadie, Angrist, and Imbens (2002). Overall, the results show that migration, including labour migration, has a negative effect on household per capita calorie intake, while it improves the Simpson and Shannon indexes. In other words, migration leads to a deterioration of households food access while improving their dietary diversity. However, after analyzing the effect of migration on the share of each food group consumed in the household, it is found that this improvement in dietary diversity is achieved through the con-

sumption of less nutritious foods to the detriment of those rich in calories. While this result explains the negative effect of migration on per capita calorie consumption in Ethiopia, it also shows that migration leads to poor dietary diversity in the country. This result supports the study of [Karamba et al. \(2011\)](#) who have also found an overall negative effect of migration in Ghana, another African country.

The paper is structured as follows: section 2 provides the conceptual framework of the analysis, and section 3 describes the data used. The empirical strategy as well as the result of the Heckman estimate are presented in section 4. Section 5 presents the robustness tests of the findings in the Heckman estimate, while section 6 discusses the overall result. The conclusion of the paper is presented in section 7.

## 2. Conceptual framework

The World Food Summit of 1996 stipulated that food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. This definition points out four dimensions of food security: food availability, food access, utilization, and stability. The first dimension refers to the availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid). The second dimension refers to the access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. Food security also depends on the utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met. The stability of access to food is also important. To be food secure, a population, household or individual should not risk losing access to food as a consequence of sudden shocks.

The theoretical relationships between migration and food security have been summarized by [Zeza, Carletto, Davis, and Winters \(2011\)](#). Migration, whether domestic or international, can impact positively or negatively on household nutrition through many channels.

Regarding the positive effect of migration, it firstly goes through remittances by allowing households to improve their food consumption and their use of nutritional services. Remittances can also have a positive indirect income effect through the possible relaxation of liquidity and insurance constraints, which would have a subsequent impact on production and investment decisions. The second channel by which migration affects the food security of households left behind is return migration. According to [Zeza et al. \(2011\)](#), migration is likely to affect nutritional habits back home through exposure to different diets and health practices in destination countries. This may have a positive effect on the quality of food consumed through a transmission of knowledge on best nutritional practices.

Several negative effects of migration on household food security can also be identified. Indeed, by increasing the reservation wage of individuals in migrant households, remittances may lead to a reduction of their labor supply. The consequence on nutrition will then be negative if remittances do not offset the loss in income resulting from the reduction of the labor supply ([Gibson, McKenzie, & Stillman, 2011](#)). Remittances can also have no significant effect on the nutrition of received households. Previous studies have shown that additional incomes do not significantly affect individual's nutrition, since they usually lead to an increase in the consumption of tasty food less rich in calories ([Banerjee & Duflo, 2011](#); [Behrman & Deolalikar, 1987](#); [Bouis & Haddad,](#)

1992; Deaton & Drèze, 2009). On the other hand, migration itself means the loss of labor in the household, resulting in a potential drop in food production and the labor endowment of the household in the long term. Furthermore, the time and quality of child care may be reduced, either because of the migration of the mother or because of additional responsibility resulting from the migration of the spouse or the husband.

It is thus difficult to access *a priori* the overall effect of migration on food security of households.

### 3. Data and descriptive

#### 3.1. Data

The empirical analysis is based on panel data from the wave 2 and 3 of Ethiopian Socioeconomic Survey (ESS), which was implemented by the Central Statistics Agency of Ethiopia (CSA) in collaboration with the World Bank Living Standards Measurement Study (LSMS) team as part of the Integrated Surveys on Agriculture program. The first wave was implemented in 2011/2012, while the second and the third waves were implemented in 2013/2014 and 2015/2016, respectively. The first wave, originally referred to as ERSS, but since retitled ESS1, covered only rural and small-town areas. The second and the third waves, respectively referred to as ESS2 and ESS3, added samples from large-town areas. Therefore, only ESS2 and ESS3 are nationally representative. The sample is a two-stage probability sample. The first stage of sampling consisted of selecting primary sampling units, or CSA enumeration areas (EAs). A total of 433 EAs were selected based on probability proportional to size of the total EAs in each region. For the rural sample, 290 EAs were selected from the AgSS EAs. A total of 43 and 100 EAs were selected for small-town and urban areas, respectively. The second stage of sampling involved the selection of households from each EA. For rural EAs, a total of 12 households were sampled from each EA; of these, 10 households were randomly selected from the sample of 30 AgSS households. In wave 2 (ESS2), 5,469 households were interviewed, while in wave 3 (ESS3), 4,954 were followed up on. However, due to large missing data on household food consumption, 641 and 153 households were dropped from ESS2 and ESS3 samples, respectively. This leaves the analysis database with a panel of 9,639 households. The database provides information on household characteristics, water quality, community post-planting agriculture, livestock, and post-harvest agriculture. The household information covered demographics, education, health, labor and time use, food and non-food expenditures, household non-farm income-generating activities, food consumption and shocks, safety nets, housing conditions, assets, banking and saving, credit, and others sources of household income.

#### 3.2. Characteristics of migration and households in ESS2 and ESS3

To identify a migrant in the ESS, households were asked the following question: Is [NAME] still a member of this household? When the answer is no, they are asked the reasons why an individual  $i$  left the household. They also provide the current location of individual  $i$ ; whether he resides in rural or urban locations; and whether he resides inside or outside Ethiopia? We consider that migrants are the individuals who left their household and currently reside in other locations <sup>1</sup>. However, in the analyses, a

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<sup>1</sup>The definition of migrant adopted in this paper is that of International Organization of Migration (IOM) which defines a migrant as any person who is moving or has moved across an international border or within a

restriction to labour migration alone was also considered for comparison.

Table 1 and 2 presents the rate of individuals who left their households according to the reasons for leaving and their current location. It shows that individuals left the households for three main reasons: cohabitation, left for work, and left for studies. Indeed, in ESS2, almost 44% of individuals left their household to cohabit with other persons, either as a result of marriage or because they have a family living in another location. In ESS3, this figure sands for 40.31%. The second reason of displacement is work reason, with 22% and almost 18% of individuals moving for work in ESS2 and ESS3, respectively. Regarding study, which is the third most reason of migration, almost 17% and 13% of individuals left their household for this reason in ESS2 and ESS3, respectively. Those who left their households because of marriage, or to join a family already living in another location, mostly went in rural areas; while individuals who left for work or studies moved to urban areas.

Table 1 and 2 also indicates that most of Ethiopian who migrated outside their country went for work reason. Indeed, of those who have migrated outside Ethiopia, 71% and 75% went to work in ESS2 and ESS3, respectively. However, international migration remains relatively uncommon in Ethiopia. For instance, in ESS3, 5% of Ethiopians migrated abroad compared to 95% who migrated within the country.

Table 1.: Distribution of individuals according to the reasons of leaving their household and destination places (2013-2014)

	All sample	Rural	Urban	Inside Ethiopia	Outside Ethiopia
Divorce/separation	3.78	4.95	1.99	3.89	2.27
Left for studies	16.88	4.12	45.51	17.97	1.52
Left for work	22.03	12.04	26.74	18.65	71.21
Left to find better land	1.37	1.98	0.33	1.37	0.76
Health reasons	0.93	0.66	1.00	0.84	2.27
Security reasons	0.20	0.16	0.17	0.16	0.76
For marriage/cohabitation	21.20	30.01	9.30	22.39	3.79
Join their family already living in another place	22.62	30.09	11.13	23.23	13.64
Moved with family	6.77	10.14	2.49	7.25	0.00
Left to set up own home	4.22	5.85	1.33	4.26	3.79
Total	100	100	100	100	100

State away from his/her habitual place of residence, regardless of (1) the persons legal status; (2) whether the movement is voluntary or involuntary; (3) what the causes for the movement are; or (4) what the length of the stay is.

Table 2.: Distribution of individuals according to the reasons of leaving their household and destination places (2015-2016)

	All sample	Rural	Urban	Inside Ethiopia	Outside Ethiopia
Divorce/Separation	3.63	5.35	2.70	4.10	3.06
Left for studies/Educational opportunities	13.07	3.61	34.33	15.12	5.61
Left for work	17.73	9.91	24.05	17.12	75.00
Left to find better land	0.98	1.96	0.07	1.15	0.00
Health reasons	0.61	0.45	0.87	0.69	0.51
Security reasons	0.37	0.36	0.51	0.44	0.00
For marriage/Cohabitation	20.23	30.48	14.36	23.71	2.55
To join a family already living in another location	20.08	30.34	14.50	23.43	4.08
Moved with family	4.15	6.20	2.70	4.84	1.02
Left to set own home	6.44	8.79	4.45	7.33	5.10
Other reasons	12.7	2.54	1.46	2.05	3.06
Total	100.00	100.00	100.00	100.00	100.00

### 3.3. Measuring household food security

Both ESS2 and ESS3 make it possible to construct different indicators of household food security. However, for comparison reasons, this paper focus on three indicators commonly used in the literature. The first indicator constructed is per capita calorie intake (PCCI), which measures access to sufficient nutritious food. The higher is PCCI the better is household access. The details on the construction of this indicator are provided in appendix A. In the analyses, I used the log of per capita calorie intake since the distribution of PCCI follows a log-normal pattern (Figure B1). The figure also shows that household per capita calorie intake has improved over the two periods of the survey (2013-2014 to 2015-2016).

Unlike PCCI, the two other indicators measure household dietary diversity. These indicators were implemented following [Nguyen and Winters \(2011\)](#). They used two diversity indicators, namely the Simpson index and the Shannon index to measure household dietary diversity. I also implemented the same indicators except that, instead of using household food expenditure, I directly used the food quantity consumed by households. This is because food expenditures may underestimate the actual amount of food consumed to the extent that some purchased food may be stored for future consumption. Mathematically, the Simpson index can be expressed as follows:

$$Simpson = 1 - \sum_i w_i^2$$

Where  $w_i$  is the consumption share of food group<sup>2</sup>  $i$ . The Simpson index is between zero and one, meaning that the higher the index, the more diversified is the diet. The Shannon index is expressed as follows:

$$Shannon = - \sum_i w_i \log(w_i)$$

Its values range from zero to the value of log of the highest number of food groups. The Shannon index measures not only dietary diversity but also the concentration of

<sup>2</sup>Food items were grouped into seven groups: Cereals and staples (1), Pulses (2), Vegetables and fruits (3), Tubers and streams (4), Meats and fish (5), Milk (6), Sugar and beverages (7)

food groups.

#### 4. Causal effect of migration on household food security in Ethiopia

##### 4.1. Methodology

The main difficulty in analysing the impact of migration is the endogeneity of the migration variable. In the case of food security, this endogeneity can come from two different sources: migrant self-selection and reverse causality. First, individuals who migrated are not randomly selected among household members, as their decision to migrate depends on specific characteristics which are different from that of those who did not migrate. Secondly, the recurrence of food deficit shocks can be a push factor for migration, with individuals migrating because of the unavailability of food in the household. However, in this study, I am less worried about the reverse causality bias since all migration registered in the database took place from 1999 to 2008, prior to the period 2013-2016 for which the food security analysis is being conducted. It is for this reason, unlike previous studies (Karamba et al., 2011; Nguyen & Winters, 2011) that used 2SLS, I addressed the self-selection bias by adopting the two-step estimate proposed by Wooldridge (2010) which is based on Heckman model. The estimation procedure is described as follow:

In a first step, the selection into migration is modeled from the following probit specification:

$$M_{it}^* = \theta_0 + \theta_1 X_{it} + \theta_2 Z_{it} + a_{it} \quad (1)$$

Where:

$$M_{it} = \begin{cases} 1 & \text{if } M_{it}^* > 0 \\ 0 & \text{if } M_{it}^* \leq 0 \end{cases} \quad (2)$$

and  $X_{it}$  is a vector of socio-economic characteristics of household  $i$  at time  $t$ . Equation 1 allows taking into account the selection on the observable characteristics  $X_{it}$  and  $Z_{it}$ , where  $Z_{it}$  is a vector of instrumental variables that explain the probability to migrate but have no direct effect on the food security of households.

This first step estimates the probability that the household has a migrant,  $Prob[M_{it}^* > 0] = \Phi(\theta_0 + \theta_1 X_{it} + \theta_2 Z_{it} + a_{it})$ , from which is constructed the inverse of the Mill ratio  $\lambda_1$  that allows the correction of the endogenous selection bias of households with a migrant.

$$\lambda_{1it} = \frac{\phi(\theta_0 + \theta_1 X_{it} + \theta_2 Z_{it} + a_{it})}{\Phi(\theta_0 + \theta_1 X_{it} + \theta_2 Z_{it} + a_{it})} \quad (3)$$

Symmetrically, the selection term applicable to non-migrant households is given by:

$$\lambda_{0it} = \frac{\phi(\theta_0 + \theta_1 X_{it} + \theta_2 Z_{it} + a_{it})}{1 - \Phi(\theta_0 + \theta_1 X_{it} + \theta_2 Z_{it} + a_{it})} \quad (4)$$

Now that the selection correction terms are known, it becomes possible to estimate, in the second step, the effect of migration on household food security. Since migration



is considered as a treatment variable, it leads to two potential outcomes of the level of household food security. In other words, when the household has a migrant, its food security status is  $Y_{1it}$ , while when the household does not have a migrant, it is  $Y_{0it}$ . Formally:

$$Y_{0it} = \mu_0 + X_{it}\beta_0 + e_0 \quad \text{with } E(e_0|X) = 0 \quad (5)$$

$$Y_{1it} = \mu_1 + X_{it}\beta_1 + e_1 \quad \text{with } E(e_1|X) = 0 \quad (6)$$

While the food security status  $Y_{it}$  for any household  $i$  (treated or untreated) is given by the equation:

$$Y_{it} = Y_{0it} + M_{it}(Y_{1it} - Y_{0it}) \quad (7)$$

By substituting equations 5-6 into 7, we get:

$$Y_{it} = \mu_0 + (\mu_1 - \mu_0)M_{it} + X\beta_0 + M_{it}(X\beta_1 - X\beta_0) + e_0 + M_{it}(e_1 - e_0) \quad (8)$$

By posing  $\eta = e_0 + M_{it}(e_1 - e_0)$ ,  $\alpha = \mu_1 - \mu_0$ ; and making the following assumptions:  $E(e_1|X, Z) = E(e_0|X, Z) = 0$ ,  $E(a|X, Z) = 0$ , the error terms  $a$ ,  $e_0$  and  $e_1$  follow a joint normal distribution; It can be proved that:

$$E(Y_{it}|X_{it}, M_{it}) = \mu_0 + \alpha M_{it} + X\beta_0 + M_{it}(X - \mu_x)\beta + \rho_1 M_{it}\lambda_{1it} + \rho_0(1 - M_{it})\lambda_{0it} \quad (9)$$

Where  $\lambda_1$  and  $\lambda_0$  are the selection correction terms obtained from the first step, and  $\mu_x$  is the mean of variable  $x$ . Now, the estimation of equation 9 with Ordinary Least Squares (OLS) produces consistent and efficient results under selection.  $\alpha$  denotes the average treatment effect (ATE), which is the effect of migration on the food security of household in the whole population (migrant and non-migrant households). It allows the generalization of the result to any household that will decide in the future to involve a member into the migration.

However, the paper is also interesting to the impact of migration only in the population of households with a migrant. To address this issue, I calculated the average treatment on treated (ATET), which represents the difference between the observed food security of households with a migrant and the counterfactual food security they would have if they did not have a migrant. The derivation of this difference from equation 9 can be found in Cerulli (2014).

The estimation procedure assumes a heterogeneous treatment effect across households. For this reason and for efficiency reasons, I treated the data as pooled cross-section and included year dummies to capture any time effects. In all estimations, I also controlled for regional dummies. These regional dummies capture unobservable cultural habits that are likely to affect both the migration and household food consumption decisions across communities.

## 4.2. Instruments

The main difficulty with two-stage estimation procedures is the identification of instruments, which must be correlated with the probability of migration but not directly

correlated with household food security. The instrument used in this paper is the annual average rainfall<sup>3</sup> from five to one year prior to the migration year in each region. Assuming  $t$  is the year in which individual  $i$  migrated, the corresponding value of instrument for  $i$  is the average rainfall lags ( $t - 1$  to  $t - 5$ ) in the region where  $i$  originated from. There are two main reasons for this choice. First, apart from cohabitation reasons (Table 1 and 2), individuals in ESS2<sup>4</sup> and ESS3 mostly migrate to find a job in another location. In addition, those who migrated for this reason mostly go to urban areas. Rainfall shortage can be the cause of this type of migration since it often leads to consecutive bad harvests which reduce the income in agriculture in rural areas. For instance, Affi, Liwenga, and Kwezi (2014) have shown that rainfall shortage induces out-migration in three villages in Tanzania. Therefore, the annual average rainfall five years prior to migration in each region of Ethiopia can be used to explain a large part of the migration rate in ESS2 and ESS3. The second reason for choosing this variable as an instrument for migration is that all migration in both ESS2 and ESS3 took place from 1999 to 2008, which means that the migration period is five years prior to the panel ESS1-2. Therefore, it is less likely that the average rainfall lags ( $t - 1$  to  $t - 5$ ) prior to migration (1999 to 2008) directly affect the food consumption in 2013-2014 and 2015-2016. Consequently, household food security in both 2013-2014 and 2015-2016 can not be directly impacted by the annual average rainfall one to five years prior to migration in ESS2 and ESS3.

### 4.3. Control variables

The paper follows the previous literature (Jr. & Page, 2005; Karamba et al., 2011; Margolis, Miotti, Mouhoud, & Oudinet, 2015; Nguyen & Winters, 2011; Sharma & Chandrasekhar, 2016) to select household socioeconomic characteristics that are likely to be related to their food consumption decisions. The considered vector of exogenous variables includes the household-level characteristics and the household head-related variables.

The household head variables are gender, age, marital status, and education. These variables are assumed to differently affect households nutrition. Regarding the marriage status of the household head, I expect singles to be more food secure because they have fewer individuals to feed. Concerning education, the household heads with high educational attainment are expected to be wealthier and more food secure.

The household-level characteristics include the household size, his welfare, and his living place. According to the economy of scale theory, the household size is expected to have a positive effect on the food consumption of household (Barten & Instituut, 1964; Deaton & Paxson, 1998). However, a larger household size also means a wider distribution of food within the household. Therefore, it can be a burden for households when they lack money. ESS does not provide a measure of household welfare. Therefore, to measure this welfare, we follow Margolis et al. (2015) by constructing an assets index<sup>5</sup>, which is a proxy of household income level. The asset index also captures two factors that can affect households' food security: capital available for food pur-

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<sup>3</sup>Rainfall data are from the Climatic Research Unit (CRU) of University of East Anglia (UEA)

<sup>4</sup>Ethiopian Socioeconomic Survey

<sup>5</sup>The asset index is constructed with a multiple correspondence analysis (MCA) basing on dummies variables which denote the presence/absence of the following goods: Kerosene stove, Cylinder gas stove, Electric stove, Blanket/Gabi, Mattress and/or Bed, Wristwatch/clock, Fixed line telephone, Mobile Telephone, Radio/ tape recorder, Television, CD/VCD/DVD/Video Deck, Satelite Dish, Bicycle, Motorcycle, Cart (Hand pushed), Cart (animal-drawn)- for transporting people and goods, Sewing machine, Weaving equipment, Mitad-Electric, Energy saving stove (lakech, mirt etc), Refrigerator, Private car, Jewels - Gold (in grams), Jewels - Silver (in

chase and collateral against which households can borrow to finance food production or consumption.

Table 3 reports the summary statistics of all the variables above as well as that of food security indicators for both ESS2 and ESS3 data. It shows that, in 2013-2014, migrant households have a better calorie intake than non-migrant households. However, the difference is not significant in 2015-2016. In both ESS2 and ESS3, the dietary diversity measured by the Simpson and the Shannon indexes is much better in non-migrant households than in migrant households. Table 3 also indicates that household heads in migrant households are older - the average is 50 - and less educated in both ESS2 and ESS3. Indeed, in 2013-2014, the share of heads of migrant households who attained secondary school is only 5 % compared to 11 % for heads in non-migrant households. Also, in 2015-2016, 7 % of heads in migrant households attained more than secondary school compared to 9 % in non-migrant households. In both ESS2 and ESS3, migrant households are more located in rural areas. Indeed, in 2013-2014, 86 % of migrant households were located in rural compared to approximately 60 % for non-migrant households. Likewise, the share of migrant households located in rural in 2015-2016 stands for 71 % compared to 64 % for non-migrant households. Regarding living standards, table 3 shows that migrant households are less wealthy than non-migrant households in ESS2. However, the difference is not significant in ESS3. Another important information shown by table 3 is that the number of households that reported having a migrant in 2013-2014 was 815 while it increased by 633 in 2015-2016. At the same time, all migration reported by households in both ESS2 and ESS3 took place from 1999 to 2008. Therefore, the increase in the number of migrant households in 2015-2016 can be explained by the fact that some households missed indicating that they had a migrant in 2013-2014. It may also be a consequence of the deletion of some households in ESS2 for which consumption data were missing. In both cases, this does not affect our analysis since it is based on pooled data.

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grams), Wardrobe, Shelf for storing goods, Biogas pit, Water storage pit, Sickle (Machid), Axe (Gejera), Pick Axe (Geso), Plough (Traditional), Plough (Modern), and Water Pump.) contained in the variables was retained to construct the index.

Table 3.: Summary statistics

Variables	ESS2 (2013-2014)			ESS3 (2015-2016)			Min	Max
	Migrant household	Non-migrant household	Prob of Diff	Migrant household	Non-migrant household	Prob of Diff		
Log of per capita calorie intake (PCCI)	10.33	10.2	0.063	10.52	10.54	0.22		
Simpson index	0.94	1.01	0.009	1.09	1.11	0.038		
Shannon index	0.48	0.52	0.002	0.56	0.57	0.001		
Female head	0.29	0.32	0.828	0.32	0.3	0.225	0	1
Age head	49.23	43.26	0.000	49.45	45.09	0.000		
Never Married	0.03	0.09	0.000	0.03	0.06	0.168	0	1
Married (monogamous)	0.69	0.64	0.895	0.67	0.66	0.986	0	1
Married (polygamous)	0.04	0.02	0.063	0.03	0.03	0.707	0	1
Divorced	0.06	0.09	0.069	0.07	0.08	0.347	0	1
Seperated	0.02	0.02	0.738	0.02	0.02	0.199	0	1
Widowed	0.16	0.14	0.057	0.18	0.16	0.264	0	1
Less than secondary school	0.92	0.79	0.000	0.85	0.81	0.113	0	1
Secondary school	0.05	0.11	0.001	0.08	0.1	0.812	0	1
More than secondary school	0.03	0.1	0.002	0.07	0.09	0.031	0	1
Asset index	-0.77	0.13	0.003	0.1	-0.06	0.377		
Household Size	4.78	4.41	0.134	4.69	4.73	0.000		
Rural	0.86	0.59	0.000	0.71	0.64	0.001	0	1
Small Town	0.14	0.08	0.018	0.11	0.07	0.231	0	1
Medium and large town	0	0.34	0.000	0.19	0.28	0.000	0	1
Nb of observations	815	4,013		1448	3,363			

#### 4.4. Results

Table 4 reports both the OLS and the Heckman estimate of the effect of migration on households' food security. For the Heckman estimate, the first stage result reported in Table C1 indicates that four out of five of the rainfall lags used as instruments are significant at one percent and five percent levels. In addition, in the second stage estimate, the wald test shows that, in  $\log(PCCI)$  equation,  $\rho_1$  and  $\rho_0$  are globally significant, meaning that the migration variable has effectively a self-selection bias. Therefore, the use of the Heckman procedure to address the causal effect of migration is appropriate.

When all types of migration are put together, the OLS estimates indicate that migration is negatively and significantly correlated with per capita calorie intake (PCCI). In the Heckman estimate, although this relationship is still negative, it is found to be non-significant. However, looking specifically at only the population of migrant households, the average treatment effect on the treated (ATET) is shown to be negative and significant for PCCI while it is positive but non-significant for both the Simpson and Shannon indexes. This finding means that, in the absence of migration, households that currently have a migrant would have had a better calorie intake. Therefore, migration in Ethiopia prior to 2013-2016 has led to the reduction of per capita calorie intake in migrant households. This result means that migration has a negative effect on per capita calorie intake in migrant households in Ethiopia.

In table 5, the analysis is restricted to labour migration. Estimating separately the effect of labour migration on household food security is straightforward as it is more likely to produce remittances than other types of migration. Table 5 shows that, on average, labour migration has a positive causal effect on per capita calorie consumption. Indeed, having a labour migrant is associated with a 37% improvement of per capita calorie intake in the household. This finding implies that any household sending a member to migrate in order to work will see a positive change in their per capita caloric intake as a result of migration. However, the average treatment effect

on the treated (ATET) is still negative and significant at a one percent level, meaning that households that currently have a labour migrant would have had a better calorie intake if they did not have this migrant. Therefore, the average positive effect of migration results from the average treatment effect on non treated (ATENT)<sup>6</sup> which is also positive and significant. In other words, this result implies that migration would have a higher positive impact on per capita calorie intake in non-migrant households than it has a negative impact on per capita calorie intake in migrant households. The robustness analysis will validate whether it is the negative effect that prevails over the positive effect.

Tables 4 and 5 also reported other determinants of household food security in Ethiopia. They show that households with a female head have both better calorie intake and better dietary diversity. However, households with aged head have less dietary diversity. The household head education is also shown to play a significant role in household dietary diversity. Indeed, for the two dietary diversity indicators (Simpson and Shannon indexes), each additional year of schooling for a household head has a positive and significant impact on household dietary diversity. This result is explained by the fact that a household head who has completed higher educations has a better understanding of nutritional practices. Regarding the marital status of the household head, results indicate that households with married heads have both better calorie intake and dietary diversity than other households (those with a non-married, divorced, separated, and widowed head). This result can be explained by the economies of scale theory (Barten & Instituut, 1964; Deaton & Paxson, 1998). Indeed, marriage leads to an increase in household size, which produces a substitution effect towards shared goods that become cheaper. The resources released by sharing allow more to be spent on foods. Marriage also not only can increase the household labor supply but it can also improve household knowledge on nutritional practices through the sharing of knowledge between spouses.

In all estimates, the coefficient of the asset index is positive and significant at one percent level, which means that households with higher asset index are more food secure. Indeed, a higher asset index not only implies a wealthy household but also indicates that the household has an endowment that can be exchanged for food in the market (Sen, 1981). Therefore, having a higher asset index means that the household has the means to afford food. Wealthy households are also usually those with higher education, which implies that they have a good understanding of better nutritional practices.

Regarding the household size, it is shown to have a negative and significant impact on both Simpson and Shannon indexes. This can be explained by the fact that as household size increases, so does the need for food, which can lead to a concentration of consumption on staple foods. As a result, the dietary diversity of the household will deteriorate.

Regarding the household place of residence, rural households have a better calorie intake than those in small and large towns. However, being in rural is negatively associated with dietary diversity, meaning that rural households have a poor dietary diversity than their counterpart in urban. The first finding can be attributed to the fact that agriculture is usually more developed in rural areas than in urban areas, leading to more food available. However, urban households are wealthier and have a better knowledge of nutritional practices, which leads to better dietary diversity.

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<sup>6</sup>ATENT is the difference between the current non-migrant households' food security status and the food security status they would have if they have a migrant. Notice that  $ATE = ATET \times Prob(M_i = 1) + ATENT \times Prob(M_i = 0)$

Table 4.: Effect of migration on household food security in Ethiopia: OLS and Heckman estimates

	OLS			Heckman		
	Log(PCCI)	Simpson	Shannon	Log(PCCI)	Simpson	Shannon
<b>Migration</b>	-0.048*** (0.016)	-0.003 (0.004)	0.004 (0.008)	-0.002 (0.044)	-0.009 (0.011)	-0.002 (0.021)
<b>Household head characteristics</b>						
Female	0.059** (0.024)	-0.003 (0.006)	0.080*** (0.012)	0.080*** (0.028)	0.001 (0.006)	0.098*** (0.014)
Age	-0.001 (0.001)	-0.000*** (0.000)	-0.001*** (0.000)	-0.000 (0.001)	-0.001*** (0.000)	-0.001*** (0.000)
Married (monogamous)	0.347*** (0.045)	0.038*** (0.010)	0.241*** (0.021)	0.384*** (0.050)	0.039*** (0.011)	0.261*** (0.023)
Married (polygamous)	0.311*** (0.061)	0.070*** (0.014)	0.289*** (0.029)	0.373*** (0.072)	0.065*** (0.016)	0.290*** (0.034)
Divorced	0.090* (0.049)	0.029** (0.012)	0.123*** (0.025)	0.123** (0.055)	0.026** (0.013)	0.127*** (0.028)
Separated	0.047 (0.061)	0.042*** (0.015)	0.145*** (0.033)	0.091 (0.070)	0.027 (0.017)	0.131*** (0.037)
Widowed	0.146*** (0.048)	0.021* (0.011)	0.128*** (0.023)	0.141*** (0.054)	0.023* (0.012)	0.139*** (0.026)
Secondary school	-0.029 (0.026)	0.025*** (0.006)	0.060*** (0.013)	-0.024 (0.030)	0.027*** (0.007)	0.061*** (0.015)
More than Secondary school	-0.056* (0.032)	0.031*** (0.007)	0.056*** (0.016)	-0.039 (0.037)	0.030*** (0.008)	0.055*** (0.018)
<b>Household-level characteristics</b>						
Asset index	0.030*** (0.004)	0.014*** (0.001)	0.043*** (0.002)	0.029*** (0.004)	0.014*** (0.001)	0.042*** (0.002)
Household Size	-0.005 (0.004)	-0.008*** (0.001)	-0.006*** (0.002)	-0.007 (0.005)	-0.008*** (0.001)	-0.006*** (0.002)
Rural	0.597*** (0.025)	-0.108*** (0.005)	-0.195*** (0.012)	0.620*** (0.029)	-0.110*** (0.006)	-0.200*** (0.013)
Small Town	0.326*** (0.030)	-0.047*** (0.007)	-0.095*** (0.015)	0.372*** (0.037)	-0.041*** (0.008)	-0.087*** (0.018)
Constant	9.739*** (0.054)	0.531*** (0.013)	0.838*** (0.026)	10.025*** (0.060)	0.593*** (0.014)	0.944*** (0.030)
<b>Selection terms</b>						
$\rho_1$				-0.054 (0.039)	0.007 (0.009)	0.012 (0.018)
$\rho_0$				-0.081***	0.001	0.005
Regional fixed effects	YES	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES	YES
Adjusted-R2	0.189	0.252	0.274	0.193	0.253	0.275
Observations	9505	9634	9634	9505	9634	9634
Wald Test (Ho: $\rho_1 = \rho_0 = 0$ )				4.57**	0.31	0.27
ATET				-0.16***	0.00	0.01
ATENT				0.046	-0.011	-0.005

Notes: \*\*\*, \*\* and \* denote significance at the 1, 5 and 10 percent level respectively; standard errors in parentheses are robust to heteroskedasticity

Table 5.: Effect of labour migration on household food security in Ethiopia: Heckman estimates

	Log(PCCI)	Simpson	Shannon
<b>Labour migration</b>	0.317*** (0.116)	-0.023 (0.029)	-0.025 (0.057)
Female head	0.068*** (0.026)	-0.004 (0.006)	0.087*** (0.013)
Age of head	-0.000 (0.001)	-0.001*** (0.000)	-0.001*** (0.000)
Married (monogamous)	0.362*** (0.047)	0.038*** (0.010)	0.252*** (0.022)
Married (polygamous)	0.327*** (0.064)	0.072*** (0.015)	0.302*** (0.030)
Divorced	0.080 (0.052)	0.032*** (0.012)	0.129*** (0.026)
Separated	0.057 (0.066)	0.042*** (0.016)	0.140*** (0.036)
Widowed	0.129** (0.051)	0.025** (0.011)	0.139*** (0.024)
Secondary school	-0.041 (0.027)	0.027*** (0.006)	0.064*** (0.014)
More than Secondary school	-0.063* (0.034)	0.033*** (0.007)	0.059*** (0.016)
Asset index	0.031*** (0.004)	0.014*** (0.001)	0.043*** (0.002)
Household Size	-0.006 (0.004)	-0.008*** (0.001)	-0.005*** (0.002)
Rural	0.607*** (0.027)	-0.111*** (0.006)	-0.199*** (0.013)
Small Town	0.354*** (0.033)	-0.045*** (0.007)	-0.091*** (0.016)
$\rho_1$	-0.242*** (0.071)	0.014 (0.017)	0.025 (0.034)
$\rho_0$	-0.145*** (0.052)	0.003 (0.013)	0.016 (0.026)
Constant	10.039*** (0.056)	0.588*** (0.013)	0.935*** (0.028)
Regional fixed effects	YES	YES	YES
Time fixed effects	YES	YES	YES
Adjusted-R2	0.191	0.252	0.274
Observations	9505	9634	9634
Wald Test (Ho: $\rho_1 = \rho_0 = 0$ )	9.72***	0.34	0.7152
ATET	-0.291***	0.004	0.034
ATENT	0.382***	-0.026	-0.031

Notes: \*\*\*, \*\* and \* denote significance at the 1, 5 and 10 percent level respectively; standard errors in parentheses are robust to heteroskedasticity

## 5. Robustness tests

In the previous section, Wald's test in the Heckman estimates of the Simpson and Shannon indices shows that the selection terms are not globally significant. This would imply that migration does not suffer from a self-selection bias, which is not the case. This result may, on the one hand, be due to the non-normal distribution of the two indicators (Figure B1). On the other hand, some households may have omitted or provided exaggerated quantities of certain foods consumed, thus leading to outliers that may bias the results. Therefore, it is important to conduct several robustness tests before validated the previous results. First, I estimated again the effect of migration on household food security using a non-parametric estimator which does not assume the

distribution pattern for each indicator. Second, I proxied both household food access and dietary diversity with two other indicators in order to confirm the findings for PCCI, Simpson, and Shannon indexes.

### 5.1. Quantile treatment effect estimate

In order to access the distributional effect of migration on household food security, I use the quantile treatment (QTE) effect estimator of [Abadie et al. \(2002\)](#) which takes into account the self-selection bias of migration. This estimator allows addressing both the outliers issue and the non-normal distribution pattern of the Simpson and Shannon indexes. It is also robust to the endogenous control variables which may also be correlated with the error term ([Frölich, 2008](#)).

The estimation procedure (see detail in appendix D) is based on the following specification:

$$Y_i^M = X_i\beta^\tau + M_i\delta^\tau + \varepsilon_i \quad (10)$$

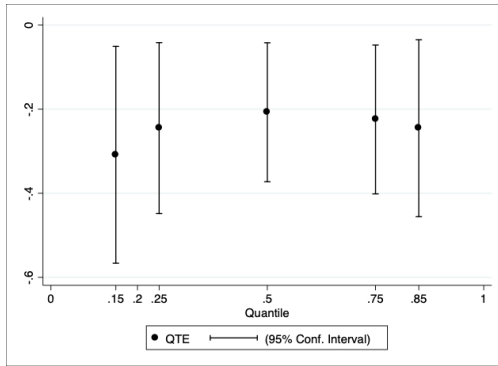
Where  $M \in (0, 1)$  is the migration variable's values, and  $\delta^\tau$  represents the quantile effect of migration at quantile  $\tau$ .  $Y_i^M$  denotes the food security status of household  $i$  that has a migration status  $M$ .

Figure 1 reports the quantile effect of migration,  $\delta^\tau$  or QTE, on per capita calorie intake, Simpson and Shannon indexes for five quantiles. At all quantiles, QTE is statistically significant and negative for per capita calorie intake (PCCI) while it is significant and positive for the Simpson and Shannon indexes. This means that migration globally has a negative effect on per capita calorie intake while it positively affects household dietary diversity. The negative effect on per capita calorie intake, therefore, confirms the finding in the Heckman estimate. However, QTE is not uniform at all quantiles. Indeed, the QTE estimate of the effect of migration at the median of the distribution of PCCI is less large than that at the other quantiles. For instance, the QTE at the median is 33% and 15% lower than the QTE at the .15 quantile and .85 quantile, respectively. For the Simpson and Shannon indexes, QTE decreases throughout the distribution, which means the effect of migration on dietary diversity becomes progressively weaker as we move up through the distribution. In other words, the effect of migration on household dietary diversity is much higher at low quantiles. Indeed, for the Simpson index, the QTE at the .15 quantile is 50% much higher than that at the .85 quantile. For the Shannon index, the difference between the QTE at the .15 quantile and QTE at the .85 quantile stands for approximately 46%.

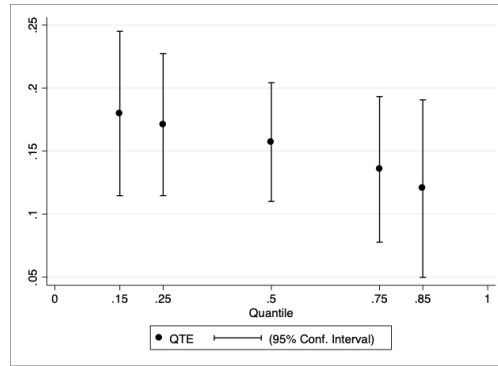
In figure 2, the same exercise is repeated for only labour migration. In contrast to the Heckman estimate, the QTE estimate argues that labour migration also has a negative effect on the PCCI. Therefore, the Heckman estimate overestimated the effect of migration for non-migrant households. Figure 2 also shows that labour migration has a positive and significant effect on household dietary diversity at all quantiles.

For more robustness, the QTE was estimated separately for each year of ESS used in the analysis. The result is reported in table 6. Panel A corresponds to the estimate of QTE for the period 2013/2014 while Panel B is for the period 2015/2016. For both Panel A and B, the QTE is negative for PCCI while it is positive for the Simpson and Shannon indexes. The finding in figure 1 is therefore robust to time-varying effect.

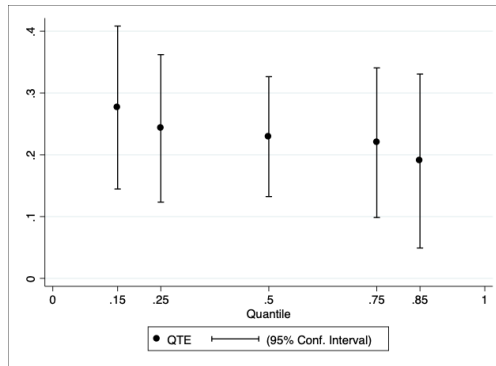




((a)) Log of per capita calorie intake

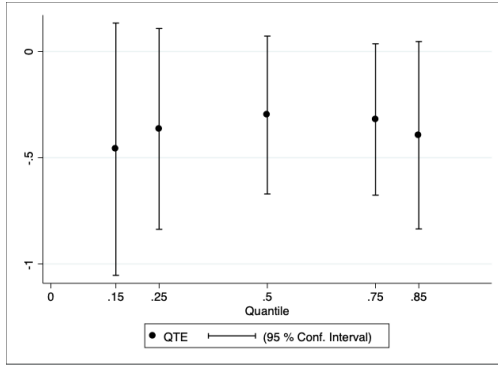


((b)) Simpson index

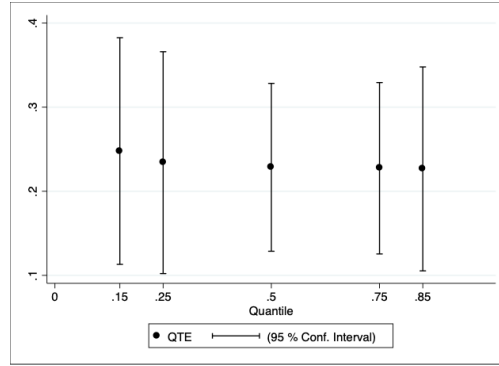


((c)) Shannon index

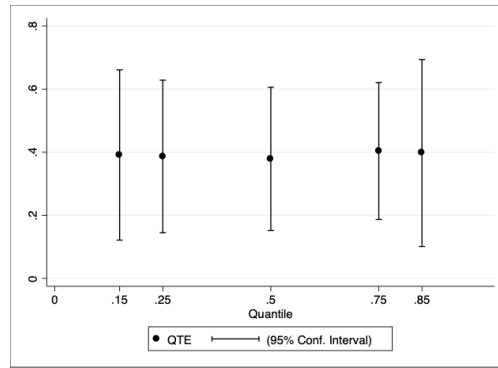
Figure 1.: Quantile effect of migration on household food security



((a)) Log of per capita calorie intake



((b)) Simpson index



((c)) Shannon index

Figure 2.: Quantile effect of labour migration on household food security

Table 6.: Quantile effect of migration by year of survey (2013/2014 and 2015/2016)

	Quantile				
	0.15	0.25	0.5	0.75	0.85
Panel A.					
Log(PCCI)	-0.283** (0.12)	-0.266** (0.104)	-0.201** (0.08)	-0.162** (0.08)	-0.169* (0.102)
Simpson	0.173*** (0.031)	0.164*** (0.031)	0.144*** (0.026)	0.122*** (0.03)	0.098*** (0.037)
Shannon	0.248*** (0.065)	0.195*** (0.061)	0.168*** (0.052)	0.141** (0.057)	0.134* (0.07)
Panel B.					
Log(PCCI)	-0.359 (0.34)	-0.309 (0.229)	-0.301 (0.187)	-0.318 (0.21)	-0.287 (0.256)
Simpson	0.196*** (0.073)	0.167*** (0.064)	0.159*** (0.051)	0.152** (0.077)	0.155 (0.095)
Shannon	0.449*** (0.164)	0.355** (0.154)	0.287*** (0.105)	0.283** (0.132)	0.256 (0.181)

Notes: \*\*\*, \*\* and \* denote significance at the 1, 5 and 10 percent level respectively; standard errors in parentheses are robust to heteroskedasticity

### 5.2. Robustness to a change of food security indicators

In order to validate the effect of migration on household calorie intake and dietary diversity, I tested here the robustness to the use of the proxies of PCCI, Simpson and Shannon indexes. In this regard, since PCCI is often employed to measure household food access, I have used the share of food expenditure in total household expenditure as a proxy, as this share can also be used to capture household access to food. The logic behind using this indicator as a proxy of food access is that wealthy households that have better food access have also a lower share of food expenditure (Engel's rule). Therefore, the more is the share of food expenditure in total expenditure, the less is the food access of the household. Regarding household dietary diversity, it is proxied with the Food Consumption Score (FCS) which is the indicator used by the World Food Program (WFP) to monitor food security in developing countries. The detail on the construction of this indicator is presented in appendix E.

Figure 3 reports the result of the QTE estimate for the food expenditure share and the food consumption score. It shows that the QTE is positive at all quantiles, and statistically significant for the first three quantiles, .15, .25, and .5. Therefore, migration leads to an increase of household food expenditure share at least for the first three quantiles, which means that migration has a negative effect on household food access. This result confirms the finding with per capita calorie intake (PCCI). However, the effect of migration on the share of household food expenditure peaks at .25 quantile, compared to .5 for PCCI.

Regarding the food consumption score, the QTE is positive and statistically significant at all quantiles. Therefore, migration induces a positive shift in the distribution of food consumption, meaning that it leads to an improvement of household dietary diversity. This result also confirms that of the previous section even though the pattern of QTE is not the same as for the Simpson and the Shannon indexes. The ascending

QTE in the FCS distribution can be explained by the fact that the FCS indicator measures not only dietary diversity but also the frequency of consumption of each food group. However, the frequency of consumption is of little information if it is not associated with the consumption of a sufficient amount of food for each group. The results on the distribution of the FCS do not, therefore, reject those on the Simpson and Shannon indexes, which are based on the quantities consumed of each food group and measure only dietary diversity.

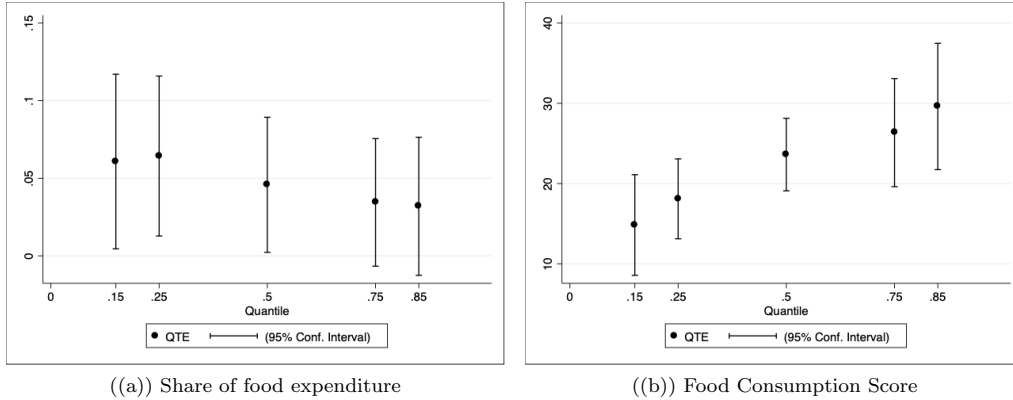


Figure 3.: Quantile effect of migration on household food expenditure share and food consumption score

## 6. Discussion: explaining the effect of migration on per capita calorie intake and dietary diversity in Ethiopia

The negative effect of migration on per capita calorie intake can be explained in several different ways. First, migration in Ethiopia, including labour migration, may not generate sufficient remittances to compensate for the loss of labour endowment due to the departure of an active member of the households. Another possible explanation is that some household members who receive remittances may have moved out from the agricultural sector to other economic activities leading to the reduction of their calorie consumption for physical heavy. For instance, [Deaton and Drèze \(2009\)](#) have observed that despite of the high growth rate of per capita income in India, per calorie consumption has been falling for a quarter of the century. They explained this finding by the fact that an increase of per capita income has probably led to a move out from the agricultural sector to the modern sector, resulting in a fall of calorie consumption for physical heavy which in turn reduces the total calorie consumption. The negative effect of migration on PCCI can also be explained by the fact that migration has resulted in a substitution effect towards the consumption of less nutritious foods in migrant-households. I assume the latter explanation. However, to validate this assumption, I estimated the quantile treatment effect (QTE) on the share consumed of the seven food groups used to calculate the Simpson and Shannon indexes.

Table 7 reports the result. Due to limited data, QTE could not be estimated for the quantiles .15 and .25 of two food groups, "meat and fish", and "milk". The results confirm that the negative effect of migration on PCCI is due to a substitution of the consumption of nutritious foods for the consumption of less nutritious foods. Indeed,

table 7 shows that migration leads to a reduction in the consumption of cereals, pulses, tubers and stems, which combined are more richer in calories. On the other hand, it also induces an increase in the consumption of less nutritious food such as milk, sugar, and beverages. Therefore, the negative effect of migration on per capita calorie intake is due to this substitution effect. It also implies that the improvement of dietary diversity is toward the consumption of fewer nutritious foods. As a result, migration in Ethiopia produces poor dietary diversity as it is not beneficial in terms of calories.

Table 7.: Quantile effect of migration on the share of each food group consumed

	Quantile				
	0.15	0.25	0.5	0.75	0.85
Cereals	-0.285*** (0.052)	-0.253*** (0.045)	-0.186*** (0.031)	-0.116*** (0.026)	-0.099*** (0.029)
Pulses	-0.074*** (0.01)	-0.089*** (0.01)	-0.114*** (0.01)	-0.149*** (0.013)	-0.181*** (0.017)
Vegetables and fruits	0.001 (0.005)	0.001 (0.006)	-0.003 (0.01)	-0.015 (0.022)	-0.028 (0.031)
Tubers and stems	0.000 (0.009)	-0.044 (0.031)	-0.202*** (0.042)	-0.277*** (0.041)	-0.265*** (0.059)
Meat and fish	-	-	0.000 (0.001)	-0.002 (0.002)	-0.006 (0.007)
Milk	-	-	0.065 (0.014)	0.184*** (0.023)	0.269*** (0.027)
Sugar and beverages	0.013*** (0.005)	0.019*** (0.006)	0.05*** (0.012)	0.137*** (0.027)	0.22*** (0.035)

Notes: \*\*\*, \*\* and \* denote significance at the 1, 5 and 10 percent level respectively; standard errors in parentheses are robust to heteroskedasticity

## 7. Conclusion

This paper investigates the effect of migration on the food security of households left behind using the second and the third Ethiopian Socioeconomic Survey (ESS) from 2013/2014 and 2015/2016, respectively. Household food security was measured by three food security indicators: per capita calorie intake (PCCI), the Simpson and the Shannon indexes. Results show that migration has a negative effect on per capita calorie intake for migrant-sending households. The same result was also found when only labour migration was considered. Results also indicate that migration positively affects households' dietary diversity. However, in the case of this paper, it is poor dietary diversity because it is the result of a substitution of the consumption of more nutritious foods for the consumption of less nutritious foods such as sugar and beverages.

The results also show that the effect of migration varies between quantiles. For the per capita calorie intake, the impact of migration is most pronounced in the median, while for dietary diversification, the impact is higher in the lower quantiles. The implication of this result, due to the overall negative effect of migration, is that migrant-households for which per capita calorie intake is at the median are more vulnerable than the other migrant-households.

This paper raises again the question on the impact of migration on household food security, especially in countries such as Ethiopia where internal migration is very dominant and where individuals migrate more to live with a relative rather than to work elsewhere. It shows that under these conditions, migration has an overall negative effect on the food security of migrant households. Therefore, in terms of policy implication, there is a need for government intervention to support these particular households.

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## Appendix A. Per capita calorie intake (PCCI)

PCCI is constructed following the same approach as [Thij, Simioni, and Thomas-Agnan \(2018\)](#). I start by transformed the quantities consumed of each food item into kilocalories using the below conversion table ([Table A1](#)). I was not able to find the conversion table of Ethiopian foods. Therefore, I used the Kenya food composition table made available by FAO. The choice of Kenya is due to the fact that it is one of the countries close to Ethiopia, and the food consumed in the two countries is almost similar.

Having estimated the total calories consumed per household, the second step is to convert caloric intake at the household level to caloric intake at the individual level using equivalence scales. Mathematically, the Household total calorie intake (THCI) can be expressed as follows:

$$THCI = CI^h + \sum_{i \neq h} CI_{g,a}^i = CI^h + \sum_{i \neq h} \mathbb{1}_{i \in \{g,a\}} \theta_{g,a} CI^h \quad (A1)$$

where  $CI^h$  is the calorie intake of head, taken as reference, and  $CI_{g,a}^i$  is the calorie intake of household member  $i$  of gender  $g$  and age  $a$ .  $\theta_{g,a} = CI_{g,a}^i / CI^h$  is the equivalence scale for a non-head member of the household of gender  $g$  and age  $a$ . From [equation A1](#), it can be derived the calorie intake of an adult reference member as follows:

$$CI^h = \frac{1}{1 + \sum_{i \neq h} \mathbb{1}_{i \in \{g,a\}} \theta_{g,a}}$$

According to OECD, the ratio of the calorie intake of a household member other than the head and aged 14 or over to the calorie intake of the head is 0.5 and the ratio of the calorie intake of a child aged under 14 to the calorie intake of the head is 0.3. Therefore,  $\theta_{g,a} = 0.5$  for  $g$  equal to either gender and  $a$  greater than or equal to 14 and  $\theta_{g,a} = 0.3$  for  $g$  equal to either gender and  $a$  less than 14. However, in this paper, I use the commonly used [Aguilar and Hurst \(2013\)](#) approach to calculate equivalence scales. This approach involves first estimating the following equation:

$$\log(THCI_i) = \gamma_0 + \gamma_1 Gender_i + \gamma_2 N_{a,i} + \gamma_3 Family_i + \varepsilon \quad (A2)$$

where  $THCI_i$  is the total calorie intake of household  $i$ ,  $Gender_i$  is the gender of the head of the household (male is taken as the reference).  $N_{a,i}$  refers to the number of adults in the household other than the head, and  $Family_i$  stands for the numbers of children by gender and age categories (0-2; 3-5; 6-13, and 14-17). Following [Santaeuillia-Llopis and Zheng \(2017\)](#) and [Thij et al. \(2018\)](#), [equation A2](#) is estimated by area of residence and by ESS wave. Next, I use the exponentiated predicted value of the regression, normalized by the value for singleton households (i.e.  $\exp(\hat{\gamma}_0)$  and  $\exp(\hat{\gamma}_0 + \hat{\gamma}_1)$  otherwise), as the equivalence scale. Per capita calorie intake is then calculated as the ratio of household total calorie intake (THCI) and household equivalence scale.

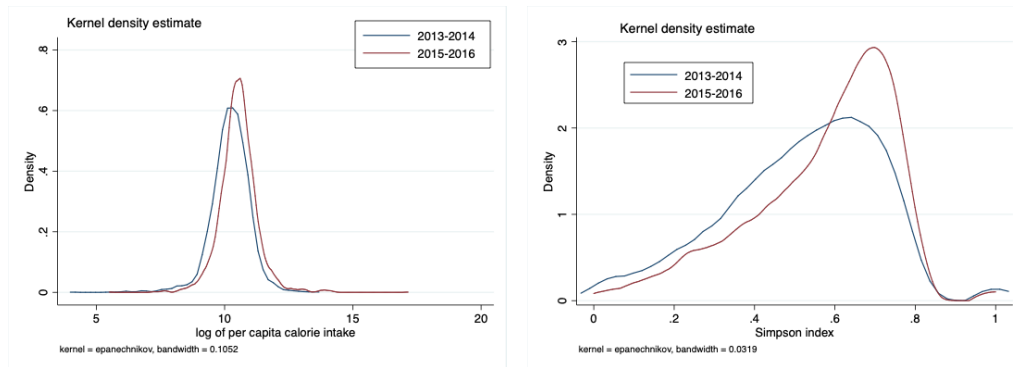


Table A1.: Calorie conversion table

Food items	Energy (Kcal/100 g EP)	Food items	Energy (Kcal/100 g EP)
Teff	351	Boye/Yam	112
Wheat	328	Cassava	173
Barley	328	Godere	131
Maize	340	Goat & mutton meat	119
Sorghum	336	Beef	284
Millet	354	Poultry	207
Horsebeans	341	Fish	73
Field Pea	341	Purchased Injera	351
Chick Pea	313	Purchased Bread or Biscuits	368
Lentils	318	Pasta/Maccaroni	370
Haricot Beans	335	Butter/ghee	739
Niger Seed	313	Oils (processed)	900
Linseed	376	Tea	0
Onion	42	Soft drinks/Soda	42
Banana	97	Beer	36
Potato	108	Tella	36
Kocho	400	Oats	373
Milk	82	Vetch	0
Cheese	401	Sesame	602
Eggs	134	Sunflower	595
Sugar	400	Fenugreek	309
Salt	0	Lemons	37
Coffee	311	Mangos	64
Chat / Kat	0	Beet root	44
Bula	336	Cabbage	26
Ground nuts	593	Carrot	30
Green chili pepper (kariya)	297	Garlic	152
Red pepper (berbere)	297	Kale	27
Greens (kale, cabbage, etc.)	27	Pumpkins	37
Tomato	22	Gesho	0
Orange	42	Avocados	185
Sweet potato	76.9		

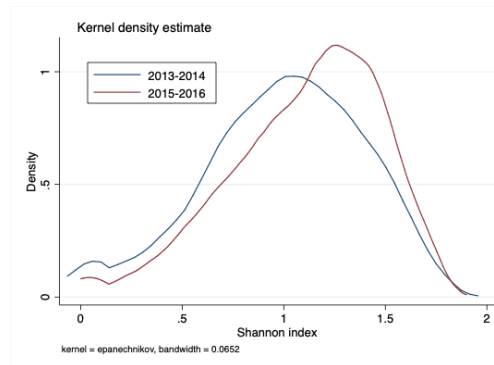
Source: FAO (2018), Kenya food composition table

## Appendix B. Kernel density for the Simpson and Shannon indexes



((a)) Log of per capita calorie intake

((b)) Simpson index



((c)) Shannon index

Figure B1.: Kernel density estimate of the Simpson and Shannon indexes

## Appendix C. First stage estimate of Heckman

Table C1.: First stage estimate of Heckman: determinants of migration

Variable	Coef.	Std. Err.	P>z
<b>Household head</b>			
female head	0.161	0.052	0.002
Age	0.008	0.001	0.000
Married (monogamous)	0.041	0.092	0.654
Married (polygamous)	0.023	0.13	0.863
Divorced	-0.247	0.109	0.023
Seperated	0.061	0.147	0.678
Widowed	-0.115	0.104	0.268
Secondary school	0.041	0.068	0.547
More than secondary school	-0.115	0.076	0.133
<b>Household level</b>			
Asset index	0.082	0.01	0.000
Household Size	-0.023	0.008	0.005
Rural	0.593	0.065	0.000
Small town	0.655	0.072	0.000
<b>Instruments</b>			
Rainfall ( $t - 1$ )	0.015	0.005	0.001
Rainfall ( $t - 2$ )	-0.048	0.003	0.000
Rainfall ( $t - 3$ )	-0.036	0.002	0.000
Rainfall ( $t - 4$ )	-0.003	0.002	0.182
Rainfall ( $t - 5$ )	0.007	0.003	0.013
Constant	6.263	0.835	0.000
Regional fixed effects		YES	
Time fixed effects		YES	
Number of obs		9,634	
Pseudo R2		0.27	

## Appendix D. QTE estimate's procedure

Consider the following linear model in which food security is explained, in each quantile, by migration and a number of observable household characteristics.

$$Y_i^M = X_i\beta^\tau + M\delta^\tau + \varepsilon_i \quad (\text{D1})$$

Where  $M \in (0, 1)$  is the migration variable's values, and  $\delta^\tau$  represents the quantile effect of migration at quantile  $\tau$ .  $Y_i^M$  denotes the food security status of household  $i$  that has a migration status  $M$ . Thus, each household has two potential food security status,  $Y_1$  if it has a migrant and  $Y_0$  otherwise. These potential food security statuses are associated with two distributions,  $F_{Y_0}$  and  $F_{Y_1}$ .  $\delta^\tau$  can therefore be defined as follows:

$$\delta^\tau = q_\tau(Y_1) - q_\tau(Y_0)$$

However, for each household we only observe  $Y = MY_1 + (1 - M)Y_0$ , i.e. the potential food security status  $Y_1$  if the household has a migrant and  $Y_0$  otherwise. And due to fact that migrant are self-selected based on some observable characteristics, the simple difference,  $q_\tau(Y | M = 1) - q_\tau(Y | M = 0)$ , can not be used to calculate the quantile treatment effect of migration. Therefore, to address this self-selection bias, [Abadie et al. \(2002\)](#) proposed an instrumental variable approach. They assume that there is a binary instrument  $Z$  which induces two potential treatments denoted by  $M_z$ .

They also impose the following assumptions:

$$\begin{aligned} (Y_0, Y_1, D_0, D_1) &\perp Z \mid X \\ Pr(Z = 1 \mid X) &\in ]0, 1[ \\ E(D_1 \mid X) &\neq E(D_0 \mid X) \\ Pr(D_1 > D_0 \mid X) &= 1 \end{aligned}$$

which imply a conditional independence between the instrumental variable  $Z$  and both the outcomes  $Y_0, Y_1$ , and the treatments  $D_0, D_1$ . Also, households with  $D_1 > D_0$  are referred to as "compliers", and the migration effect can only be identified for this group because households that always have a migrant and those who never have one can not be expected to change treatment status by hypothetical movements of the instrument. The estimation procedure is a two-step process.

The first step consists of estimating the propensity score,  $p(X)$ , using the local logit estimator.

$$p(X) = Pr(Z = 1 \mid X) \in ]0, 1[$$

At the second stage, the quantile effect of migration,  $\delta^\tau$ , is estimated from equation D1 by weighting the quantile regression with weights  $W_i^{AAI}$ . Mathematically,

$$(\hat{\beta}_{IV}^\tau, \hat{\delta}_{IV}^\tau) = \arg \min_{\beta, \delta} \sum W_i^{AAI} \times \rho_\tau(Y_i - X_i\beta - M_i\delta) \quad (D2)$$

where

$$W_i^{AAI} = 1 - \frac{M_i(1 - Z_i)}{1 - Pr(Z = 1 \mid X_i)} - \frac{(1 - M_i)Z_i}{Pr(Z = 1 \mid X_i)}$$

As explained above, estimating D2 involves using a binary instrumental variable taking values 1 and 0. Since, the instrumental variables used the Heckman estimate are continuous, they have to be first transformed into a single binary variable. I assume that the individual decision to migrate is not due to a one year shift in rainfall but based on a combination of bad rainfalls in the past. Therefore, I first constructed an index which combines all the five past rainfalls retained in the Heckman estimate. This was done using a principal component score. Positive values of the index express a high overall level of annual rainfall, while negative values characterize a low overall level of annual rainfall. Based on this result, the instrumental variable,  $Z$ , was generated, taking a value 1 if the rainfall index is positive and 0 otherwise. Finally, two separate regressions is made, one with migration and the rainfall index, and the other with migration and  $Z$ . For the two regression, it is found that both the rainfall index and  $Z$  have a negative effect on migration, which confirms the assumption that lower rainfalls are associated with more migration, while higher rainfalls reduce the probability of migrating.

## Appendix E. Food consumption score (FCS)

Food Consumption Score (FCS) is the WFPs flagship indicator for establishing the prevalence of food security in a country or region. It measures both dietary diversity

and household food access. The construction of FCS is based on a seven recall on the frequency of household consumption of 8 food groups (Staples, pulses, vegetables, fruits, meat and fish, dairy products, sugar, and oil). Each food group is assigned different weights (meat, milk, and fish, 4; pulses, 3; staples, 2; vegetables and fruits, 1; sugar and oil, 0.5), which are determined based on the energy, protein, and micronutrient that they provide. All food items as well as the weights of each food group are presented in table E1. The FCS is obtained by summing the weighted frequency of consumption of each food group. The higher the FCS is, the more the household is food secure.

Table E1.: Food Consumption score

	<b>FOOD ITEMS (examples)</b>	<b>Food groups</b>	<b>Weight</b>
1	Maize, maize porridge, rice, sorghum, millet pasta, bread and othe cereals	Main staples	2
2	Cassava, potatoes and sweet potatoes, other tubers, plantins		
2	Beans, Peas, groundnuts and cashew nuts	Pulses	3
3	Vegetables, leaves	Vegetables	1
4	Fruits	Fruits	1
5	Beef, goat, poultry, pork, eggs and fish	Meat and fish	4
6	Milk yogurt and other diary	Milk	4
7	Sugar and sugar products, honey	Sugar	0.5
8	Oils, fats and butter	Oil	0.5
9	Spices, tea, coffee, salt, fish power, small amounts of milk for tea	Condiments	0

## Appendix F. Quantile treatment estimate tables

Table F1.: Quantile treatment effect estimate: Log(PCCI)

	Quantile				
	0.15	0.25	0.5	0.75	0.85
<b>Migration</b>	-0.308**	-0.245**	-0.207**	-0.225**	-0.245**
	(0.132)	(0.104)	(0.084)	(0.09)	(0.107)
<b>Household head characteristics</b>					
Age	0.000	0.000	0.001	0.001	0.001
	(0.006)	(0.005)	(0.004)	(0.004)	(0.004)
Female	0.017	0.000	0.005	0.013	0.021
	(0.253)	(0.207)	(0.155)	(0.174)	(0.145)
Secondary school	-0.153	-0.13	-0.165	-0.147	-0.164
	(0.247)	(0.17)	(0.143)	(0.128)	(0.166)
More than Secondary school	-0.162	-0.178	-0.121	-0.113	-0.114
	(0.341)	(0.254)	(0.206)	(0.225)	(0.245)
Married (monogamous)	0.346	0.288	0.224	0.2	0.182
	(0.279)	(0.233)	(0.161)	(0.202)	(0.148)
Married (polygamous)	0.202	0.148	0.124	0.179	0.262
	(0.45)	(0.422)	(0.246)	(0.333)	(0.302)
Divorced	0.118	0.09	0.044	-0.049	-0.061
	(0.561)	(0.457)	(0.339)	(0.418)	(0.547)
Separated	0.036	-0.039	-0.079	-0.153	-0.283
	(0.454)	(0.372)	(0.354)	(0.359)	(0.291)
<b>Household-level characteristics</b>					
Household size	0.005	0.006	0.007	0.004	0.006
	(0.046)	(0.035)	(0.029)	(0.032)	(0.043)
Asset index	0.05	0.051	0.045	0.042	0.029
	(0.043)	(0.037)	(0.039)	(0.033)	(0.036)
Rural	0.29	0.325	0.378*	0.441**	0.426*
	(0.3)	(0.25)	(0.193)	(0.196)	(0.239)
Small Town	-0.019	-0.008	0.063	0.097	0.042
	(0.294)	(0.212)	(0.166)	(0.163)	(0.197)
Constant	9.709***	9.897***	10.197***	10.559***	10.808***
	(0.466)	(0.356)	0.298	(0.291)	(0.292)

Notes: \*\*\*, \*\* and \* denote significance at the 1, 5 and 10 percent level respectively; standard errors in parentheses are robust to heteroskedasticity

Table F2.: Quantile treatment effect estimate: Simpson index

	Quantile				
	0.15	0.25	0.5	0.75	0.85
<b>Migration</b>	0.18*** (0.033)	0.171*** (0.029)	0.157*** (0.024)	0.136*** (0.029)	0.12*** (0.036)
<b>Household head characteristics</b>					
Age	0.000 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)
Female	0.058 (0.051)	0.04 (0.056)	0.032 (0.044)	0.019 (0.046)	0.013 (0.062)
Secondary school	0.087 (0.055)	0.09 (0.056)	0.095 (0.042)	0.078* (0.045)	0.074 (0.052)
More than Secondary school	0.054 (0.087)	0.069 (0.079)	0.081 (0.052)	0.058 (0.055)	0.046 (0.065)
Married (monogamous)	0.098* (0.059)	0.046 (0.066)	0.02 (0.046)	-0.01 (0.051)	-0.023 (0.065)
Married (polygamous)	0.183* (0.098)	0.108 (0.09)	0.108 (0.077)	0.039 (0.075)	0.026 (0.098)
Divorced	-0.002 (0.084)	-0.075 (0.08)	-0.086 (0.152)	-0.079 (0.124)	-0.065 (0.148)
Separated	0.045 (0.071)	-0.029 (0.092)	-0.081 (0.142)	-0.054 (0.213)	-0.033 (0.114)
<b>Household-level characteristics</b>					
Household size	-0.005 (0.01)	-0.005 (0.01)	-0.009 (0.009)	-0.007 (0.008)	-0.006 (0.009)
Asset index	0.023** (0.01)	0.017 (0.011)	0.012** (0.008)	0.01 (0.009)	0.009 (0.013)
Rural	-0.056 (0.088)	-0.09 (0.074)	-0.08 (0.053)	-0.067 (0.059)	-0.052 (0.08)
Small Town	0.043 (0.073)	0.039 (0.062)	0.046 (0.047)	0.055 (0.057)	0.057 (0.066)
Constant	0.189 (0.145)	0.354*** (0.126)	0.516*** (0.096)	0.638*** (0.099)	0.686*** (0.113)

Notes: \*\*\*, \*\* and \* denote significance at the 1, 5 and 10 percent level respectively; standard errors in parentheses are robust to heteroskedasticity

Table F3.: Quantile treatment effect estimate: Shannon index

	Quantile				
	0.15	0.25	0.5	0.75	0.85
<b>Migration</b>	0.277*** (0.067)	0.243*** (0.061)	0.229*** (0.049)	0.22*** (0.062)	0.19*** (0.072)
<b>Household head characteristics</b>					
Age	0.000 (0.003)	-0.001 (0.003)	-0.001 (0.002)	-0.001 (0.003)	-0.002 (0.003)
Female	0.206 (0.19)	0.154 (0.141)	0.102 (0.117)	0.069 (0.114)	0.051 (0.145)
Secondary school	0.215 (0.153)	0.183 (0.123)	0.188* (0.103)	0.139 (0.094)	0.133 (0.094)
More than Secondary school	0.026 (0.254)	0.08 (0.221)	0.147 (0.137)	0.108 (0.135)	0.095 (0.154)
Married (monogamous)	0.262 (0.207)	0.188 (0.154)	0.108 (0.113)	0.042 (0.119)	-0.005 (0.16)
Married (polygamous)	0.368 (0.287)	0.314 (0.211)	0.21 (0.209)	0.121 (0.185)	0.079 (0.2)
Divorced	-0.017 (0.502)	-0.114 (0.248)	-0.139 (0.477)	-0.115 (0.342)	-0.112 (0.474)
Separated	0.07 (0.183)	-0.031 (0.219)	-0.086 (0.25)	-0.024 (0.359)	-0.004 (0.446)
<b>Household-level characteristics</b>					
Household size	0.006 (0.024)	-0.003 (0.019)	-0.006 (0.016)	-0.005 (0.018)	-0.003 (0.02)
Asset index	0.059*** (0.022)	0.047* (0.027)	0.036 (0.024)	0.033 (0.021)	0.031 (0.025)
Rural	-0.028 (0.253)	-0.124 (0.187)	-0.144 (0.14)	-0.141 (0.143)	-0.114 (0.171)
Small Town	0.095 (0.206)	0.051 (0.152)	0.057 (0.121)	0.076 (0.14)	0.077 (0.162)
Constant	0.218 (0.469)	0.587** (0.291)	0.937*** (0.239)	1.224*** (0.21)	1.36*** (0.268)

Notes: \*\*\*, \*\* and \* denote significance at the 1, 5 and 10 percent level respectively; standard errors in parentheses are robust to heteroskedasticity



Table F4.: Quantile treatment effect estimate: Food expenditure share

	Quantile				
	0.15	0.25	0.5	0.75	0.85
<b>Migration</b>	0.061** (0.029)	0.064** (0.026)	0.046** (0.022)	0.034 (0.021)	0.032 (0.023)
<b>Household head characteristics</b>					
Age	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
Female	0.083** (0.049)	0.072 (0.05)	0.038 (0.042)	0.035 (0.053)	0.033 (0.05)
Secondary school	-0.023 (0.062)	-0.028 (0.051)	-0.017 (0.053)	-0.014 (0.051)	-0.013 (0.048)
More than Secondary school	-0.135* (0.073)	-0.128 (0.089)	-0.079 (0.075)	-0.061 (0.075)	-0.056 (0.087)
Married (monogamous)	0.032 (0.05)	0.024 (0.056)	-0.004 (0.046)	-0.011 (0.058)	-0.01 (0.049)
Married (polygamous)	0.05 (0.075)	0.027 (0.071)	-0.002 (0.109)	0.000 (0.081)	-0.007 (0.069)
Divorced	-0.044 (0.128)	-0.047 (0.126)	-0.018 (0.123)	-0.027 (0.161)	-0.027 (0.19)
Seperated	-0.05 (0.469)	-0.001 (0.204)	-0.001 (0.188)	0.009 (0.082)	-0.005 (0.076)
<b>Household-level characteristics</b>					
Household size	0.004 (0.009)	0.005 (0.008)	0.001 (0.007)	-0.001 (0.007)	-0.001 (0.007)
Asset index	-0.021* (0.012)	-0.018* (0.01)	-0.018 (0.013)	-0.016 (0.013)	-0.015 (0.013)
Rural	0.129 (0.082)	0.135** (0.064)	0.14** (0.07)	0.115 (0.073)	0.106 (0.083)
Small Town	0.089 (0.076)	0.085 (0.066)	0.111* (0.063)	0.098 (0.067)	0.094 (0.08)
Constant	0.342*** (0.117)	0.401*** (0.098)	0.553*** (0.095)	0.675*** (0.11)	0.736*** (0.105)

Notes: \*\*\*, \*\* and \* denote significance at the 1, 5 and 10 percent level respectively; standard errors in parentheses are robust to heteroskedasticity

Table F5.: Quantile treatment effect estimate: Food Consumption Score (FCS)

	Quantile				
	0.15	0.25	0.5	0.75	0.85
<b>Migration</b>	14.836*** (3.201)	18.098*** (2.54)	23.614*** (2.307)	26.347*** (3.436)	29.603*** (4.013)
<b>Household head characteristics</b>					
Age	-0.011 (0.077)	-0.009 (0.069)	-0.046 (0.092)	-0.07 (0.149)	-0.099 (0.157)
Female	1.377 (3.317)	1.166 (3.547)	0.756 (6.108)	1.824 (6.513)	0.545 (7.467)
Secondary school	1.532 (4.102)	2.306 (4.656)	5.8 (6.585)	9.156 (7.525)	10.588 (9.615)
More than Secondary school	4.905 (7.705)	7.721 (7.426)	11.149 (7.465)	12.685 (10.006)	13.213 (9.582)
Married (monogamous)	2.931 (3.64)	2.671 (3.724)	1.936 (6.577)	-0.097 (7.175)	-2.42 (8.764)
Married (polygamous)	5.158 (5.921)	4.617 (5.416)	3.92 (7.865)	-0.051 (9.653)	-1.037 (16.096)
Divorced	-3.382 (14.375)	-1.107 (5.811)	-3.485 (6.936)	-7.033 (11.796)	-10.134 (13.355)
Separated	2.597 (8.649)	3.621 (18.462)	2.112 (10.12)	-2.937 (13.693)	-3.205 (23.311)
<b>Household-level characteristics</b>					
Household size	0.418 (0.522)	0.406 (0.468)	0.575 (0.699)	0.638 (0.937)	0.57 (1.128)
Asset index	1.939 (1.203)	2.182** (0.984)	1.932 (1.2)	2.387 (1.657)	2.334 (2.304)
Rural	-6.057 (6.097)	-5.802 (6.863)	-7.854 (7.49)	-7.021 (9.512)	-8.79 (12.748)
Small Town	-2.614 (5.968)	-2.589 (6.608)	0.846 (7.578)	4.585 (9.061)	6.552 (13.608)
Constant	19.042** (7.497)	22.387** (8.699)	32.793*** (10.831)	44.584*** (13.565)	54.9*** (15.102)

Notes: \*\*\*, \*\* and \* denote significance at the 1, 5 and 10 percent level respectively; standard errors in parentheses are robust to heteroskedasticity