DETERMINANTS OF HOUSEHOLD FOOD SECURITY IN RURAL ETHIOPIA: AN EMPIRICAL ANALYSIS

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Keywords
household food security, determinants, principal components analysis (PCA), Ethiopia

Abstract
Food insecurity and malnutrition present key policy challenges in Ethiopia. This paper examined the determinants of food security among rural households in Ethiopia using data from the latest round of Ethiopian Rural Household Survey. Two measures of household food security (a self-reported food security status and a multidimensional index generated based on principal components analysis - PCA) were used. OLS regressions were first run to identify important determinants based on the two measures, disregarding endogeneity problems. Then Instrumental Variable (IV) estimation was carried out to account for endogeneity issues. The results revealed that age and education of household head, adequacy of rainfall, livestock possession, participation in off-farm activities, soil conservation practices and per capita consumption expenditure were strongly and positively related to household food security; while access to credit and remittance had a negative influence. Accordingly, the study suggests that a judicious combination of interventions that enhance income diversification opportunities in rural areas through promoting off-farm activities, education, training and extension services, and improving livestock productivity could help enhance household food security. Provision of awareness creation on better and productive utilization of such resources as credit should also be emphasized in rural areas.

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Ⅰ. Introduction

Food insecurity is a growing concern worldwide. According to the 2010 State of Food Insecurity report of the United Nation's Food and Agriculture Organization (FAO), nearly one billion people are estimated to be undernourished, of which developing nations account for 98% (FAO 2010). In particular, since the 2008 food price crisis, food security has once again become a key issue for many poor countries and a key global problem as well. Ethiopia is one of the poorest countries in the world with worst scenario of poverty and food insecurity. Close to a quarter of the population in Ethiopia is malnourished with the largest proportion suffering from chronic hunger. The country has been structurally food deficient over the last four decades. The food gap in the country, for instance, rose to 5 million tons in 1993/94 from 0.75 million tons in 1979/80 (Befekadu and Berhanu 2000). In 2006, an estimated 15 million rural people were food insecure (Mitiku et al. 2013), while in 2012, an estimated 3.2 million people were reportedly food insecure, down from a peak of 4.5 million during the year 2011.[2]

Although various policy measures have been designed to address the problem, and despite the implementation of major market liberalization in the country as well as surpluses in food grain production in recent years, there have been reports that food availability still remains at low levels and food insecurity persists. Food insecurity emerged as a key problem and development challenge in Ethiopia in the early 1970s and became pervasive in the subsequent decades. A host of factors, including natural and man-made, have resulted in the growing food insecurity problem in many parts of the country. Frequently recurring droughts and erratic rainfall patterns, land degradation, rapid population growth, and poor rural infrastructure have also been cited as some of the causes of food insecurity and widespread poverty in the country. Other factors contributing to food insecurity are the low levels of technology employed in agriculture and the resulting low productivity of the sector (Sabates-Wheeler et al. 2012).

The concept of food security encompasses multiple dimensions such as food production, access and absorption. Factors that may lead to a situation of

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[2] Horn of Africa drought accessed on 31 May 2012 (http://www.irinnews.org/country/et/ethiopia)

food insecurity, therefore, mainly include non-availability of food, lack of access to food and improper utilization of food. Hence, the determinants of household food security in effect comprise the factors that determine each component of food security. In general, the determinants of food security are different at different levels of application, i.e. global, national, regional, household and individual levels (Khan et al. 2012).

Numerous studies have analyzed factors that determine food security at national and household levels in rural areas. Per capita land holding, livestock availability, education, household per capita income from agricultural and non-agricultural activities, soil fertility, and conflicts have been some of the major and commonly cited factors in the literature (Gebre-Selassie 2005, Negatu 2004, Ramakirshina and Demeke 2002, Madeley 2000). However, the findings have been quite mixed and conflicting. Moreover, despite the depth of the problem of food security in Ethiopia, there is relatively little empirical research on the subject.

Hence, the current study attempts to fill this deficit by analyzing the determinants of food insecurity in rural Ethiopia using the latest wave of the Ethiopian Rural Household Survey data conducted in 2009. In particular, the study aims at employing the principal components analysis (PCA) procedure to construct household food security index capturing the various aspects of food security. The rest of the paper is organized as follows. The next section presents a review of past literature on food security. Section three outlines the analytical framework of the study. Section four provides the results and discussion. Finally section five concludes the paper.

II. Food Security: Determinants and Measurements

Food insecurity has long been recognized as a multifaceted problem with multidimensional consequences. The term ‘food security’ is used to describe whether people have access to sufficient quantity and quality of food. Narrowly defined, food security implies availability of sufficient food at the global, national, community or household level. However, availability alone doesn’t guarantee access and that if food security is to be a measure of household or individual welfare; it has to address the issue of access (Pinstrup-Andersen 2009).

Food security came to the forefront in the 1970s, when it was explicitly acknowledged for the first time as an issue that concerns the whole of mankind at the 1974 World Food Conference in Rome. Since then, the whole concept of food security has evolved, developed and diversified a lot (Maxwel 1996, Napoli et al. 2011). The definition that has acquired the widest acceptance is that of the World Food Summit (WFS) held in 1996, which states "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996).

There are four important interlinked components imbedded in this definition. The first component relates to the *availability* of food in a given country or household through any means (production, imports or food aid, for example). The second aspect concerns *access* to food by people or households as reflected by their ability to get food through purchases from market, own stock/home production, gift or borrowing. The third component relates to food *utilization,* i.e., the actual processing and absorption capacity of the supplied nutrients by the body. Finally the fourth component relates to *stability* and *sustainability* over time (Napoli et al. 2011).

Food (in)security has been a widely researched area. Quite a number of studies have analyzed factors that determine food security at different levels: global, national, regional, sub-regional, provincial, district village household and individual levels. Identifying the determinants of food security requires examining the determinants of the major dimensions of food security. In particular, it is important to examine what determines the availability of food as well as access to food, the two widely researched dimensions of food security. Factors that determine food availability operate on the demand side while those determining access to food operate on the supply side. Consequently, factors that cause changes in the demand for and the supply of food would also bring changes in the availability of and access to food respectively, ultimately influencing food security.

A key step in food security analysis is finding an appropriate measure. In the literature, there are several indicators that are used as a measure of food security. Webb et al. (2006) highlight the lack of precise measures of household food security and that the most commonly used measures of food security are based on proxy measures. In particular, measures of the 'access' dimension of food security have centered on agricultural productivity, food shortage, or chil-

dren's nutritional status. In their study on the indicators of food security based on copping behaviors, Maxwell et al. (2008) list the widely employed measures of household food security, which include nutritional status, actual household food consumption level based on a 24-hour recall, coping strategy index, household income/expenditure, productive assets, food shortage, dietary diversity and household food insecurity access scale.

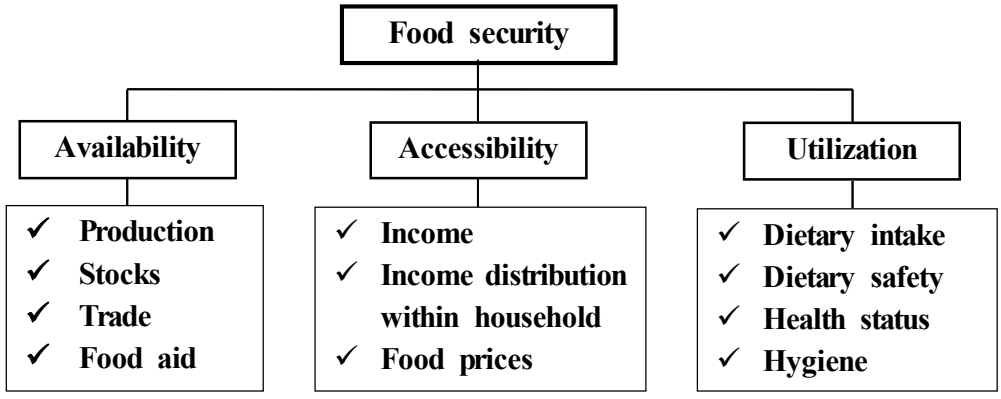
Other types of subjective measures attempt to assess the various components of food insecurity, through a series of questions about self-reported behaviors and attitudes. One such indicator is the Household Food Insecurity Access Scale (HFIAS) which identifies three key domains of household access to food: perceptions of insufficient quantity of food; perceptions of inadequate quality of food; and uncertainty about whether the food budget or supply is adequate to meet basic requirements (Swindale and Bilinsky 2006). Other studies have documented indicators such as dietary diversity and food frequency as the most common and valid indicators of nutrient adequacy and/or energy intake (Weismann et al. 2006, Hoddinott and Yohannes 2002, Ruel 2003).

Although survey questions about the self-reported behaviors cover the key central dimensions of household food insecurity, they do not represent all aspects of the phenomenon. The questions focus on whether the household has enough food or money to meet its basic food needs and on the normal behavioral and subjective responses to that condition, as these have been observed. Other elements of the broad, conceptual definition of food security, such as food safety, nutritional quality of diets, and "social acceptability" of food sources – including the unusual and sometimes ingenious coping behaviors that food-insecure households may undertake to augment their food supply – are not measured by those food security related questions in most surveys (Bickel et al. 2000).

In general, most of the indicators do not provide a comprehensive picture of the complexity of food security. Although there has been a lot of progress made in terms of deriving an appropriate measure/indicator of food security, there is still a long way to go to find broadly applicable measures of food security (Maxwell et al. 2008). According to Webb et al. (2006), most of the proxy measures of household food security only capture a small part of the broader, multifaceted problem. Moreover, it has been shown that the relationship between measures like caloric sufficiency and household food security is unpredictable across a range of circumstances (Coates et al. 2003).

Various methods have been employed in the past to analyze the determinants of food security. In their review of determinants of rural household food security in Africa and Asia, Bashir and Shilizzi (2013) conducted a meta-analysis of literature based on a conceptual model that takes into account the three components of food security and the factors that determine each of them as depicted in figure 1 below. Accordingly, factors like education, household head's age, input availability, technology adoption, farm size, land quality, price of inputs, and credit have been identified as determinants of the availability component of household food security. On the other hand, factors like income, distribution of income within the household, household size, total earning members and family structure are identified as determinants of the access aspect. Finally, gender and expenditure on food and health are considered as determinants of utilization aspect.

FIGURE 1. Conceptual model of rural household food security



Source: Adapted from Bashir and Schilizzi (2013).

While the meta-analysis presented above provides a useful insight in terms of systematically analyzing recent studies on the determinants of food security, it also shows that much of the focus in those studies was on food availability and accessibility components. However, food utilization component has been mostly ignored. Moreover, the findings with respect to each of the widely studied determinants differ from study to study and are generally characterized by lack of consensus.

Another useful framework for analyzing the determinants of food security is the Sustainable Livelihood Framework (SLF) of the Department for

International Development (DFID). The SLF indicates that the livelihood of a given household is dependent on its asset endowments—mainly human capital, social capital, physical capital, financial capital and natural capital—which together enable households to pursue a sustainable livelihood. Accordingly, food security, which is one part of livelihood security, is mainly determined by a household's resource endowment (Demeke et al. 2011).

Coming to the situation in Ethiopia, the country has been persistently facing a wide-scale food insecurity problem for several years. As one of the poorest countries in the world, the proportion of the total population living in poverty is 44 % with per capita income of about US$ 160, less than Sub-Saharan African countries average of US$ 500 (World Bank 2007). Like many other developing countries, agriculture takes the lion's share in the overall economy, accounting for about half of the Gross Domestic Product (GDP), 60 % of the exports, and 80 % of the national employment (CSA 2008a).

According to the results from a nation-wide Welfare Monitoring Survey conducted in 2004, 31% of Ethiopian households had difficulty meeting their food demands during the past 12 months prior to the survey (Demeke et al. 2011). Empirical evidence on food security in Ethiopia indicates the prevalence of a high level of food insecurity, with significant idiosyncratic and spatial characteristics. Studies by Kidane et al. (2005), Hailu and Regassa (2007), Bogale and Shimelis (2009), Adenew (2004), Mitiku et al. (2013) generally suggest that the depth and intensity of food insecurity are high.

Ramakrisha and Demeke (2002) conducted an empirical study in North Wello province of the Amhara regional state of Ethiopia. Based on food balance sheet and aggregate food security index, they report a high incidence of food insecurity in the province, with the majority of the sampled households being dependent on famine relief assistance. Moreover, the results from their logit model revealed that cereal production, education, fertilizer consumption, livestock, and land size, reduce the probability that households are food insecure while, family size increase the probability of insecurity (Ramakrishna and Demeke 2002).

Similarly, Kidane et al. (2005) analyzed determinants of food security in Oromia region of Ethiopia using the Rural Household Survey data. The authors used logistics regression to identify the determinants of food security in the region. The empirical evidence revealed that access to fertilizer, educational level of household heads, access to land, and access to family planning improve

the probability of food security in the study area. On the other hand, off-farm employment opportunities in rural Ethiopia are limited in both availability and income-generating potential. Only 44% of rural households surveyed by the Ministry of Labor in 1996 reported any non-agricultural sources of income, and these contributed only for 10% to household income (Befekadu and Berhanu 2000).

The bulk of the empirical evidence available on the analysis of food insecurity in Ethiopia are mainly based on caloric intake and self-reported status of households' food consumption behaviors as a measure of food security. Moreover, majority of the studies were carried out at the level of a specific district, region or province and fail to capture the diversity in agro-ecology and livelihood patterns in the country. This study, therefore, attempts to fill in such gaps. In doing so, we make use of two different indicators for analyzing the determinants of household food security. In particular, we employ a household food security index that captures all the three major dimensions of food security through a statistical procedure called principal components analysis (PCA). Furthermore, we use the latest wave of a nationally representative data from the Ethiopian Rural Household survey that covers a sample of households from districts representing the diversity in agro-ecology and the different livelihood patterns in the country.

Ⅲ. Materials and Methods

3.1. Data types and source

The data used for this study comes from of the Ethiopian Rural Household Survey (ERHS) conducted by Addis Ababa University in collaboration with the International Food Policy Research Institute (IFPRI) and the Center for the Study of African Economies (CSAE) of Oxford University. The data was administered in selected rural peasant associations of Ethiopia in 15 villages for seven rounds between 1994 and 2009, the most recent two occurring in 2004 and 2009. The 15 rural villages are representative of the diverse farming systems practiced in rural Ethiopia including the grain-plough areas of the Northern and Central highlands, the enset-growing areas and the sorghum-hoe

areas (Dercon et al. 2009). The ERHS is a very comprehensive survey that involved several visits to each household during each round of data collection, and therefore, is well equipped to measure several aspects of rural life. The duration, sample size, and geographic scope of this data collection make ERHS unique among household surveys from East Africa, and among a handful of such surveys in the developing world as a whole (Gray and Mueller 2012).

The sampling design is such that regions were selected to represent the main agro-ecological zones in the country.[3] On the other hand, the selection of districts as well as households within each district is based on stratified sampling. A list of all households was constructed with the help of the local Peasant Association (PA) officials. Within each village, random sampling was used, stratified by female headed and non-female headed households. The sample was stratified within each village to ensure that a representative number of landless households were also included (Dercon et al. 2005, Dercon et al. 2012). The study communities were originally selected as a judgment sample intended to be approximately representative of the rural highlands, and comparisons with the census indicate that the communities are similar to the rural highlands as whole (Dercon et al. 2009).

The data collection in each round included the implementation of a structured questionnaire in each sample household. The dataset so collected included information on demographic composition, farm and non-farm assets, expenditures, agricultural activities, ownership and value of land and livestock units, anthropometrics, schooling and other individual and household characteristics. Socio-economic and demographic characteristics of households are gathered by interviewing household heads, where a household is defined as a group of people living and eating together. In this study, data from the last round, that is, from the seventh round conducted in 2009 is used. The data includes 1,577 households.

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[3] Ethiopia is a federal state composed of 9 regional states and 2 administrative regions. Each region is divided into Zones, which are in turn subdivided into Woredas. Woredas in turn are divided into Peasant Associations (PAs) and Kebeles in rural and urban areas respectively, representing the lowest administrative units in the hierarchy.

3.2. Conceptual framework

Two measures of household food security status are used. The first indicator is a self-reported indicator of whether there was a shortfall of food availability to the household during a year. We denote this by RFSI. This measure was constructed from the self-reported status of households' response (yes/no) to a set of questions[4] pertaining to the availability and consumption of food. Accordingly, responses[5] to each of the six food consumption related questions were summed up and divided by six (the number of questions) to create self-reported food security status of each household with values ranging from 0 to 1.

On the other hand, the second measure is a composite index constructed using a multivariate statistical procedure called Principal Components Analysis (PCA) based on a selected set of indicators that are intended to capture the various components of household food security status. We denote this by PCAI. Since food security is a complex concept and not readily observable, the PCA approach helps capture its multiple dimensions based on a set of selected indicators. The selection of the indicators was guided by insights drawn from the food security literature as well as availability of data. All the three major dimensions (availability, access and utilization) have been represented by at least one indicator. However, due to lack of availability of data and the nature of our analysis, which is cross-sectional, it was not possible to include indicators capturing the stability/sustainability dimension of food security. Accordingly, the variables selected for constructing the index are: land area, availability of food stocks, number of crops cultivated, ownership of cattle (number of oxen, bulls, cows, sheep and goats), and utilization of sanitary services (improved toilet, improved water supply) at household level. The justification for selection of each variable is briefly explained below.

In the context of rural areas, a household's access to food depends on availability of sufficient land and other productive resources to grow its own food. Hence, the indicators land area and number of oxen owned were used as a proxy for access to food. On the other hand, households in rural communities commonly store crops for future use during times of food shortage. Hence,

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[4] Annex I at the end of the paper presents the set of questions mentioned.

[5] These responses are re-coded to take a value 1 (="no") indicating security and 0 (="yes") indicating insecurity

availability of stored crops can show households' capability to cope with unexpected food crisis situation. It can also serve as an indicator of food security at the household level (Haddad et al. 1994).

Similarly, a large body of evidence suggests that dietary diversity is an important indicator of food security which reflects the nutritional quality of the food consumed (Smith and Subandoro 2007). Studies have also shown the positive association between dietary diversity and high food consumption (Hoddinott and Yohannes 2002). In this regard, the types of crops grown could indicate household's risk aversion behavior and also indirectly show that the household's enterprise and food consumption patterns are diversified (Demeke et al. 2011). Hence, the number of food groups cultivated was included as a proxy for dietary diversity.

Finally, with regard to the utilization aspect, the role of sanitation and hygiene is indispensable in terms of ensuring the health and hence better utilization of food consumption at household level. Factors like water scarcity, poor water quality, and inadequate sanitation negatively impact food security, livelihood choices, and educational opportunities for poor families across the developing world. This means effective tackling of development problems in areas of health, food security, and education necessitates addressing water, sanitation and hygiene issues. To this end, we include utilization of improved water supply and toilet facilities by households as indicators of sanitation and hygiene. The type of toilet facility indicates the level of hygiene and sanitary situation of the household and is associated with the status of the health of its members. The health of members is in turn associated with the ability of household's members to make the best nutritional utilization of food consumption. Similarly, access to improved sources of water is also a crucial input for better health status of household members. Consequently, these two indicators are included to capture the utilization aspect of food insecurity.

Following the identification of the indicators as explained above, the PCA was employed. The PCA is a data reduction method used to re-express multivariate data in fewer dimensions. The procedure transforms the selected indicators into smaller components that capture most of the information (variation) in the original indicators. A detailed account of the use of PCA for constructing socio-economic status indices has been outlined in Vyas and Kumaranayake (2006). While this technique has been widely applied by the World Food Program for generating national food security index, it has also

been used by Qureshi (2007) and Demeke et al. (2011) for constructing household food security index.

Application of PCA on the selected indicators would yield a series of components with the first component explaining the largest variance in the data and subsequent components explaining additional but smaller proportion of the variance in the original variables. Using the factor scores from the first principal component as weights, a dependent variable can then be constructed for each household, which has a zero-mean and variance equal to one. It is this dependent variable that can be regarded as households' food security index (Vyas and Kumaranayake 2006). Accordingly, our dependent variable (PCA-based household food security index) will be generated as follows:

$$PCAI_j = \sum \frac{F_i(X_{ji} - X_i)}{S_i} \tag{1}$$

where $PCAI_j$ is the value of the j^{th} household's food security index obtained using PCA technique, F_i is the weight for the i^{th} variable in the PCA model, X_{ji} is the j^{th} household's value for the i^{th} variable, and X_i and S_i are the mean and standard deviations of the i^{th} variable over all the sample households.

After generating the household food security index as outlined above, the next step is to use it as dependent variable. For the analysis of the determinants of food security, we employ the Sustainable Livelihood Framework outlined in section two. Accordingly, the following model is formulated to estimate the determinants of household food security:

$$HFS = f\ (H,\ S,\ P,\ F,\ N) \tag{2}$$

where *HFS* refers to household food security status (the two indicators, i.e., RFSI and PCAI); *H, S, P, F*, and *N* refer to human, social, physical, financial and natural capital respectively.

We initially estimate equation (2) using OLS regression for both measures of food security to identify the determinants. However, OLS may not address endogeneity problems that are inherent in such analyses. Endogeneity arises when the outcome of interest – household food security – is jointly determined with one or more of the variables included in the analysis. In our case, participation in off-farm activity, which is one of the major determinants

of food security, might itself be influenced by other determinants of food security and hence is likely to be endogenous. Similarly, per capita consumption expenditure too might be endogenous. In such a situation, OLS estimates might be biased and inconsistent. We address this problem by employing instrumental variable estimation technique.

3.3. Description of explanatory variables

Based on the Sustainable Livelihood Framework (SLF) discussed earlier, the selection of our explanatory variables used in regression analysis was made in a way reflective of households' endowments of the different forms of capital. Variables like level of education of household head, age of household head, sex of household head, and availability of labor are key factors representing households' human capital (Demeke et al. 2011, Handa et al. 2004). We include these variables into the model to control for human capital endowments at the household level. With regard to financial capital, availability of credit, remittance and participation in off-farm activities have been recognized in the literature to affect food security (Aidoo et al. 2013). Credit can be used as a means of consumption smoothing during times of food shortage by households. Off-farm activities are also hypothesized to influence food security. Accordingly, household access to credit, remittances and participation in off-farm activities are included as financial capital. With regard to physical capital, livestock and land are included. For social capital, membership in iddir[6] is included.

With regard to natural capital, the role of rainfall among agricultural households in Ethiopia is widely acknowledged as agriculture in the country is predominantly rain-fed. Hence, any irregularity in its timing and/or fluctuation in amount will have adverse welfare consequences. Given the difficulty in obtaining accurate meteorological data on rain fall, we use a subjective rainfall index as a measure of rainfall. The subjective rainfall index is calculated to represent households' perceived rainfall adequacy in the preceding agricultural sea-

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[6] Iddir can be conceived as an ubiquitous indigenous insurance institution (found in Ethiopia) that covers different risks such as funeral ceremonies, death of major productive assets (such as draft oxen), medical expenses, food shortages, and so on (Aredo 2010).

son[7]. Following Quisumbing (2003) and Demeke et al. (2011), the responses for these questions were dichotomized in such a way that favorable responses are re-coded into one and unfavorable responses into zero (see Annex II). The re-coded responses are then summed up and divided by the number of rain-related questions (five). So the most favorable rainfall outcome is one and the least is zero. Finally, other variables included are household size, per capita consumption, soil conservation practice, and use of chemical fertilizers. The list of variables used along with summary descriptive statistics is provided in Table 1.

TABLE 1. List of variables used in the regression analysis

Variable	Description	Mean	SD	Min	Max
Human capital					
HHDAGE	Age of household head	49.16	12.53	15	100
HHDSEX	Sex of household head (male = 1)	0.80	0.40	0	1
HHDEDU	Household head's level of education (1 = primary, 2 = secondary, 3 = other[8]	0.28	0.45	0	1
NADULT	Number of economically active family members (aged 15-64)	3.16	1.44	1	9
Natural/physical capital					
RFI	Rainfall satisfaction index	0.55	0.32	0	1
LAND	Land area cultivated in ha	0.69	1.78	0	9.6
LVST	Livestock possession in TLU	3.59	3.77	0	26.8
Social/financial capital					
CREDIT	Access to credit (1 = yes, 0=no)	0.65	0.48	0	1
REMIT	Remittance income (1 = yes, 0=no)	0.48	0.50	0	1
POFFARM	Participation in off-farm activities (1 = yes, 0=no)	0.46	0.49	0	1

[7] Similar to the technique used to construct the subjective food security measure in section three.

[8] This includes adult education and other non-formal education types

Variable	Description	Mean	SD	Min	Max
IDDIR	Iddir membership (1 = yes, 0=no)	0.87	0.34	0	1
Others					
HHDSIZE	Family size	7.4	2.31	2	16
SOILCONSV	Practice soil conservation (1 = yes, 0=no)	0.56	0.50	0	1
FERT	Fertilizer use (1 = yes, 0=no)	0.73	0.45	0	1
LPCE	Log of Per capita consumption expenditure	4.62	1.17	0.04	8.36
INCINPR	Whether there was increase in input price (1 = yes, 0=no)	0.39	0.49	0	1
NPRLND	Percentage of less-productive land	13.1	24.63	0	100

IV. Results and Discussion

4.1. Construction of the food security index

Following the procedure described in the previous section, we employed PCA to construct food security index (PCAI) at household level. Previous study by Demeke et al. (2011) has used five variables as indicators that captured two of the four dimensions of household food security, namely, access and nutritional diversity. We extend this analysis by considering additional indicators that capture utilization dimension. Accordingly, utilization of improved toilet facility and water supply are included in addition to the variables pertaining to food availability and access components as described in section 3.2. This approach is justified because the type of toilet facility and water supply is associated with sanitation and hence the health of the household, which is a key aspect in terms of utilization of food consumed.

The PCA results reveal that the first factor (number of oxen) explained 24.6% of the total variation in the data, while the second factor (stored crops) explained another 22.3% of the total variance. Table 2 below presents the loadings and other details of the PCA.

TABLE 2. Summary of component loadings of selected indicators of food security[9]

Variable	Mean	SD	Loadings
Number of oxen owned	1.36	1.47	0.528
Number of crops cultivated	2.09	1.01	0.444
Whether crops are stored	0.82	0.38	0.319
Toilet facility	4.59	1.13	0.179
Water supply	3.82	1.82	-0.167
Land size	2.41	9.01	0.112

As can be seen in table 2, the loadings in the first component for the indicators are positive as expected. The value of the Kaiser-Meyer-Olkin (KMO) – a measure of sampling adequacy – is 0.68 indicating the presence of strong patterns of correlation among the selected variables, justifying the use of PCA for our analysis (Dunteman 1994). Based on the first principal component, the food security index was constructed.

4.2. Descriptive statistics

Sample households are classified into relative food security groups using the mean of the index as cut-off point, which is zero. Households with positive index values are categorized as relatively more food-secure, while those with negative values were categorized as less food-secure in relative terms. Accordingly, about 51.8% of the households are relatively food insecure, i.e., less food-secure. Past studies have reported even higher figures: 64% in Beyene and Muche (2010), and 67.3% in Goshu et al. (2013). Though the measures of food security used by the studies mentioned are different, they nevertheless indicate that the extent of food insecurity problem in rural Ethiopia is quite high. In Table 3, we examine the differences between the two groups based on various household characteristics.

[9] Summaries for remaining variables included (number of cows, sheep and goats) not shown here for brevity

TABLE 3. Differences in household characteristics by food security status (based on PCAI)

Characteristics	More secure	Less Secure	Significance[a]
Mean age of household head, year	49	50	-1.41
Mean household size	7.9	7.2	-5.91***
Mean per capita consumption expenditure, Birr	162.9	91.2	-7.54***
Household head is literate, %	68.6	51.9	41.43***
Household faced food shortage during last rainy season, %	90.7	95.4	12.33***
Mean rainfall index	0.55	0.39	-10.49***
Credit taken last year, %	62.5	75.2	27.01***
Household has received remittance, %	56.9	51.3	4.50**
Household used fertilizer during last five years, %	70.2	74.8	3.70*
Mean number of livestock owned, TLU	6.9	1.7	-1.77*
Mean number of oxen	1.2	0.6	-9.82***

[a] Statistical significance based on chi-squared test for categorical variables and t-test for the rest. * and *** show statistical significance at 10% and 1% levels respectively.

As can be seen in the table, there is a significant difference between more secure and less secure households with respect to most of the household characteristics considered. More specifically, relatively better food-secure households have higher mean per capita consumption expenditure, have more literate heads, report relatively less food shortage, report more favorable rainfall, and have more number of livestock than their less food-secured counterparts, all of which exhibit statistically significant difference. Moreover, more food secure households have relatively more number of oxen, which is an important input of farming in rural areas. On the other hand, we observed that there are relatively more number of less food-secure households who have taken loans and received remittances, suggesting that these two variables may be negatively related to food security status of households. The same is true of fertilizer use.

4.3. Econometric analysis

We first estimated OLS regression on the two indicators of household food security status, disregarding endogeneity problem. Next, we run an Instrumental Variable (IV) regression – our preferred model – to account for the possible

endogeneity problem. Before we move on to our preferred estimates, we report the results from the OLS estimations in Table 4 below. Model I is based on the self-reported household food security status (RFSI), while Model II is based on the multidimensional household food security index constructed through the PCA technique (PCAI).

TABLE 4. Determinants of household food security: Ordinary Least-Squares regression

	Model I (RFSI)		Model II (PCAI)	
	coef	t	Coef	t
HHDAGE	0.001***	4.450	-0.003**	-2.307
HHDSEX	-0.033***	-3.366	0.058	1.398
Household head's education				
PRIMARY	0.081***	8.774	-0.060	-1.428
SECONDARY	0.105***	7.343	-0.110**	-2.112
OTHER[a]	0.029**	2.372	-0.074	-1.622
RFI	0.065***	3.769	0.317***	5.287
LVST	0.000***	62.456	0.322***	17.305
CREDIT	-0.022***	-2.578	-0.037	-1.235
REMIT	-0.008	-1.079	-0.016	-0.546
POFFARM	0.029***	3.059	-0.036	-1.125
MIDDIR	0.041	1.528	-0.055	-0.614
HHDSIZ	-0.004**	-2.402	0.041***	4.307
SOILCONSV	0.003	0.262	-0.041	-1.230
FERT	-0.064***	-5.581	-0.013	0.387
LPCE	0.051***	11.280	0.090***	5.539
Region dummies	Yes	.	Yes	.
_cons	-0.175***	-7.688	-1.184***	-9.634
Number of observations	1,473		1,478	
Adjusted R2	0.423		0.602	

Note: *** p<0.01, ** p<0.05, * p<0.1, [a] Other refers to non-formal education like adult education, religious and illiteracy campaign education programs.

Among the variables included in the analysis, household age, level of the education of the household head, rain fall index, livestock possession, participation in off-farm activities and per capita consumption expenditure were

found to have a significant positive influence on household food security as measured by the self-reported food security index (i.e. Model I). Sex of household had a significant negative effect implying that male-headed households were less food secured than their female-headed counterparts based on the same measure. Similarly, household size carried a significant negative sign, implying that households with more family members are more food insecure as measured by self-reported food security status. Contrary to prior expectation, fertilizer use had a significant negative sign. Other variables were insignificant.

On the other hand, parameter estimates from Model II indicate that rainfall index, livestock possession, household size and per capita consumption expenditure have a significant positive effect on food security as measured by the PCA-based multidimensional food security index as expected. Household head's age had a negative and significant coefficient indicating that households with older heads are less food secure (more food insecure) than their younger counterparts. Similarly, contrary to prior expectation, households headed by secondary level of education were found to be less food secure than their illiterate counterparts. A possible explanation could be that literate households might be constrained by other factors to productively use their knowhow towards achieving food security. Similar findings have been reported for Ethiopia in Beyene and Muche (2010) and for Mozambique in Garrett and Ruel (1999).

The parameter estimate of the number of livestock possession in TLU was positive in Model II, indicating that larger livestock possession positively contribute to household food security as expected. This finding lends support to the idea that livestock possession mitigates vulnerability of households during crop failures and other calamities. Moreover, livestock possession is one of the major means of wealth accumulation in rural areas (Beyene and Muche 2010). Livestock possession is also closely related to production in the context of rural Ethiopia as oxen are the main sources of traction power for farming.

The variable land was not included as explanatory variable despite its importance as key determinant of food security. This was because land was already used in the PCA for generating the multidimensional food security index. Though not reported here, land was found to have a positive significant effect on self-reported household food security. This is in line with findings of many other previous studies (Shiferaw et al. 2013, Goshu et al. 2013, Beyene and Muche 2010). Given that land is one of the important assets and basic input in farming among rural households, it is directly associated to the ability of

households to produce crops for consumption and sale, thereby, positively contributing to food security.

Comparison of the two regressions reveals that the variables per capita consumption expenditure, livestock ownership and favorability of rainfall are significantly and positively associated with household food security irrespective of the measure used. On the other hand, the variables remittances, membership in Iddir and soil conservation practice were insignificant in both models. However, the results from the two models exhibited quite divergent results with respect to some significant variables. In particular the variables age of household head, education level of household head and household size – while significant in both models – assumed opposite signs. Though this could be due to the quite different aspects of household food security the two indicators measure, these results are nevertheless suggestive of the need for caution in the use of different indicators for the same purpose. As mentioned in the literature review part, self-reported indicators have their own limitation in that, they are more subjective and less comprehensive. To this end, the PCA-based index may be a more comprehensive indicator, as it is an indirect measure that takes into account of the various dimensions of food security.

As pointed out in section 3.2, the results from the OLS regressions in table 4 might be biased and inconsistent due to endogeneity problem. Specifically, since participation in off-farm income is not randomly distributed among households, it is likely to be endogenous[10]. Firstly, as household food security might affect labor productivity and hence access to different activities including off-farm activities, there could be could be a reverse causality problem. Secondly, participation in off-farm activities might be influenced by household unobservables, which could potentially lead to correlation with the error term. To address such an endogeneity problem, we employed instrumental variables (IV) regression technique.[11] The results are presented in Table 5. The objective was to find instruments likely to influence participation in off-farm activities without directly affecting household food security itself. Two instrumental variables: adult household members (NADULT) and whether or not

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[10] Per capita consumption expenditure was not found endogenous, though we tried specifications that considered its endogeneity.

[11] The method of estimation used here is 2SLS using the 'ivregress' command in STATA 11.

there was large increase in input price during the year (INCINPR) were selected in the case of the self-reported index (Model III). On the other hand, the percentage of 'less productive land' possessed by households was used besides the two instruments mentioned above in the case of the PCA index (Model IV).

Both the Durbin[12] and Wu Hausman[13] tests were found significant, implying rejection of the null hypothesis of exogeneity of off-farm participation. This confirms that off-farm participation was in deed endogenous, hence validating the use of IV regression. Moreover, the Sargan test[14] indicated that the joint null hypothesis of no correlation between the instruments and the error terms could not be rejected even at the 10% level of significance, implying that that the instruments were not correlated with the error terms and hence are valid. The results of these two diagnostic tests taken together indicate the OLS estimates were in deed biased and inconsistent and that the use of IV regression was in deed justified.

TABLE 5. Determinants of household food security: Instrumental Variables (IV) regression

	Model III (RFSI)		Model IV (PCAI)	
	coef	t	coef	t
POFFARM	0.159*	1.792	0.578**	2.098
HHDAGE	0.001***	3.246	-0.001	-0.609
HHDSEX	-0.025*	-1.884	0.045	0.923
REMIT	-0.018*	-1.729	-0.084**	-2.261
Household head's education				.
PRIMARY	0.084***	6.677	-0.040	-0.820
SECONDARY	0.089***	4.644	0.105*	1.710
OTHER[a]	0.033**	2.430	-0.061	-1.162
HHDSIZ	-0.005**	-2.452	0.093***	11.308
LVST	0.000***	7.762	0.001***	2.857
RFI	0.070***	3.968	0.271***	3.959
FERT	-0.052***	-4.245	0.200***	4.354
CREDIT	-0.019**	-1.973	-0.103***	-2.855

[12] Chi2 (1) = 4.047, p-value = 0.0023 for Model III and 21.577, p = 0.000 for Model IV

[13] F(1, 1454) = 4.014, p-value = 0.0045 for Model III and F(1, 1459) = 21.608, p-value = 0.000 for Model IV

[14] Chi2 (1) = 0.751, p = 0.386 for Model III and chi2 (2) = 2.792, p = 0.129 for Model IV

	Model III (RFSI)		Model IV (PCAI)	
	coef	t	coef	t
SOILCONSV	0.036*	1.718	-0.066	-1.101
LPCE	0.044***	7.263	0.214***	10.422
Regional dummy	yes		yes	
_cons	-0.167***	-5.223	-2.533***	-9.067
Number of observations	1,473		1,478	
Adjusted R2	0.259		0.385	

Note: *** p<0.01, ** p<0.05, * p<0.1, [a] Other refers to non-formal education like religious and illiteracy campaign educations. Dependent variable is PCA-based household food security index.

The results reveal that participation in off-farm activities, age of the household head, education of the household head, livestock possession, rainfall index, soil conservation practices and per capita consumption expenditure enhance household food security, while remittance, being male-headed household, household size, fertilizer use and access to credit reduce household food security as measured by self-reported index (Model III). On the other hand, based on the multidimensional measure of food security, participation in off-farm activities, education of the household head (secondary level of education in particular), household size, livestock possession, rainfall index, fertilizer use and per capita consumption expenditure were statistically significant determinants with positive impact on household food security; while remittance and credit access had a negative and statistically significant impact on household food security, after accounting for endogeneity.

Quite unexpectedly, the coefficients of access to credit and availability of remittance receipt by the household were negative and significant in both regressions indicating that households who have access to credit sources and receive remittance income were likely to be less food secure. A possible explanation for the negative impact of access to credit could be due to the fact that loans obtained are not put to productive uses, though this requires further investigation. The implication of this could be that the mere availability and expansion of credit services in rural areas doesn't translate into positive results unless recipients are equipped with the knowhow and awareness on how to utilize the financial resources productively. Similar explanation could apply to remittance as well.

Quite interestingly, participation in off-farm activity, which was insignificant in Model II turned out to assume a significant positive impact after accounting for endogeneity problem, while, it continued to be a significant in model III. In fact in Model III, the impact got even larger once endogeneity is accounted for. The positive impact of off-farm activities on food security has been well acknowledged in the theoretical as well as empirical literature. For instance, Beyene and Muche (2010), Demeke et al. (2011) for Ethiopia; Aidoo et al. (2013) for Ghana and Omotesho et al. (2007) for Nigeria have reported a positive and significant effect on household food security of off-farm and non-farm activities in rural areas. Our findings are, therefore, consistent with the theory and past empirical findings.

With the exception of the estimates for household size and fertilizer use, comparison of the two regressions indicates that the findings were qualitatively similar for the two measures of food security. Compared to the OLS estimates, there were fewer contradicting results on determinants that are significant in the IV regression models. On most of the variables, the IV estimates have turned out with increased coefficient estimates than their OLS counterparts, indicating that OLS estimates have been biased downwards and hence understating the corresponding impacts. Overall, the IV models performed fairly well with marked improvements in estimation. The results are also consistent with the preliminary findings in the descriptive analysis part.

Ⅴ. Conclusion

Food security is a multidimensional concept with a multi-faceted consequence. In this study, we examined the determinants of household food security. The results from the descriptive analysis indicate that 51% of rural households are relatively food insecure. Further descriptive analysis carried out to examine differences among more food-secured households with those of less food-secured ones revealed that the former have higher mean per capita expenditure, are headed by literates, did not face food shortage prior to the survey, received favorable amount of rainfall, and have more number of livestock than the latter, all of which exhibit statistically significant differences. In terms of credit and remittance, it was found that there were more number of less food-secure

households who have taken loans and received remittances than their more food-secured counterparts, suggesting that these two variables may be negatively related to food security status of households. However, there was no significant difference among the two groups of households in terms of the age of household head.

Econometric analysis was then carried out to empirically examine the factors that significantly determine household food security after controlling for the influence of other confounding variables. The results from OLS regression using the two different measures of household food security status indicated that the variables per capita consumption expenditure, livestock ownership, favorability of rainfall are significantly and positively associated with household food security irrespective of the measure used (self-reported or PCA index). On the remaining variables, the findings were quite mixed and in some cases conflicting. While household head's age, education and participation in off-farm activities were found to be associated significantly and positively with self-reported household food security status, sex of the household head, fertilizer use access to credit and family size were found to have a significant negative influence based on the same indicator. On the other hand, family size had a significant positive contribution to improving food security as measured by the PCA based multidimensional measure, while the age of the household head had a negative impact.

The observed differences in significance and magnitude of the estimated parameters were suggestive of the need for caution in the use of different indicators for the same purpose. In a way, the differences are expected as the two indicators are measuring different aspects of a relatively complex and multifaceted problem of household food security. However, due to the inherent limitations of self-reported indicators in terms of comprehensiveness and objectivity, we consider the PCA-based indicator to be relatively superior. In particular, the fact that the latter indicator, which is a composite index based on multiple indicators capturing the various dimensions of food security makes it appealing.

Results from our preferred IV regression estimates indicate that education of household head, adequacy of rainfall, livestock possession, participation in off-farm activities, and per capita consumption expenditure were found to be important determinants contributing positively to food security among rural households, while access to credit and remittance were negatively associated

with food security irrespective of the measure used. Moreover, age of the household head and soil conservation practices had a significant positive impact on self-reported food security status, while household size, fertilizer use and being male-headed household had a significant negative impact. On the other hand, household food security as measured by multidimensional PCA index was positively related with family size and fertilizer use.

These findings suggest that rural food security could be improved through a comprehensive and judicious combination of interventions aiming at enhancing income diversification opportunities in rural areas such as off-farm activities, promoting education, and improving livestock productivity among others. Provision of awareness creation on better utilization of such resources as credit should also be emphasized besides expansion of access to credit in rural areas.

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ANNEX I. Consumption related questions for construction of self-reported indicator

Question	Original codes	New codes
During the last rainy season, did your household suffer any shortage of food to eat?	1 = yes, 2 = no	1 = no, 0 = yes
Compared to your usual diet, did you eat foods that you ordinarily would not eat, "less preferred foods"?	1 = yes, 2 = no	1 = no, 0 = yes
Compared to your usual diet, did you cut back quantities served per meal to adult males?	1 = yes, 2 = no	1 = no, 0 = yes
Compared to your usual diet, did you cut back quantities served per meal to adult females?	1 = yes, 2 = no	1 = no, 0 = yes
Compared to your usual diet, did you cut back quantities served per meal to boys?	1 = yes, 2 = no	1 = no, 0 = yes
Compared to your usual diet, did you cut back quantities served per meal to girls?	1 = yes, 2 = no	1 = no, 0 = yes

ANNEX II. Rainfall related questions for construction of rainfall satisfaction index

Question	Original codes	New codes
Did the rain come on time?	1 = On time, 2 = too late, 3 = too early	1 = on time, 0 = others
Was there enough rain on your fields at the beginning of the rainy season?	1 = enough, 2 = too much, 3 = too little	1 = enough, 0 = others
Was there enough rain on your fields during the growing season?	1 = enough, 2 = too much, 3 = too little	1 = enough, 0 = others
Did the rains stop on time on your fields?	1 = On time, 2 = too late, 3 = too early	1 = on time, 0 = others
Did it rain near the harvest time?	1 = yes, 2 = no	1 = no, 0 = others