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IMPLICATION OF ANIMAL FEED AND WATER SCARCITY ON LABOR ALLOCATION, FOOD PRODUCTION AND PER CAPITA FOOD CONSUMPTION IN TIGRAI REGION, ETHIOPIA*

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Inadequate quantity and quality of animal water and feed resources are major factors limiting the productivity of livestock farming in Ethiopia. It is common that households spend a considerable share of their daily time to search for theses scarce resources by displacing available labor time away from more productive farming activities and leisure consumption. This paper examines the impact of time spent looking for animal water and grazing feeds on households' agricultural food production and per capita food consumption expenditure using NMBU-MU Tigrai Rural Household Survey of 518 sample farmers. To address our objectives, we employ IV 2SLS for estimating per capita food consumption expenditure and double log for estimating food production drawing on non-separable farm household model. Our results do support the hypothesis of a negative relationship between total household labour input to crop farming and resource scarcity. Likewise, the findings confirm that reducing time spent looking for water leads to an increase in food production, per capita food consumption, and food security. In addition for the median household, the total impact revealed that decreasing searching time for water, grazing and collecting time for straw leads to an increment in food security. The results from the quantile regression further proved that the effect of these scarce resources is not uniform across the food production and consumption distribution. In line with our suspicion, the income variable was found to be endogenous and instrumental variables for it were statistically significant and bear the expected signs.

Keywords: Animal Feed, Water Scarcity, Food Production, Food Consumption; Ethiopia
JEL Classification: Q01, Q16, Q57, Q13

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1. INTRODUCTION

Land degradation significantly contribute directly to poverty, by reducing the availability of important environmental goods and services to poor rural households, leading to increasing the demands on labor needed to seek for such goods in East Africa (Lal and Stewart, 2010; Kirui et al., 2014). Rural households in developing countries heavily rely on environmental products such as fuelwood, fodder, and water to meet their daily animal water and feed requirements. One possible negative consequence is the reallocation of labor time from farm, off farm and leisure activities to searching these scarce resources. The scarcity of these resources may impact agriculture and food security by influencing the allocation of factors of production, namely labor since scarce resources require more time to spend on their collection. Reduction in agricultural output stemming from less labor input is very likely to have detrimental welfare consequence (Cooke, 1998; Cooke et al., 2008; Mekonnen et al., 2015).

Rural households face considerable tradeoffs in the allocation of time between crop production and collecting these scarce resource for animal feed and energy sources (Cook et al., 2008). Households that rely on agricultural outputs as a source of food and those that spend considerable time for animal feeding, watering may have then less time left to devote to food production. This has a negative implication for future agricultural production and food security in general (Mekonnen et al., 2014; Mekonnen et al., 2015; Yilma et al., 2011). The scarcity affects household food production and consumption either by affecting livestock production directly, affecting crop and off farm income through labor reallocation or through its direct impact on time for leisure consumption and food preparation. In poor households, searching and collecting scarce resources are a significant cost of production where poor farmers lack alternatives to these resources.

In Africa, livestock production depends mainly on natural resources such as grazing land and water (Bezabih and Berhane, 2014) but feed shortage, water scarcity and diseases are frequently ranked as the most binding constraints for animal rearing (Bishu, 2014). The livestock sector is a key player in increasing water use and water depletion (Steinfeld et al., 2006). A recent survey in rural Ethiopia and South Africa found that feed and water shortage, labor scarcity and lack of capital were major constraints limiting livestock production (Descheemaeker, 2008; Tegegne, 2012). Ownership of livestock in Ethiopia has steadily declined mainly due to low availability of feed and water (Abegaz et al., 2007). Likewise, results from Hassen et al. (2010) revealed that shortage of water and feed are common in dry season as compared to wet season in Ethiopia. Thus, increasing scarcity of grazing land, water for animal and straw can be a significant burden to poor households, as grazing and water are a key factor of agricultural production in the country.

The research question that we want to answer is whether households reduce labor input in agriculture as a result of increasing time allocation to searching grazing, water for animal and collecting straw due to feed and water scarcity and test whether the time allocation to search and collect these scarce reduces crop production on the production side and household's utility on the consumption side by taking away time from leisure. In regard to this issue, we add to a relatively small list of studies examining this relationship. One early analysis is the article by Cooke (1998), which revealed that households that have higher costs of collecting environmental products devote less time to farming activities and thus reductions in agricultural output, thereby low welfare in Nepal. The studies from Damte et al. (2012) and Mekonnen et al. (2015) suggest that as a result of increasing water, grazing land and feed scarcity, many households increase the time they spend on collecting these resources. It is further suggested that increasing competition on household members' time allocation between searching and collecting scarce resource and cropping, reduces agricultural output that further diminishes households' food supply and incomes, and hence their capacity to achieve food security and human welfare (Damte et al., 2012; Mekonnen et al., 2015; Tangka et al., 2005).

The results of Mekonnen et al. (2015) in Ethiopia show that the shadow price of fuelwood has a negative and significant impact on time spent on agriculture; however, scarcity of water for humans has no effect on time spent on agriculture. The only directly and slightly related to our study are of Mekonnen et al. (2017), whose result indicated that farming productivity decreases as time spent collecting dung increases in rural Ethiopia and Bandyopadhyay et al.(2011), whose result indicates that amount of biomass negatively affected rural per capita consumption expenditure in Malawi. To the best of our knowledge, empirical studies examining the effect of grazing, water and straw on food production and consumption are, unfortunately, missing (Cooke et al., 2008; Khan, 2008; Tangka et al., 2005).

For this purpose, we draw on the agricultural farm household model (Singh et al., 1986) as a framework for the analysis by incorporating the time spent for searching these resource in to the model. Following Yotopoulos et al. (1976), an econometric estimation was presented using the NMBU-MU Tigrai Rural Household Survey dataset collected in 2015. In aggregate, the findings confirm that reducing time spent looking for water by 1% leads to an increase in food production by 0.155%, PCFE by 0.133% and food security by 0.142% while a 1% decrease in time wastage for searching grazing land increase food production, PCFE and food security by 0.279%, 0.086% and 0.102% respectively. Besides, an increment of 0.328% in food production and 0.0731% of PCFE is achieved by 1% reduction in straw collecting time, leading to an aggregate effect of 0.092% increment in food security.

The noble contribution of this paper is that it considers time allocation on animal feeding and watering, and its effect on food production and food consumption. This is important because livestock production in Ethiopia is an important economic activity that promotes and sustains people's livelihoods. It is a major source of capital investment and employment: ensure food security by providing milk and meat; improve soil fertility through manure (Herrero et al., 2013). Few studies by Cooke (1998) and Kumar and Hotchkiss (1988) in Nepal and Mekonnen et al. (2015) in Ethiopia focused on the effects of scarce environmental goods such as fuelwood, leaf fodder and grass on labor allocation farming and farm activity, there is scarce evidence on how grazing, water and straw scarcity affect household food production and food consumption expenditure. This paper, unlike the previous studies, use unique information on the entire set of food production and consumption, along with the distance to grazing, water and crop residue of each household. The use of IV estimation method also gives an extra information that treating income as exogenous and hence estimating the consumption model using OLS would give misleading result for both policy and inference. Finally, estimating the effect of scarce resources on total food security provides extra information in assessing farm management across ecological zone.

2. REVIEW OF BACK GROUNF AND EMPIRICAL STUDIES

In Ethiopia, the agricultural sector is a cornerstone of the economic and social life of the people. Livestock sector contributes about 12–16% of the total GDP, and 40% of total agricultural GDP excluding the values of draught power, transport and manure, and contributes to the livelihoods of about 60–70% of the population (Asresie et al., 2015; Halderman, 2005). Ethiopia is a home of 35 million tropical livestock unit (TLU), and on average, one TLU requires about 25 liters of water per day and the total daily water requirement for livestock is estimated at 875 million liters amounting to about 320 billion liters per year. Despite its large population size, the contribution of livestock production to agriculture is deteriorating (Ilyin, 2011). The major feed resources are crop residues and natural pasture but their availability is gradually declining as a result of crop expansion, settlement and land degradation (Gebremedhin et al., 2009). Both human and livestock suffer from the shortage of water and feed. Most of the year, animals have to walk long distances in search of water and are usually watered once in two to three days(Abegaz, 2005).

In many parts of the highlands, feed and water deficits start in December–January, when the natural pastures are at their lowest quantity and the supply of stored crop residues is beginning to diminish. There is usually a gap of four to five months of the dry season before the start of the short rains. The gap which lasts for about 150 days between October and March is, therefore, the critical period in a feeding and watering system that is largely based on natural grazing pasture (Sileshi et al., 2003). According to CSA (2010c), the total agricultural land is reported to be about 16 million ha occupied by 12.9 million households accounting for an average of 1.23 ha per household, out of the total agricultural land, 75 % is used for temporary crops while grazing land accounts for 9%. Total grazing land in the study region is estimated to be 47,431 km2 while tropical livestock unit (TLU) per km2 of grazing land was increased from 44,000 TLU in 2001/02 to 55,000 TLU in 2007/08 (Tilahun and Schmidt, 2012).

Based on Tesfaye (2010), the estimated crop residues from cultivated land in the region is found to be about 1,229,651 tons dry matter/year. The region has an estimated 878,322 ha of arable land available for crop production and contributes about 45% of the animal feed demand. Belay et al. (2013) revealed that the most important problems of livestock production perceived were feed shortage (100%) and water shortage (27%) in Ethiopia. Livestock suffers from a seasonal shortage of feed (grazing land) and water (Descheemaeker, 2008). In the high altitude zone, livestock cover less than 1 km distance to reach water compared to the low altitude zones (Hassen et al., 2010). As a result, there is a shortage of labor for livestock management (Tegegne, 2012). Nahusenay et al. (2015) found that adult males are much more responsible for feeding animals (57%) and adult female accounts for 25% in feeding animals.

Cooke (1998) considered the effect of time spent on the collection of fuelwood, leaf fodder and cut grass on labor time to agriculture and his result revealed that a reallocation of time away from farm work and leisure may occurred as environmental goods became scarce and costly in Nepal. The work of Kumar and Hotchkiss (1988) linked time allocation behavior and deforestation in Nepal. They found that time spent in farming declines with a higher degree of deforestation (fuel scarcity). Mekonnen et al. (2015) examined the effect of the scarcity of fuelwood and water on time spent in agriculture using a panel data set collected from Ethiopia. The results of the empirical analysis show that fuelwood scarcity, as reflected by the shadow price of fuelwood, has a negative and significant impact on time spent on agriculture; however, scarcity of water has no effect on time spent on agriculture. Likewise, Cooke (2008) explained the effect of forest scarcity on the livelihood of rural people in Nepal and found a negative effects on health, labor burden and agriculture. Another related study by Damte et al. (2012) in Ethiopia indicated that rural households respond positively to fuelwood shortages by increasing their labor input for fuelwood collection even if they fail to investigate whether the increase in labor comes from agriculture or other activities.

According to Bandyopadhyay et al. (2011) study in Malawi, more time spends on scarce fuelwood collection was associated with negative welfare even if the effect on their overall welfare is small. Bhattacharya and Innes (2006) highlighted that forest degradation spurs rural poverty in Sub-Saharan Africa. In addition, Mekonnen et al. (2017) explored the effect of time spent on dung, fuelwood and crop residue on agricultural productivity and the result indicated that agricultural productivity decreases with increasing time spent on collecting animal dung but increases with time spent on collecting crop residue. None of the above studies examine the effect of grazing and water for animal on time allocation, food production and food consumption (Cooke et al., 2008; Khan, 2008).

3. THEORETICAL MODEL

In a mixed crop–livestock farming systems, Ethiopia owns a significantly large livestock population (Tegegne, 2012). In the country, livestock production mainly depends on natural resources such as grazing land, water and own crop residue (Bezabih and Berhane, 2014). The contribution of livestock to food and nutritional security is significant and serves as an important source of livelihood (Swanepoel et al., 2010).

However, crop - livestock farming activity require huge inputs of labor either from own family or labor market. In rural farm households, total time endowment is divided into three main activities: farm activities, off-farm activities and leisure, where rural farms take a significant share of total time endowment and a substantial part of the production is retained at home for consumption. The scarcity of grazing and water resources for animal may even takes the largest proportion of family labor time in countries like Ethiopia, which is characterized by a critical shortage of animal feed and water, having a negative implications for agricultural production and food security (Tangka et al., 2005).

Considering the time spent on looking scarce resource, the total time endowment is further divided into four main activities: farm activities, off-farm activities, leisure and searching or collecting these resources activities. Labor allocation for these scarce resource displaces household's labor from productive activities such as agricultural production and off-farm employment, food preparation and leisure, resulting in low welfare (Cooke et al., 2008; Mekonnen et al., 2015). The scarcity of grazing and water resources adversely affects household food production and consumption either by affecting livestock production directly, affecting crop and off farm income through labor reallocation or through its direct impact on time for leisure consumption and food preparation.

The theoretical framework for modeling the effect of resource scarcity on food production and consumption is, in general, built within the framework of household utility model. Modeling households' decision of production and consumption as a recursive method enables us to understand the households' action as if it first maximizes profit (Straus, 1986). Following the work of Singh et al. (1986), it makes sense first to maximize profit and then decide consumption and leisure since income and utility are positively related. For simplicity, the well-behaved quasi-concave household utility function have the following form:

$$U = U(X, X_L; \phi), \tag{1}$$

where X reprents vector of home produced goods such as meals and purchased goods consumed, and X_L is consumption of leisure. The meal production is a function of agricultural goods Q_j, off farm income E, fuel sources such as straw or dung S as well as labor days the household spend on searching grazing land, water and crop residue T_A. The production of household goods is also influenced by the vector of household characteristics, ϕ:

$$X = X_j\left(Q_j, E, S, T_A; \phi\right). \tag{2}$$

An implicit production function which is assumed to be the quasi-convex relating outputs and inputs, increasing in outputs and decreasing in inputs (Strauss, 1986), and which allows for a separate production function for each output or joint production function is therefore formally denoted by:

$$F(Q_j, V, K, T_A) = 0, \quad (3)$$

where $F(Q_j, V, K, T_A)$ is implicit production function, Q is vector of household productions such as crops, V and K are vectors of variable inputs including labor, and fixed inputs respectively. T_A is labor time spent by the household on searching grazing land, water and crop residue as a proxy of scarcity indicator. Expressing total income of a farm household as the sum of its time endowment, value of households' production and other incomes such as transfer, minus the value of variable inputs required for production, the budget constraint stating total consumption equals total income can be presented as:

$$\sum_{j=1}^{L} P_j X_j = P_L(T + T_A) + \sum_{j=1}^{n} P_j Q_j - \sum_{i}^{m} P_i V_i - P_L L + E, \quad (4)$$

where X_j is commodities consumed, P_j is price of output, T is time endowment, P_L is wage, Q_j is household production, P_i is price of variable inputs, V_i is non-labor variable inputs, L is labor demand and E is exogenous income. While the left hand side of equation (4) $(P_j X_j)$ represents market value of commodity consumed with the last term $(P_L X_L)$ being the value of leisure, the right hand side gives full income of the household which consists of households time endowment, plus the value of households total production, minus the value of variable inputs including labor, and plus exogenous income which is generated outside the household such as transfer from relatives or friends.

Generally, the household maximizes utility subject to production function, budget constraint, and time constraint. Maximizing output by the households depends only on the choice of variable inputs, and maximizing profit is the same as maximizing full income given by the right-hand side of equation (4) subject to the production function. Then, the household maximizes utility subject to its full income upon achieving maximum income through profit maximization. The Lagrangian function of the utility maximization subject to full income and production function can be expressed as follows:

$$L = U(X_j(Q_j, E, S, T_A; \phi), X_L) + \lambda[(T + T_A) + \sum_{j=1}^{n} P_j Q_j - \sum_{i}^{m} P_i V_i - P_L L + E - \sum_{j=1}^{L} P_j X_j] + \gamma[F(Q, V, K, T_A)]. \quad (5)$$

Assuming that interior solution exists, the first order conditions based on Straus (1986) are:

$$\frac{d\mathcal{L}}{dX_j} = \frac{dU}{dX_j} - \lambda P_j = 0, \quad (5.1)$$

$$\frac{d\mathcal{L}}{dL} = \gamma \frac{dF}{dL} - \lambda P_L = 0, \quad (5.2)$$

$$\frac{d\mathcal{L}}{dV_i} = \gamma \frac{dF}{dV_i} - \lambda P_i = 0, \tag{5.3}$$

$$\frac{d\mathcal{L}}{dT_A} = \frac{dU}{dX_j}\frac{dX_j}{dT_A} + \lambda P_L + \gamma \frac{dF}{dT_A} = 0, \tag{5.4}$$

$$\frac{d\mathcal{L}}{dQ_j} = \frac{dX_j}{dQ_j} + \lambda P_j + \gamma \frac{dF}{dQ_j} = 0, \tag{5.5}$$

$$\frac{d\mathcal{L}}{d\gamma} = \mathrm{F}(Q, V, K, T_A) = 0, \tag{5.6}$$

$$\frac{d\mathcal{L}}{d\lambda} = P_L(T + T_A) + \sum_{j=1}^{n} P_j Q_j - \sum_{i}^{m} P_i V_i - P_L L + E - \sum_{j=1}^{L} P_j X_j = 0. \tag{5.7}$$

Following Straus (1986), the solution to the first order conditions of the above expressions yields standard demand function for inputs and outputs in terms of all prices, the wage rate, time for searching and collecting scarce resource, fixed land, and capital. Substituting optimal labor, and optimum output into RHS of Eq (4) produces optimum income or full income under the assumption of maximized profit. Likewise, the first order conditions of the LHS of Eq (4) gives consumption demand function in terms of prices, the wage rate, and income and household's preferences represented by household demographic characteristics. The effect of scarce resource on agricultural production $\left(\frac{dF}{dT_A}\right)$ is investigated through the production sector and its direct impact on household's utility $\left(\frac{dX_j}{dQ_j}\right)$ is explored through consumption sector. Thus, the total effect which is sum of the two effects can be explained using the budget constraint total income as

$$\frac{dM}{dT_A} = \frac{dX_j}{dy}\frac{dy}{dT_A} + \frac{dX_j}{dT_A}, \tag{6}$$

where $y = \sum_{j=1}^{n} P_j Q_j - \sum_{i}^{m} P_i V_i - P_L L$ represents the net agricultural out put or profit from agricultural production and total income of the household Y is equal to households time endowment, plus the value of households total agricultural production, minus the value of variable inputs including labor, and plus exogenous income in the RHS of Eq.4. The main question that interests us is whether scarcity of these resources adversely affects crop production and per capita food consumption expenditure. The hypothesis to be tested here is that farmers that spend more time on searching these scarce resources are likely to have less time for crop production and leisure consumption that is we test weather $\frac{\partial L}{\partial T_A} < 0$, or $\frac{dF}{dT_A} < 0$ and $\frac{\partial X_j}{\partial T_A} < 0$ using walking distance[1] to these resources sites as indicator of scarcity in the study area.

[1] See for a similar approach in the work of (Cooke, 1998; Cooke et al., 2008 and Baland et al., 2010)

In this case, utility and production decision problems can indeed be solved recursively, despite their simultaneity in time (Straus, 1986). Barnum and Squire (1979) show that household characteristics can be introduced into the model as linear functions and prove that introducing them as linear functions will not change the analysis as long as household characteristics are treated as fixed variables. Since solving the above system of equations becomes more tiresome as the number of commodities consumed and outputs produced increase, an alternative approach to estimating separated production function for each output type is aggregate production. Aggregation gives a greater chance to cancel out errors when some households report zero variable input for some products but positive outputs and will not only reduce the number of parameters to be estimated but also addresses the probable existence of jointness (Strauss, 1986).

4. DESCRIPTION OF STUDY AREA AND DATASET

Ethiopia is a federal country divided into 9 regions and 2 administrative cities. Each region is subdivided into zones and zones into woredas. Woredas, in turn, are divided into Peasant Associations (PA) or Tabias, an administrative unit consisting of a number of smallest villages and individual households. The study is conducted in Tigrai region, the northern part of Ethiopia by randomly selecting 632 sample households from 21 PAs. This study used a cross-sectional data from NMBU-MU[2], Tigrai Rural Household Survey (TRHS)[3] dataset collected in 2015. TRHS includes a panel of five rounds conducted in 1997/98, 2002/03, 2006/07, 2009/10 and 2014/2015 where the author is involved only in collecting the data for the last round. The data has been originally designed by a doctoral student from Ethiopia in Norway and PhD students who joined the same university continued to use the same design. The available panel dataset provides comprehensive household and plot level data on household characteristics, agriculture and livestock information, food consumption, rental market participation, land certificate perception as well as community level data on GPS information including rainfall, total cultivated, irrigated and grazing area, wages, and conservation activities under safety net activities.

The primary data used in this paper is adapted from the last, 2014/2015, household survey since some variables used in this estimation were only added in the last round of the wave. Table 1 presents the basic socio-economic characteristics of 518 farm households drawn from a total of 632 sample farmers. For this study, the need for information regarding livestock activity restricted us to use only 518 farmers, those who only owned cattle during the study year (82 percent of the original data, 632). The dependent variable in the production side is aggregate household agricultural production

[2] NMBU-MU refers to Norwegian University of Life Science-Mekelle University.

[3] This dataset has been used by Gehbru Hosaena (2010); Holden et al. (2009, 2011). Hagos and Holden (2011) and others.

or monetary value of all crops produced during the survey production season. In the consumption side, the dependent variable is per capita food consumption expenditure.

Table 1. Descriptive and Summary Statistics

N=518

VARIABLES	Description	Mean	SD	Min	max
	Dependent Variables				
PCFE(ETB)[e]	Monetary value of per capita food expenditure	2,490	3,722	22.22	34,962
Output (ETB)	Monetary value of crop production[a]	41,645	87,517	152.40	892,500
Income(ETN)	Monetary value of total income[b]	49,521	92,642	300	892,730
	Independent Variables				
Market distance	Distance to nearest market in minute	82.30	54.79	10	240
Water distance	Distance to animal water source in minute	74.85	65.54	10	360
Feed distance	Time to transport crop reside and grass	576.55	557.87	18	6,000
Family size	Household family size in number	5.87	2.41	1	12
Age	Household head age in years	56.83	15.20	18	99
Religion	1 if household head is orthodox and 0 Muslim	0.82	0.38	0	1
Gender	1 if household head is male	0.74	0.44	0	1
Education	1 if household head is literate	0.33	0.47	0	1
TLU	Herd size in TLU	3.92	3.20	0.01	22
Grazing distance	Time spent looking for grazing land in minute	91.12	83.44	10	1,200
Shocks(2012-2014)	Number of shocks due to theft, flood, death	0.58	0.83	0	5
Irrigation	1 if household head has access to irrigation	0.26	0.44	0	1
ashock13	1 if household face animal shock in 2013	0.04	0.20	0	1
Shock exposure	1 if household face any shock in2012-2014	0.09	0.29	0	1
Information	1 if hh had access to TV, radioand mobile	0.42	0.49	0	1
Network	1 if hh get support from relatives andfriends	0.61	0.49	0	1
Water harvest	1 if hh access water harvesting well, ponds	0.02	0.14	0	1
Location	1 if hh lives in highland(>2500masl)	0.06	0.24	0	1
Oxen	Number of oxen the household head own	1.93	1.05	1	9
Area	Total cultivated land in tsmdi[c]	4.45	3.14	0.25	22
Family labor	Total adult family labor in man day	85.52	69.33	1	778
Fertlizer	Total fertilizer used in KG	68.55	49.24	0.5	425
Manure	Total manure used in KG	775.60	1,585	1	20,000
Farm tool (ETB)	Total monetary value farm tool[d]	639.10	1,451	10	14,650

Notes: a: It includes crop, fruit and vegetable production

b: It includes income from Agriculture, off-farm, transfer and safety net

c: One Tsmdi is approximated to one-fourth hectare

d: Total monetary value of all farm implements such as plough parts ,hoe, cart, sickle, spade

e: ETB refers to Ethiopian currency in which 1USD~ 23 ETB

Crop production in Ethiopia is dominated by small-scale subsistence farm households that on average cultivate less than a hectare of land. The main agricultural products produced in the surveyed villages are Teff, barely, wheat, maize, millet, sorghum, field pea, lentil, linseed etc. An average household owns a production capital worth about 639 birr and has produced an average agricultural output of worth 41,645 birr in the year. In addition, the average livestock endowment of the sample households is 4 TLU which expected to increase food security (Kassa et al., 2002), and average total income including sales from agricultural outputs is worth 49,426 birr while the average per capita food expenditure is 2,490 birr.

Referring to figures of zonal distribution of production and per capita consumption in the appendix, the average per capita food expenditure was 3200 Birr for Southern and around 2000 for the rest zones, showing that average per capita food expenditure in Southern is much higher than the overall average result; perhaps this is due to the densely populated livestock of the zone compared to other zones. The same result in the appendix display that average values of output and income of that household living in the southern zone are 3.7 and 3.3 times larger than their respective values by an average household in the other zone.

On average the households spend 75 minutes to reach a water source for animal and 91 minutes to search for communal grazing land daily, maximum time reaching up to 6 hours for water site and 8 hours for grazing land in the data. Besides, the average time spent on transporting crop residue by the households is 576.6 minutes, ranging from a minimum value 18 to maximum value of 6000 minutes in the study area. Households that are situated far from a water and grazing land source require longer time. The graphical display in the appendix showed that farmers living in Raya Azebo district travel 110 minutes to reach grazing land followed by Easterners while those from central zone spend minimal time. With regard to distance to animal water source, North Westerners commute about 90 minutes followed by South Easterners. Households from North West spend around 800 minutes to transport crop residue while Easterners travel half of the distance of North West (400 minutes).

Farmers having a larger size of livestock holding (TLU) seem to be more worried to supply enough feed to their animals and spend more time to search for feed and water. In relation to this, Bishu (2014), whose study in Ethiopia indicated that there was a shortage of water during the dry season for livestock drinking in the study site (Abegaz, 2005; Tesfaye, 2010). It is therefore hypothesized that any labor spent on searching scarce resources is inversely related to the production and per capita consumption (Mekonnen et al., 2015). The distance to the nearest market, on average, was 82 minutes. Thus, its expected effect on consumption is negative, indicating that longer distance leads to less frequency of visit and hence less likely to get market information about selling and buying prices (Feleke et al., 2005; Shiferaw et al., 2003). As of the survey, average land holding is 1 ha, which is less than the family member size in the study area and holding large size is expected to play a significant role in influencing households' food production and food security positively (Najafi, 2003).

Fertilizer and manure are used in most studies as a proxy for technology that augments agricultural productivity and is expected to boost the overall production, contributing towards attaining household food security. Each household uses an average of 68.5 KG fertilizer and 775.6 KG manure during the harvesting period, while the number of oxen by an average household is 2. All inputs are expected to increase production and thus food consumption (Brown, 2004; Di Falco et al., 2011). In many developing countries, oxen serve as a source of traction, thereby significantly affecting households' crop production and consumption by enabling households to cultivate greater areas of land (Govereh and Jayne, 1999). Hence, a positive relationship between ox ownership and food expenditure and crop production is expected in this study. On average, each household had 85.5 man day labor used for farm production.

The magnitude of this variable is smaller than the result from the previous empirical finding of Sakketa and Gerber (2017) and Mekonnen et al. (2015), who found the average household labor time is about 114 and 117 man day in Ethiopia. I have also tried to look at the correlation between the time spent on searching water, grazing land and crop residue and time spent on crop farming. The result indicated that farm time and resource scarcity are negatively associated in the study area. This is consistent with result of Mekonnen et al. (2015), who investigated the impact of scarcity of fuelwood and water for human on labor allocated to agriculture. Given adequate land, adequate labor supply input is expected to foster production and is expected to have a positive effect (Di Falco et al., 2011; Sarris et al., 2006).

Out of the total sample, 6.4% lives in highland parts of the region. Only 27% of the households have access to irrigation and only 2% are involved in water harvesting practices such as ponds and well. Nearly 39% of the households report that they have been severely affected by eleven different level of shocks including, drought, pests, flood, theft, illness and death, loss of job and home damage in the last harvesting season, and 4.25 % of households report having been affected by animal shocks one year before the harvesting season. Both shocks are expected to affect production and consumption negatively (Abdulai and Huffman, 2014; Dercon et al., 2005). Evidence showed that male headed households have a better opportunity in terms of access to a resource such as labor, land, modern input, education, credit and extension services compared to female headed households (FAO, 2001). 74% of the households are male heads with an average age of 57 years and family size of 5.87. Since resources are very scarce, high family size may put much more pressure on consumption than it contributes to production. The expected sign of consumption is then negative because food requirements increase with the number of persons in a household.

Nearly 32% of the household heads have at least a one or more years of education. Thus, it is hypothesized that education is negatively related to consumption value. Around 82% of the households are Orthodox followers while 18% of the households are Muslim households in the study area. Out of the 518 households in the sample, 61% got assistance either from their relatives or friends and is expected to increase production and consumption (Di Falco et al., 2011). More than 40 percent of household heads site attend media via TV, radio and mobile phone about any development intervention. Hence, it is expected that households with information are more likely to produce more and be food secure. The expected effect on production and consumption is positive (Di Falco et al., 2011).

5. ECONOMETRIC MODEL SPECIFICATION

This paper draws on the AHM which provides a holistic framework to analyze the economic relations of production and consumption decision in the farm household. We choose the recursive AHM since it has an advantage of econometric estimation simplicity and fits best to the available data. Although the separation property of the recursive model enables us to separate the estimation of consumption and production sectors, it will result in inconsistent estimators whenever one of the assumptions does not hold true. This problem is even more significant for studies that deal on production side than consumption (Delforce, 1994). But, as the focus of this study mainly inclines to consumption side. The problem is less worrisome.

With regard to estimation, first, the production function was identified. Multiple crop outputs are aggregated into a single output measure using the medians of their reported village's prices within each village following Jacoby (1993) and Gutu (2016). Then, food demand equation (per capita food expenditure) was specified using the utility maximization results of the AHM. The parameters from production side were estimated using the Cobb-Douglas production function since the output is a simple function of labor and capital. However, it does not allow other variables than just the two which can significantly affect production such as fertilizer and land. For this reason, the General Cobb-Douglas (GCD) production function, developed by Diewert (1973) was adopted in order to incorporate these variables into the production function and denoted as:

$$y = m \prod_{i=1}^{n} \prod_{n=j}^{n} \left(\frac{1}{2}x_i + \frac{1}{2}x_j\right)^{\alpha_{ij}}, \tag{7}$$

where y is output, $x_1, \cdots, x_n$ are quantities of the n inputs, $m > 0$, $\alpha_{ij} = \alpha_{ji}$ and $\sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_{ij} = 1$ (This is the assumption of constant return to scale). Assuming that $\alpha_{ij} = 0$ for all $i \neq j$, and taking natural log of equation (7) produces a standard Cobb-Douglas equation with many inputs, which is to be estimated in its natural log form:

$$ln\, y = \alpha_0 + \sum_{i=1}^{n} \alpha_i \, ln\, x_i + e, \tag{8}$$

where $\alpha_0 = ln\, m$, m is the constant term in equation (8), and e is the error term.

The GCD production function is often criticized for being restrictive due to its assumptions of constant returns to scale (CRTS) and perfect competition in both input market and output market even if it handles a large number of inputs. Its assumptions make it difficult to measure technical efficiency levels and growth effectively. But, the assumption about market does not significantly affects the estimation power of Cobb-Douglas production function as long as factors are paid according to their relative shares (Murthy, 2004). In addition, Miller (2008) argued that GCD can be estimated by relaxing the CRTS assumption and then test whether the summation of the coefficients is significantly different from one using the standard econometric procedure.

In order to estimate consumption side, we are forced to approximate calorie intake by per capita food expenditure due to limited data assuming that the demand equation from the utility maximization of the recursive household model has a functional form of log-linear. Thirumarpan (2013) and Asfaw et al. (2012) used consumption expenditure to reflect the socio-economic welfare of household and is a reliable indicator of food accessibility and degree of vulnerability to food insecurity. Its capability of estimating respective elasticities as its coefficient and modeling nonlinear effects makes it applicable and preferable (Oum, 1989). Oum added that the log-linear demand function resembles the demand function obtainable from a Cobb-Douglas utility function with the drawback of invariant estimated elasticities across all data points. Like in the production side, aggregate demand equation per household is estimated for per capita food consumption expenditure rather than estimating single demand equations for each product consumed or for each individual member of the household.

$$lnM = \beta_0 + \delta Y + \sum_{i=1}^{n} \beta_n \ln x_i + \nu, \tag{9}$$

where M is households per capita food consumption expenditure; x_i for $i = 1, \cdots, n$, includes consumption side variables and household characteristics; ν is an error term which is assumed to be uncorrelated with the production function error term e. δ and β are parameter coefficients of income and the vectors of an exogenous variables, x_i. The effect on agricultural production is investigated through the production sector and its direct impact on household's utility is explored through consumption sector.

Since farm and off-farm income is not randomly distributed among rural households, this variable is likely to be endogenous, which could be caused by omitted variables, measurement error, simultaneity or household unobservable (Hidalgo et al., 2010), First, a reverse causality problem might exist, because per capita food expenditure at the household level might also influence labor productivity and thus farm productivity. Second, farm and off-farm income might be influenced by household unobservable, which can lead to correlation with the error term. In the presence of endogeneity, the use of the OLS estimator biases the effect of income. In order to avoid an endogeneity bias, we adopted Two-Stage Least Squares (2SLS) approach, using household shock experience and a number of plots as instruments (Angrist and Evans, 1998) which are the most common instrumental variable estimator (Wooldridge, 2009). This is similar to approaches that have been used by Sarris et al. (2006) and Abdulai and Huffman (2014) in different contexts. With this procedure, the structural equation is specified as

$$lnM = \delta + \delta^{iv}\hat{Y} + \sum_{i=1}^{n} \beta_n \, ln \, x_i + \varepsilon, \tag{10}$$

where lnM is per capita food expenditure, $\hat{Y}$ is predicted values of the endogenous income variables and ε is an error term, that is uncorrelated with Y, δ and β are parameter coefficient of income and the vectors of an exogenous variables, x_i. To obtain income (Y), first stage regression equations is estimated by OLS based on the following specifications;

$$ln \, Y = \alpha + Z'\gamma + \sum_{i=1}^{n} \beta_n \, ln \, x_i + \varepsilon, \tag{11}$$

where $ln \, Y$ is total farm and off farm income of the household, γ is parameter coefficients of the vector of the instrumental variables, Z which are assumed to correlate with income Y but not with the error term, ε in the structural equation (10). The estimated per capita food consumption expenditure of the household, in (10) is now assumed to be unbiased.

6. ECONOMIC RESULTS

6.1. Estimation of Household Labour Allocation to Crop Farming

What is the consequences of increasing grazing, water and straw for agricultural labour input? We answer this question by examining the link between resource scarcity and labour input to crop farming in rural areas of Ethiopia using similar estimation methods of Cooke (1998) using cross section data in Nepal. In this paper, the variables of greatest interest are animal water and feed scarcity measured by the time taken to collect them. A priori, animal water and feed scarcity should reduce labour time on the crop farm because they take away time from crop farms and leisure as people search for these resources. The estimate of the effect of resource scarcity on time spent in crop farming is presented in Table 6.

Our results do support the hypothesis of a negative relationship between total household labour allocation to crop farming and resource scarcity at the household level. With respect to the variables of interest, higher searching times of water, grazing and collecting straw were shown to significantly reduce labor time to crop farming. We found that that a 1% increase in searching times of water, grazing and collecting straw results in a 0.0598%, 0.0929% and 0.0992% respectively decrease in time spent on crop farm. This result finds favor among a number of researchers (Cooke, 1998; Cooke, 2008; Bandyopadhyay et al., 2011; Mekonnen et al., 2015). We found significant effects of other covariates as well. Land area in crops has a significant positive effect on total household labour input to farming. Real off farm wage has a significant positive effect on household farm labor input.

As expected, we also found that large family households spend more time on crop farming. The households living in lowland areas spend more farm labour input to farming than their counter part. Wealthier households who have more livestock spend more time for farming. Higher on-farm income is associated with household's more time input to crop farming. Hiring labor from the local market decrease labor family input to farming and higher altitude motivate farmers to allocate more labor input to crop farming. These findings correspond to the results of previous studies by Cooke (1998), Okwi and Muhumuza (2010), Bandyopadhyay et al. 2011) and Mekonnen et al.(2015).

6.2. Estimation of Monetary Value of Aggregate Production

In order to estimate production sector of the farm households, we used ordinary least square (OLS) on the log-transformed form of the GCD production function specified in section 5. The dependent variable is aggregate household agricultural production, which is the monetary sum of all crops produced during the survey harvesting season. The estimates of the production function and the effect of water, grazing the land and feed scarcity on agricultural production are presented in Table 2 under 3 columns respectively. In general, the estimation shows that all explanatory variables exhibit significant and theoretically expected signs. Variables of interest in this paper are time spent on looking water and feed resources included so as to capture the effect of feed and water scarcity on agricultural production. The first column presents the estimation of the food production function with water scarcity taken into account as do the second and the third columns, putting grazing land and feed transport into consideration. The result is in favor of our hypothesis.

As expected Column (1) of Table 2 indicated that time spent on animal water source is found to be negative significant, suggesting that a one percent increase in time spent looking for water decreases agricultural production by 0.155 percent, and time spent on searching grazing land have stronger effect than this variable as shown in Column (2) i.e., a one percent increase in time spent searching for grazing decreases agricultural output by 0.279 percent. Another feed scarcity related variable is time spent for transporting crop-residue from threshing center to homestead. Increasing distance significantly resulted in a negative sign as expected, implying that farmers that spend one minute more for collecting crop residue produce about 0.328 percent less output (Column 3). The output effect obtained here support the claim that time spent for searching scarce resources displace labor time from production activity and hence reduce crop production in line with the findings of (Damte et al., 2012; Mekonnen et al., 2015; Tangka and Jabbar, 2005), who generally concluded that collection of scarce resources such as water, firewood, and grass negatively affect production activity by reducing labor time allocated to crop farming.

The estimated coefficient for land (0.278, 0.304 and 0.201) shows that increasing land size by one percent increases agricultural production, on average, by almost 0.3 percent, implying that land is a vital input of agriculture. The result is similar to what it was found by Nisrane et al. (2011), whose study revealed that cultivated land had a positive effect on agricultural production in Ethiopia. Moreover, Foster and Rosenzweig (2010) showed that land size had a positive impact on net revenue in India while the empirical results from Sarris et al. (2006) in Tanzania also appear to support the above result.

Table 2. OLS Estimation of log Monetary Value of Aggregate Agricultural Production

VARIABLES	(OLS) Ln(output)	(OLS) Ln(output)	(OLS) Ln(output)
Ln(area)	0.278***	0.304***	0.201***
	(0.0595)	(0.0579)	(0.0523)
Ln(manure)	0.0854**	0.0857**	0.0501
	(0.0369)	(0.0363)	(0.0324)
Ln(oxen)	0.228**	0.248***	0.186**
	(0.0973)	(0.0951)	(0.0851)
Ln(fertilizer)	0.145**	0.174***	0.150***
	(0.0665)	(0.0652)	(0.0581)
Ln(family labor)	0.353***	0.306***	0.197***
	(0.0650)	(0.0641)	(0.0581)
Hired labor(1/0)	0.472***	0.481***	0.307***
	(0.0928)	(0.0907)	(0.0822)
Location(1/0)	-0.493***	-0.453***	-0.544***
	(0.174)	(0.169)	(0.150)
Ln(farm tool)	0.0566**	0.0561**	0.0162
	(0.0254)	(0.0249)	(0.0224)
Ln(mktdistance)	0.0745	0.0808	-0.000798
	(0.0551)	(0.0538)	(0.0485)
Info(1/0)	0.0959	0.0549	0.0264
	(0.0851)	(0.0836)	(0.0746)
Well(1/0)	-0.260	-0.218	-0.0514
	(0.299)	(0.292)	(0.261)
Ln(shocks)	-2.160***	-2.091***	-1.932***
	(0.321)	(0.311)	(0.278)
Irrigation(1/0)	0.0627	0.0931	-0.0440
	(0.0980)	(0.0955)	(0.0860)
Education(1/0)	0.284***	0.246***	0.243***
	(0.0904)	(0.0887)	(0.0790)
Ln(water distance)	-0.155***		
	(0.0475)		
Ln(grazing distance)		-0.279***	
		(0.0471)	
Ln(feed distance)			-0.328***
			(0.0254)
Constant	6.873***	7.383***	9.496***
	(0.500)	(0.492)	(0.476)
Observations	509	508	509
R-squared	0.394	0.423	0.538

Note: P-values are for slopes; ***P<0.01; **P<0.05 and *P<0.10 = Significant at 1%, 5% and 10% probability level respectively.

As expected fertilizer and manure use are found to be significant and positive variables incongruent to the studies conducted by (Demeke et al., 2011; Kidane et al, 2005; Nisrane et al., 2011; Di Falco et al., 2011) in Ethiopia. In Ethiopia ox is the main capital input used for ploughing and threshing and can be considered as an equivalent substitute of the uses of the tractor. In this paper number of oxen is found to be significant, leading to a 0.23 percent increase in the agricultural output. A similar result is found in the study of Mekonnen et al. (2015) who found a positive effect of ox input food crop productivity in Ethiopia.

In line with the predictions of economic theory, inputs such as farm capital and labors are significantly associated with an increase in the quantity of production value. A one percent increase in man day labor causes to increase production by about 0.353 percent, a finding that is consistent with this notion is of Di Falco et al. (2011) and Abdulai and Huffman (2014). But the coefficient on seed input contrasts with the findings by Di Falco et al. (2011) in Ethiopia and Bulte et al. (2014) in Tanzania, who both found a positive significant on harvest. Farmers hiring one percent extra labor seems to increase their production value by 0.481 percent, confronting with the result of Sarris et al. (2006) whose result revealed a negative relation. Another capital input included in the analysis is production capital which is the monetary value of farm tools. It is found to be statistically significant. A one percent increase in production capital has the ability to increase agricultural output by 0.056 percent. This finding is consistent with the earlier study by Sarris et al. (2006).

Not surprisingly, we found that shock experience appears to be negatively related to the household's production. An increase in shock has a quite large detrimental effect of food production (-2.16%) which is consistent with a previous study (Abdulai and Huffman, 2014) who confirmed a negative effect of drought or illness shock on production. The variable representing education of the farmer is positive and significantly different from zero, suggesting that more educated farmers are more likely to produce more in favor of Abdulai and Huffman's (2014) result.

6.3. Per Capita Food Expenditure Estimation

The objective of utility maximization by the household is analyzed using the demand functions derived from maximized utility subject to budget constraint and technology constraint of farm production and its estimated result is presented in Table 3 using naïve OLS and IV method, where total income is instrumented by shock occurrence and a number of plots of the household head. Shock caused by crop theft and death of a household member is expected to affect income and output negatively, thereby reducing food expenditure (Abdulai and Huffman, 2014; Dercon et al., 2005). The exposure of previous year's shock (2012-2014) have a direct effect on the household income and indirect effect on the consumption side through its effect on income. The source of rural farm income is mainly from crop or animal farming which is operated by family labore. Thus, farm income is expected to decrease with increasing any shock on crop or animal farming caused by a theft or illness of the household. Then, its effect on consumption reaches through its effect on farm income.

Table 3. IV Estimation of log Per Capita Food Expenditure

VARIABLS	(OLS)	(IV)	(OLS)	(IV)	(OLS)	(IV)
	lnPCFE	lnPCFE	lnPCFE	lnPCFE	lnPCFE	lnPCFE
Ln(output)	0.0940***	0.0562***	0.0909***	0.0563***	0.0986***	0.0623***
	(0.0121)	(0.0171)	(0.0125)	(0.0169)	(0.0122)	(0.0170)
Ln(livestock)	0.0336***	0.0277**	0.0334**	0.0289**	0.0352***	0.0295**
	(0.0129)	(0.0137)	(0.0131)	(0.0137)	(0.0130)	(0.0137)
Ln(Family size)	-0.385***	-0.357***	-0.397***	-0.369***	-0.388***	-0.362***
	(0.0529)	(0.0562)	(0.0535)	(0.0566)	(0.0534)	(0.0564)
Gender(1/0)	-0.119**	-0.140**	-0.0993*	-0.117*	-0.115*	-0.136**
	(0.0588)	(0.0621)	(0.0590)	(0.0620)	(0.0593)	(0.0624)
Info(1/0)	0.0591	0.0370	0.0454	0.0247	0.0487	0.0260
	(0.0539)	(0.0570)	(0.0545)	(0.0573)	(0.0544)	(0.0573)
Location(1/0)	-0.0411	-0.0543	-0.114	-0.133	-0.149	-0.173
	(0.140)	(0.147)	(0.140)	(0.146)	(0.141)	(0.147)
Ln(mktdistance)	0.00283	0.0196	0.00252	0.0200	0.00144	0.0174
	(0.0337)	(0.0358)	(0.0340)	(0.0360)	(0.0340)	(0.0359)
ashock13(1/0)	-0.489**	-0.379*	-0.550***	-0.442**	-0.540***	-0.440**
	(0.191)	(0.203)	(0.192)	(0.204)	(0.193)	(0.204)
Ln(shocks)	0.212	0.374*	0.307	0.465**	0.267	0.428**
	(0.198)	(0.214)	(0.199)	(0.214)	(0.200)	(0.215)
Religion(1/0)	0.121*	0.152**	0.101	0.130*	0.115	0.145*
	(0.0700)	(0.0741)	(0.0705)	(0.0743)	(0.0706)	(0.0744)
Network(1/0)	-0.0833	-0.191***	-0.0761	-0.178***	-0.0729	-0.177***
	(0.0554)	(0.0666)	(0.0559)	(0.0665)	(0.0558)	(0.0667)
Age(years(	-0.000477	-0.000808	-0.000535	-0.000848	-0.000554	-0.000886
	(0.00174)	(0.00183)	(0.00175)	(0.00184)	(0.00175)	(0.00184)
Ln(income)	0.0440***	0.0593***	0.0433***	0.0581***	0.0439***	0.0587***
	(0.00187)	(0.00498)	(0.00189)	(0.00499)	(0.00189)	(0.00499)
Ln(wat distance)	-0.122***	-0.133***				
	(0.0309)	(0.0327)				
Ln(graz distance)			-0.100***	-0.0860**		
			(0.0336)	(0.0354)		
Ln(feed distance)					-0.0642***	-0.0731***
					(0.0240)	(0.0253)
Constant	6.018***	5.959***	6.046***	5.862***	5.917***	5.872***
	(0.291)	(0.306)	(0.318)	(0.337)	(0.305)	(0.319)
R-squared	0.710	0.670	0.705	0.668	0.705	0.667
First stage Shock		-20.124***		-20.076***		-20.123***
		(2.184)		(2.185)		(2.183)
Landsize		-0.476		-0.4976		-0.487
		(0.308)		(0.306)		(0.306)
Observation	496	496	496	496	496	496

Note: P-values are for slopes; ***P<0.01; **P<0.05and *P<0.10 = Significant at 1%, 5% and 10% probability level respectively.

Similarly, the land holding size of the household head can be considered as a substitute for sources of wealth in rural areas and is expected to influence total income positively (Sarris et al. (2006)). In the same fashion, cultivation of more plots in rural areas of the country is a good indicator of wealth and directly affects the farm income he/she harvests. Increasing number of plots is expected to increase farm income directly but consumption indirectly thought its effect on income. Table 3 compares results from naive OLS and 2SLS estimates for all variables of interest, namely water, grazing land and crop residue distance.The potential candidate instruments used in the estimation were tested to check if they could pass the necessary requirements for an instrument to be as an instrument.

Table 4 reports test results for all scenarios presented in Table 3. The Wu-Hausman F-test with a p-value less than 0.05 rejected the null hypothesis that OLS estimation is consistent or income is exogenous and motivates the use of instruments. Besides, the Sargan chi2 –test fails to reject the null hypothesis that all instruments are uncorrelated with the error term in the structural model or all instruments are valid. This enables us to conclude that the instruments pass the over-identification requirement for all estimates. Finally, instruments were also tested if they could pass the second most important criteria that the instrument should be correlated or relevant to the endogenous variable income. To ensure the relevance of instruments, the Stock and Yogo (2005) F-test was employed and F-values for three models are about 42 which is extremely higher than the rule of thumb of at least greater than 10(Table 4).

Table 4. Instrumental Variables Tests

ESTIMATES	ENDOGENEITY	VALIDITY	RELEVANCE
		CRITERIA	
	Wu-Hausman (P-value)	Sargan(P-value)	Stock and Yogo, F-value
WATER SCARCITY MODEL	(0.0008)	(0.5562)	42.28
FEED SCARCITY MODEL	(0.0011)	(0.5236)	42.27
FEED COLLECTING MODEL	(0.0013)	(0.5417)	42.56

The first stage regression results of two-stage least square (2SLS) which are not reported here for the purpose of saving space show that both instruments have a negative relationship with income but only shock variable is found to be statistically significant in all scenarios (Table 3). Total income of the household which have positive coefficient significantly affected per capita food expenditure. Column (1, 3, and 5) of Table 3 shows the ordinary estimates of the income effect by estimating the consumption model using OLS estimator. The coefficient of income suggests that a 1% increase in income increases per capita food expenditure by around 0.044 %, whereas the 2SLS result display that a one percent increase in total income leads to 0.59 percent increase in per capita food expenditure in all estimates. It turns out that this naive ordinary estimate grossly underestimates the income effect than effects from the IV-2SLS estimate. This implies that estimating the model using OLS is not the correct approach and ignoring these differences would bias the income effect. The findings of Njimanted et al. (2006) in rural Cameroon, and Demeke et al. (2011) in rural Ethiopia also confirm that household income is one of the key determinants of food expenditure and food security in rural areas.

As hypothesized, time spent for searching animal feed and animal water directly affected per capita food expenditure. Time spent looking for water and grazing land has resulted in a negative sign as expected and they are found to be an important factors of per capita food expenditure. A one percent increase in minutes traveled to reach water source and grazing land leads to a 0.133 and 0.086 percent decrease in per capita food expenditure respectively (Table 3) referring to the IV estimates. In addition, a one percent increase in minutes traveled to collect crop residue from threshing fields to homestead leads to 0.073 percent decrease in per capita food expenditure. This supports the argument by Tangka and Jabbar (2005),whose study conclude that feed scarcity reduces livestock, crop, and non-farm productivity as well as access to food, resulting in less food security and low welfare by traveling long distance with an animal in search of feed and water in less developing countries.

We also report that agricultural output significantly affects households' food consumption. It is also the case that the OLS estimates significantly overestimate the size of the coefficient of the output variable. The elasticity of food consumption per capita with respect to the gross crop value is equal to 0.094 % for OLS and 0.056% for IV in the water scarcity estimates. Similar effects are found in the feed and transport estimates presented in Table 3 of Column 3 to 6.The larger elasticity originates from the fact that a larger share of income is derived from agriculture in rural areas. This is in line with Sarris et al. (2006) who found that that agricultural output significantly affects per capita consumption expenditure in Ethiopia.

The variable livestock ownership is positively correlated with welfare, suggesting that farmers with high herd size have a higher food consumption expenditure. Studies by Sarris et al. (2006) in Tanzania and Dercon et al. (2005) had similar findings in Ethiopia. Another significant variable is household size, leading to 0.357 percent decrease in per capita food expenditure for one percent increase in the number of family size, in line with the findings of Dercon et al. (2005) in Ethiopia and Sarris et al. (2006) in Tanzania but contradicts with the studies of Alene and Manyong (2006) in Nigeria. The dummy variable for the gender of household head is also found to be significant and has a negative sign against the findings of Dercon et al. (2005) in Ethiopia.

Experiencing an animal shock at least once in the previous year lowers per capita consumption by 0.379%, 0.442% and 0.440% for the three cases taking the estimated value of IV in Table 3. Dercon (2004) found that a livestock shock negatively affects per capita consumption expenditure in rural Ethiopia. The coefficient of household's religion is 0.152 % and is statistically significant, implying that orthodox households have 0.152 percent per capita consumption higher than Muslim group which is opposite to the result of Oldiges (2012) and Sinha (2005), who together found a positive relation between Muslim follower and per capita cereal consumption in India. Although the location is insignificant, per capita food consumption for farmers living in the highland is lower than for those living in the lowland area. This is in favor of results from Asmamaw et al. (2015) whose study in Ethiopia indicated that people from highlands are more chronically food insecure, and consume less than 50% of total calorie requirements than in the lowlands.

The negative and significant sign of network shows that individuals who got social supports have 0.191 % less per capita food expenditure, implying that supports from relatives or friends are not adequate enough to cover food expenditure for the recipient households (Sarris et al., 2006). Other insignificant variables are proximity to market (positive), the age of the household head (negative) in line with the study of Matchaya and Chilonda (2012).

6.4. Total Effect of Feed and Water Scarcity on Food Security

This analysis finalizes its discussion by exploring the total effect of animal water and feed scarcity on food security. In rural Ethiopia, households spend a large portion of their daily productive time searching for water and grazing land for the animal. Based on the descriptive statistics in Table 1, the median household in this sample spends up to one 75 minutes to travel to a water source, 91 minutes to search for grazing land and 577 minutes to transport crop residue yearly. The labor hours allocated for these resources then reduces the total time available for crop farming activities in addition to the reduction in the households' leisure consumption. Its effect on agricultural production is investigated via the production sector and its direct impact on household's utility is analyzed through consumption sector. The aggregate of the two shows the total welfare effect on the household's livelihood.

Then, the total effect is simply calculated by taking the slope coefficient of income in the consumption regression multiplied by the coefficient of time allocation in the production estimation, plus the coefficient of time allocation in the consumption regression. Based on Table 5, the total impact of time spent searching for water, feed and transporting feed on per capita food consumption expenditure is -0.142, -0.102 and -0.092 respectively. This implies that for a one percent increase in minutes traveled to a water and feed source, per capita food consumption decrease by 0.142%, 0.102%, and 0.092% respectively. If the median household in this data spends about 60 minutes to look for water and feed source and have per capita food consumption expenditure of 2490 birr. For the median household, decreasing traveling minutes to a water and feed source by 0.6 minutes will increase per capita food consumption expenditure by 354 birr, 254 birr and 229 birr. The results of this analysis based on per capita food expenditure can be good indicators of a necessary condition for food security (FAO, 1996).

Table 5. Aggregate Effect of Resource Scarcity on Output, Food Expenditure, and Food Security

Estimates	Effect On Output (Y)	Effect On PCFE	Total Effect
	$\frac{dY}{dT}$	$\frac{dPCFE}{dT}$	$\frac{dPCFE}{dY}\frac{dY}{dT}+\frac{dPCFE}{dT}$
Effect Of Water Scarcity($\boldsymbol{T_w}$)	-0.155	-0.133	-0.142
Effect Of Feed Scarcity ($\boldsymbol{T_f}$)	-0.279	-0.086	-0.102
Effect Of Feed Collection ($\boldsymbol{T_t}$)	-0. 328	-.0731	-0.092

Table 6. Estimation of Household Labour Allocation to Crop Farming

VARIABLES	(OLS) Ln(Family Labore)
Real wage(Wage/milk price) in ETB	0.0112*** (0.0035)
Ln(Wat distance)	-0.0598* (0.0360)
Ln(Graz distance)	-0.0929** (0.0402)
Ln(Feed distances)	-0.0992*** (0.0287)
Ln (Family size)	0.3570*** (0.0659)
Ln (Mark distance)	0.0267 (0.0422)
Ln(land area)	0.3420*** (0.0462)
Ln(oxen number)	0.1420* (0.0732)
Ln(livestock in TLU)	0.0312** (0.0142)
Gender of household head(Male=1)	0.0677 (0.0722)
Age of Household head (Years)	0.0012 (0.0022)
Household head literacy(Literate=1)	0.0512 (0.0692)
Hired Labore(1/0)	-0.1510** (0.0698)
Household home altitude (GPS)	0.0005*** (0.0001)
Ln(farm output value)	0.0601*** (0.0149)
Location(1/0)	-0.4570*** (0.1640)
Constant	2.2990*** (0.5080)
Observations	502
R-squared	0.3400

Note: P-values are for slopes; ***P<0.01; **P<0.05and *P<0.10 = Significant at 1%, 5% and 10% probability level respectively

7. CONCLUSION AND SUGGESTION

In the least developed countries, it is common that households spend a large share of their daily hours available for production activities per day on searching the animal water and feed as well as collecting crop residue. This directly impacts farm production and utility consumption by displacing labor from production and leisure activity. This study analyzes the economic implication of animal water and feed scarcity on agricultural production and consumption activities of rural farm households in North Ethiopia. For the analysis, the agricultural farm household model has been adopted and time spent for searching the animal water and feed resources, capturing water and feed scarcity has been integrated into the model. The econometric model derived from the recursive AHM and an empirical application has been applied using a sample size of 518 extracted from Tigrai Rural Household Survey conducted during 2015.

The results in this paper provide an interesting picture of smallholders in Ethiopia and hint at several areas that could be important for improving food security. Our results do support the hypothesis of a negative relationship between total household labour allocation to crop farming and resource scarcity at the household level. As expected, it appears that time spent looking for water and feed has a significant and negative effect on both production and consumption sectors. In aggregate, reducing time spent looking for water by one percent leads to an increase in food production by 0.155 percent, per capita food consumption by 0.133 percent and food security by 0.142 percent. Similarly, a one percent decrease in time wastage for searching grazing land increase food production, per capita food consumption and aggregate food security by 0.279 percent, 0.086 percent, and 0.102 percent respectively, and an increment of 0.328 percent in food production and 0.0731 percent in per capita food consumption is achieved by one percent reduction in feed transporting time, leading to an aggregate effect of 0.092 increment in food security. Thus, the total effect of water and scarcity on per capita food consumption expenditure shows that reducing time spent on this resource can bring a significant contribution to food security, and as a result improves the welfare of the society.

Another major conclusion is that the use of inputs such as land, family and hired labor, fertilizer, manure, oxen and farm physical tool appears to be positively related to the household’s agricultural production, and are significant determinants of farm productivity as predicted by the economic theory. However, aggregate production seems to be impeded by the occurrence of shock and agroecology, indicating that farmers experiencing shock and living in the highland seem to suffer from less production. On the consumption side variables such as agricultural output, income, livestock ownership and religion affiliation are found to be major positive contributing factors but shock occurrence, family size, male headship and social network are found to reduce per capita food consumption. Results confirm the theoretical prediction that having a higher number of family member and shock exposure affect per capita food consumption expenditure adversely.

The empirical results presented in this paper lead to the following policy conclusions. Two areas of policy intervention can be emerged as relevant. The first involves policies and institutions that facilitate easier access to animal water tap by advocating on emergency relief grounds. The second area of policy intervention involves the introduction of more efficient animal feed management strategy that can be implemented by helping households adopt new technologies that improve cattle production and reduce land degradation. Third, given the evidence in this paper, it appears that policies that seek to promote information and reducing shock exposure would be useful in enhancing household level food security.

In general, this study can be helpful for policy makers working to alleviate animal water and feed problems in Ethiopia to justify their actions with an empirical result. Besides, this study’s result can give a good lesson for policy analysts that labor allocation for reaching water and feed source imposes a negative impact on crop farm output and food consumption and hence on food security. Helping farmers to have a nearby water and feed source do not only alleviate labor constraints but also saves time that could be used for other productive farming activities. Such strategy enables farmers to keep their animals at the homestead in the form of stall feeding and tethering around the backyard.

APPENDIX

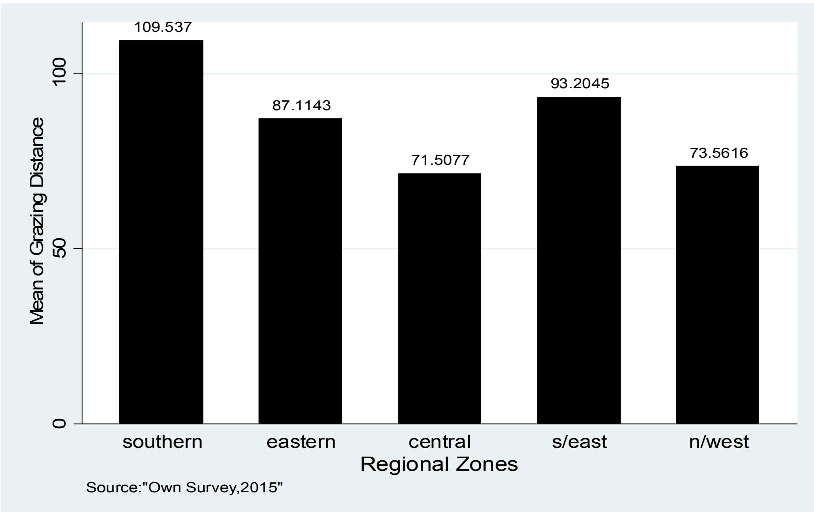

Fig A1. Zonal Distance to Grazing Land

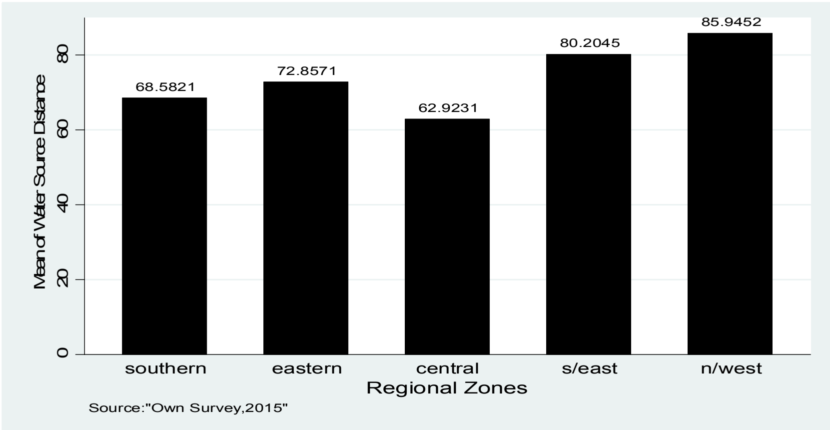

Fig A2. Zonal Distance to Water Source

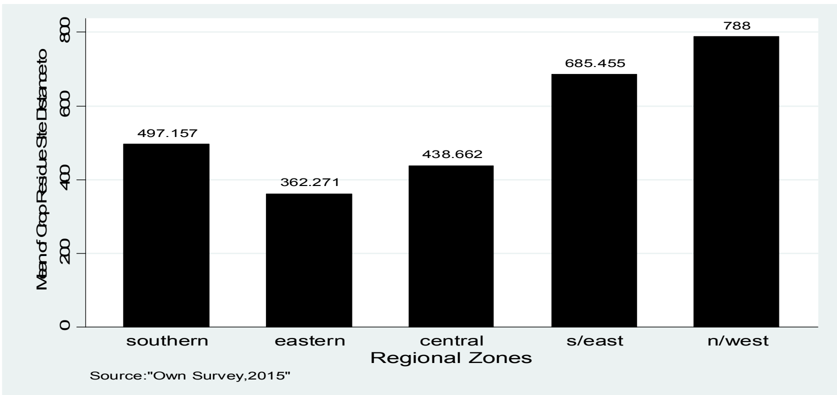

Fig A3. Zonal Distance to Crop Residue Site

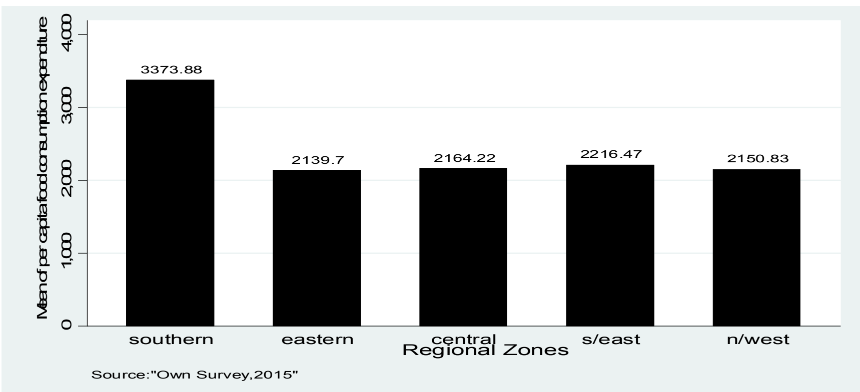

Fig A4. Zonal Per Capita Food Consumption Expenditure

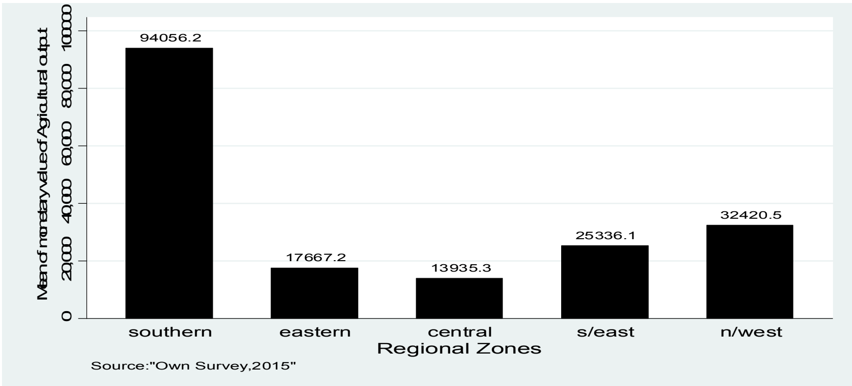

Fig A5. Zonal Monetary Value of Farming Output

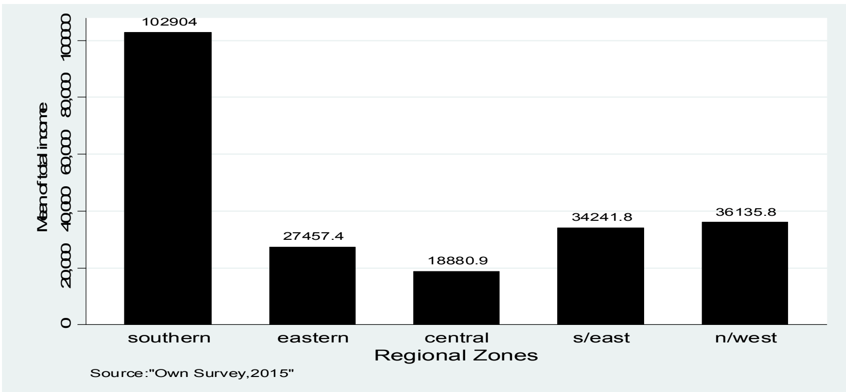

Fig A6. Zonal Total Income

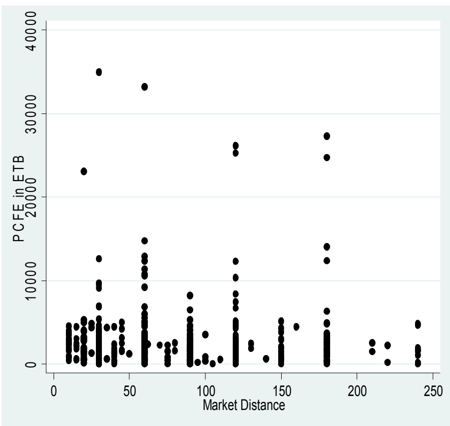

Fig A7. PCFE Vs Market Distance

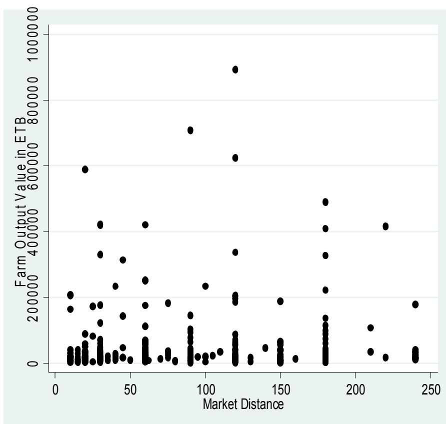

Fig A8. Output Vs Market Distance

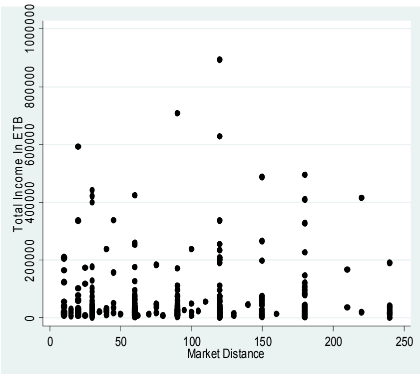

Fig A9. Total Income Vs Market Distance

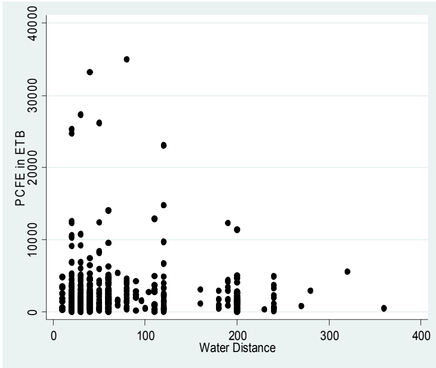

Fig A10. PCFE Vs Water Distance

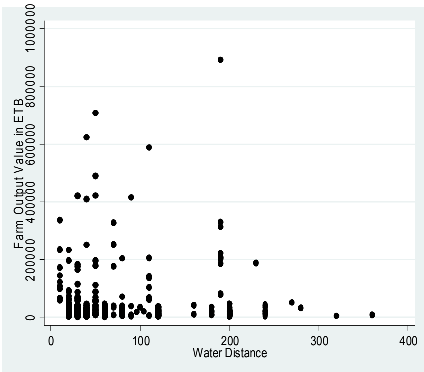

Fig A11. Output Vs Water Distance

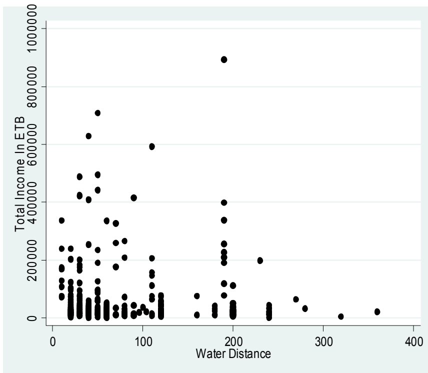

Fig A12. Income Vs Water Distance

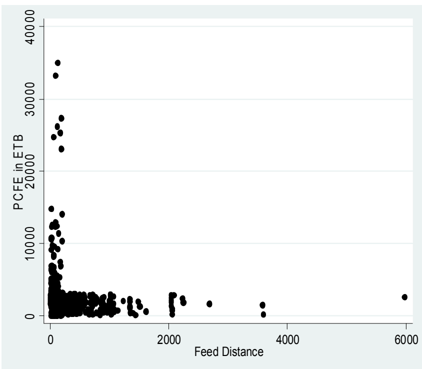

Fig A13. PCFE Vs Feed Distance

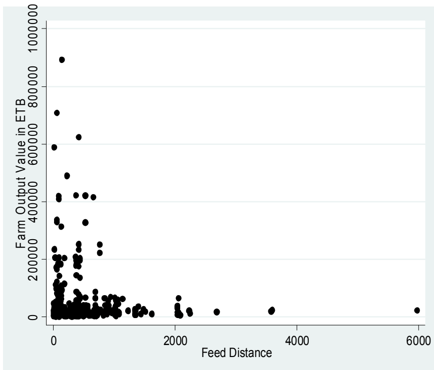

Fig A14. Output Vs Feed Distance

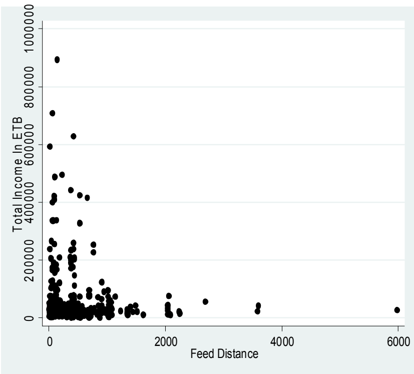

Fig A15. Income Vs Feed Distance

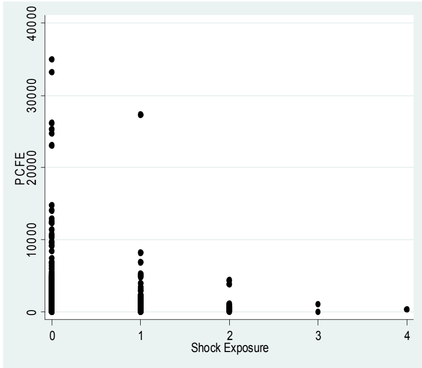

Fig A16. PCFE Vs Shock Exposure

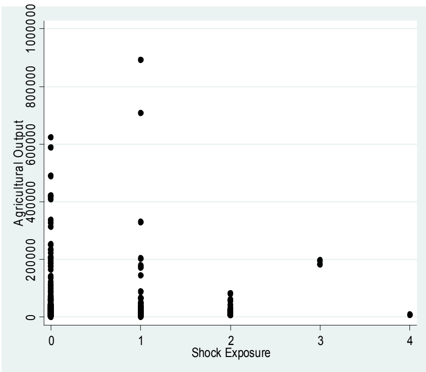

Fig A17. Output Vs Shock Exposure

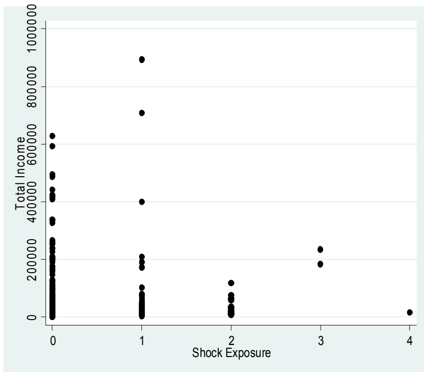

Fig A18. Income Vs Shock Exposure

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