Attaining Secure Rural Livelihood: The Role of Household Strategies and Public Interventions

Hvordan oppnå trygge rurale levekår: Husholdsstrategier og offentlige tiltak

Philosophiae Doctor (PhD) Thesis

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Dedication

To my father Legesse Debela who sacrificed much to educate his children

and

To my mother Aregash Bati

Acknowledgement

Let me take a moment of praise to the Almighty GOD for solving all the obstacles I faced, sending miracles and bringing me up to this point in my life. Glory to His Mother Holy Virgin Mary who has been a shed all the way here. I thank the Holy Angels, Holy Fathers and Holy Martyrs for helping me with my problems.

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Bethelhem Legesse Debela

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Introduction

Attaining Secure Rural Livelihoods: The Role of Household Strategies and Public Interventions

Bethelhem Legesse Debela

1. Introduction

Rural households in developing countries are exposed to a range of idiosyncratic and covariate shocks that threaten their livelihoods. [1] In order to deal with these calamities, households devise mechanisms that cushion the consequences of shocks. Such strategies can either be ex-ante risk mitigating strategies or ex-post risk-coping strategies (Fafchamps, 2003). Ex-post coping strategies include selling productive assets, dissaving, temporarily reducing consumption or searching for off-farm employment or other sources of livelihood (Paxson, 1992; Dercon, 2000; Fafchamps, 2003; Dercon, 2005). With rural households being subject to credit market constraint, they use their assets-for example livestock- as a buffer stock when faced with shocks. This is, however, less damaging when the price of the asset is expected to be stable subsequent to the shock period (Kazianga and Udry, 2006). In the event that households encounter repeated severe shocks and employ rather damaging coping strategies, they may end up being stuck in a poverty trap (Zimmerman and Carter, 2003; Carter and Barrett, 2006).

Income diversification is one of the means through which poor rural households achieve livelihood security when faced with unanticipated shocks. Many rural households diversify their income sources by engaging in low-return activities as it reduces the risk of falling into destitution (Dercon, 2000; Ellis, 2000a). Households living in areas with easy access to forests have the tendency to use forests both to

[1] Covariate shocks are those that affect an entire village or region while idiosyncratic shocks are individual shocks affecting a particular household.

weather the disaster they face (Pattanyak and Sills, 2001; Vedeld et al., 2004; Hegde and Bull, 2008) and to diversify their sources of income. The former strategy is using forests as a "natural insurance" or a safety net (Angelsen and Wunder, 2003).

Since rural households are unable to fully insure against the shocks they face, public interventions that protect the poor in the wake of shocks, i.e., social protection programs, are fundamental (Devereux, 2001). Food aid is one type of social protection which is mostly provided to shock-stricken households (Dercon, 2011). Among the countries that benefit from food aid, Ethiopia is the largest recipient of food aid due to the recurrent droughts and chronic food insecurity situation of rural households (Jayne et al., 2001; Caeyers and Dercon, 2012). As the number of chronically food insecure households needing support was continually growing, the government of Ethiopia launched a long-term social protection program in 2005, namely the Productive Safety Net Program (PSNP) (Nega et al., 2010; Siyoum et al., 2012a). The long-term objective of the program has been to provide predictable transfers for a predictable period to targeted chronically poor households in vulnerable communities. The program is expected to have an effect on the welfare of beneficiaries- including asset accumulation, children's education and nutrition.

This dissertation focuses on three main areas. It analyzes privately devised coping strategies of rural households in response to shocks; it examines the welfare implications of a government designed safety net; and it studies differences in asset ownership within female- and male-headed households. Paper 1 investigates whether households use income diversification in the face of unanticipated shocks and whether losses from shocks precipitate the use of forests. Paper 2 studies the effect of Ethiopia's Productive Safety Net Program on livestock accumulation and children's education.

Paper 3 then examines whether Ethiopia's Productive Safety Net Program improves child nutrition. Paper 4 analyzes whether there are differences in livestock ownership between female-and male-headed households in Northern Ethiopia.

Papers in this dissertation contribute to the existing literature in terms of data use and method of analysis. One, it broadens the range of shocks considered when examining household responses to shocks. Previous studies focused on a narrow range of shocks. Two, it expands and updates the literature on the effect of the PSNP by: (a) using a baseline data to compare outcomes, (b) examining conflicting results on livestock accumulation and children's education in previous works; (c) investigating the nutrition effect of food aid after the introduction of PSNP using the new WHO growth standard; and (d) investigating underlying mechanisms conditioning nutrition effect of PSNP. Three, it explores factors contributing to differences in the ownership of livestock between female- and male-headed households, which other studies did not carry out.

The introduction chapter has the following structure. Section 2 provides theoretical framework and literature review. Section 3 then discusses food aid programs in Ethiopia and provides an overview of the PSNP. Section 4 describes the study sites and data sources. The methods used to analyze papers in this dissertation are then explained in Section 5. This is followed by summary of papers and their limitations in sections 6 and 7, respectively. Section 8 finally gives conclusions and policy implications.

2. Theoretical Framework and Literature Review

This section contains the theoretical framework underlying the topics covered in this dissertation and the relevant literature in the area. It shows where each paper within the framework. Figure 1 illustrates the conceptual linkages and the focus of the papers in this dissertation.

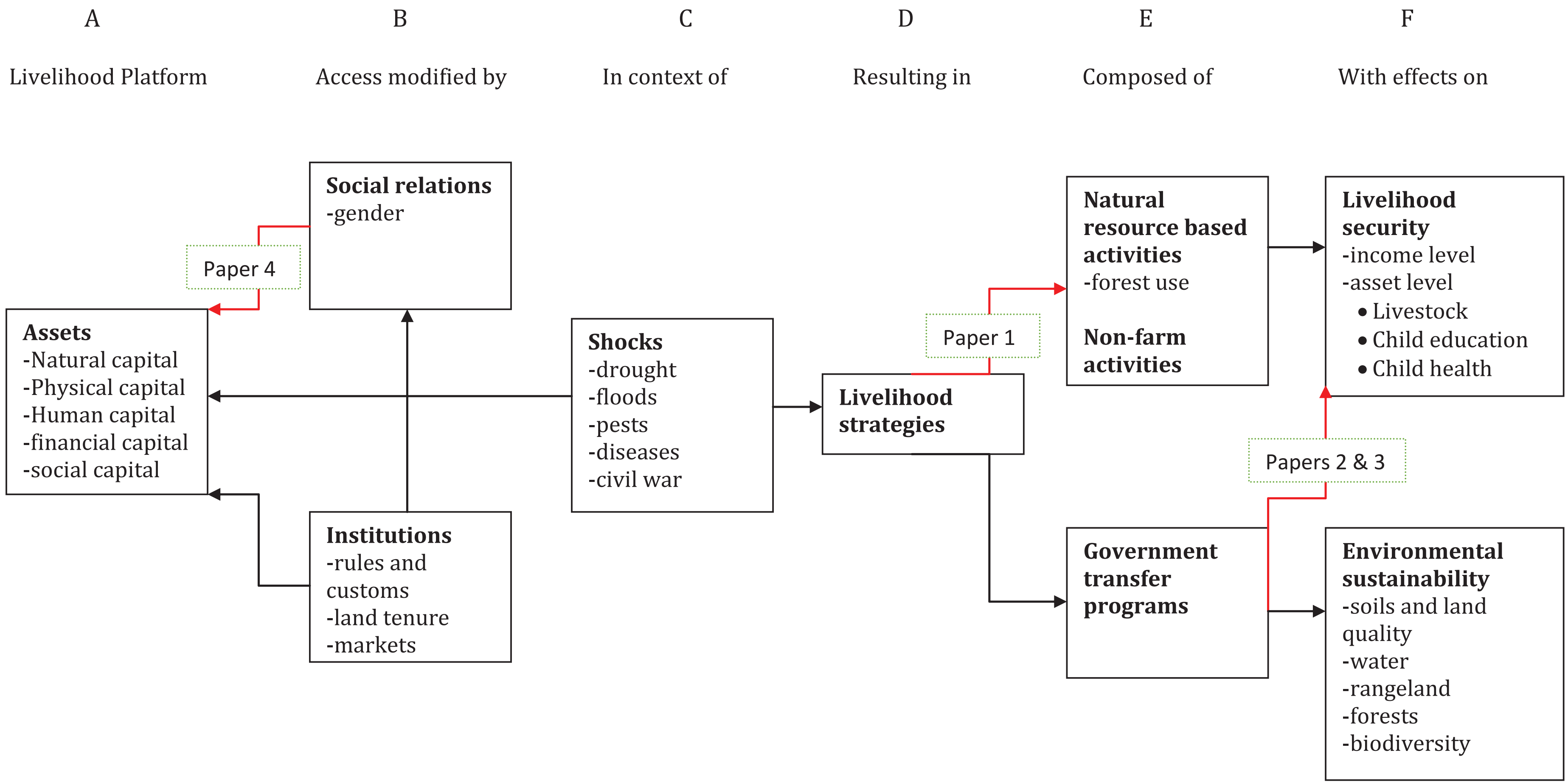

Figure 1. Conceptual framework for rural livelihood analysis

Source: Adapted from Ellis (2000b:30)

2.1. Vulnerability and Asset Poverty

Vulnerability[2] is a defining feature of rural livelihoods in developing countries (Devereux, 2001). According to Sen (1981), central to the poverty status of households in a given time is their vulnerability to shocks. Households' movement in their temporal poverty map is therefore linked to threats on their livelihood caused by shocks (Baulch and Hoddinott, 2000). This is mainly associated with the possibility that households take damaging coping strategies- for example, the disposition of assets in response to shocks-which can eventually lead to a worsened poverty status. Consequently, households become vulnerable and unable to withstand future shocks (Morduch, 1999; Dercon, 2005; Fafchamps, 2003). A study conducted in Ethiopia and Honduras by Carter et al. (2007) showed that lower wealth households had longer term effect due to shocks and were less able to rebuild their stocks of assets compared to better off households. Hence, susceptibility to livelihood shocks is associated with the initial asset endowment of households (Chambers, 2006; Devereux, 2001), including land, labor and other physical assets (Baulch and Hoddinott, 2000). Asset building is therefore important not only for improving rural livelihoods but also to withstand the consequences of shocks. Ultimately, asset ownership serves as a pathway out of poverty (Carter and Barrett, 2006).

In rural areas of developing countries, access to assets is shaped by social relations such as gender (Ellis, 2000b). Female-headed households are often constrained in terms of access to important agricultural assets (Kassie et al., 2014). Differences in access to credit and labor markets; information and inputs from extension agents; endowment of labor and

[2] Vulnerability refers to households' exposure to shocks combined with the difficulty to cope with them (Chambers, 2006; Devereux, 2001). Chambers (2006) calls the latter effect defenselessness.

other complementary assets contribute to gender disparities in the ownership of assets (Schmidt and Sevak, 2006; Carter and Barrett, 2006; Quisumbing, 2011; FAO, 2011). Further, cultural norms limit women's access to major assets (Njuki and Sangina, 2013). Resulting differences in asset ownership have implications on women's livelihood options and path out of poverty. Paper 4 in this dissertation examines differences in the ownership of livestock assets between female- and male-headed households.

2.2. Coping Strategies

Rural households devise their own strategies to deal with the shocks they face and gain livelihood security. Strategies can be categorized into ex-ante and ex-post strategies (Fafchamps, 2003). While the former is a risk mitigating mechanism which is applied prior to the shock, the latter is a shock-coping mechanism taken after the shock occurs (Fafchamps, 2003; Fisher and Shively, 2007). Risk mitigating mechanisms include crop and field diversification, choice of low mean, low variance agricultural technologies, involvement in portfolio of occupations, and strategic migration of family members (Alderman and Paxson, 1992).

Ex-post coping strategies can either be household-based or group-based through risk sharing (Dercon, 2000). Risk sharing arrangements involve consumption smoothing through transfers from extended families, ethnic groups, neighborhood groups and professional networks (Dercon, 2000; Skoufias, 2003). While idiosyncratic shocks can be insured through group-based risk sharing, the aggregate nature of covariate shocks makes it difficult if not impossible for risk sharing arrangements to be relied upon (Bardhan and Udry, 1999; Dercon, 2000; Devereux, 2001; Skoufias, 2003). The remaining discussion focuses on household based coping mechanisms since it is the focus of the dissertation (paper 1).

Coping strategies include selling assets; reducing consumption; working off-farm; getting loans; migrating seasonally or temporarily; drawing down savings; and altering investment in human capital (Chambers, 2006; Baulch and Hoddinott, 2000; Dercon, 2000; Skoufias, 2003). In most rural settings, households rarely rely on a single coping strategy. During the 1980s famine in Ethiopia, coping strategies adapted by households were mainly cutting back consumption, selling assets, collecting wild foods, selling livestock and migrating for work. Reducing consumption was the most common strategy in four out of the six villages studied (Dercon, 2000). In a study carried out in 1998 for Northern Ethiopia, Hagos and Holden (2002) found that household ranked selling animals as their first coping response to moderate drought.

Income diversification is among the self-insurance strategies of the poor. It can be both an ex-ante risk management and ex-post risk coping strategy for rural households. By involving in various income generating activities, poor households try to achieve livelihood security (Ellis, 2000a). Put differently, they avoid putting all their eggs in one basket and broaden their options (Chambers, 2006). Entry constraints, however, hinder poor households from engaging in profitable activities which eventually leave them to enter into low-return activities. This in turn limits households' ability to handle risks (Dercon, 2000). Since engaging in diversified sources of activities requires labor force, the extent to which poor households - whose main asset is their labor- use an income diversification strategy depends on their labor endowment, such as their skills, household members' ability to work and earn (Chambers, 2006).

Rural households residing around forests use forest extraction as a means to diversify their sources of income. Forests in such areas also serve as safety nets at times of unexpected shortfall (Byron and Arnold, 1999; Angelsen and Wunder, 2003). The natural insurance function of forests has been found to be more attractive for households that are asset poor (Takasaki et al., 2004; Fisher and Shively, 2007), headed by male (Fisher and Shively, 2005), distant from the market (Godoy et al., 1998) and headed by young adult (McSweeny, 2004). Paper 1 studies whether households in western Uganda use forests as safety nets and whether they diversify their income sources in response to shocks.

2.3. Social Protection Programs

Poor rural households have limited ability to self-insure using the coping strategies at their disposal (Devereux, 2001). Government intervention that protects the poor against otherwise uninsured risks is therefore paramount (Devereux, 2001; Dercon, 2005). In line with this, social protection programs are aimed at protecting the poor from vulnerability, minimizing the damage due to shocks and providing secure livelihoods (Adato and Hoddinott, 2008).

Social protection refers to a public intervention providing social insurance, social assistance and services enabling access to social insurance and social assistance (Dercon, 2011). While social insurance covers the poor in the event of shocks, social assistance provides cash or in kind benefits such as food and fertilizer to the rural poor independent of exposure to shocks(Devereux, 2001; Adato and Hoddinott, 2008; Dercon, 2011). Since the focus of this dissertation (papers 2 and 3) is on social assistance, particularly food assistance provided in the form of food and/or cash, the following discussion concerns social transfer programs.

Social transfers have important roles in reducing poverty and contributing to economic growth (Barrett et al., 2008; Dercon, 2011). Although it has been traditionally assumed that social protection programs relocate resources from growth promoting activities, recent literature has indicated that such programs can contribute to economic growth in a number of ways (GSDRC, 2014). These include encouraging investment in human capital, overcoming market failures and increasing ability to take and manage risks (DFID, 2006; GSDRC, 2014). Hence, social transfer programs provide an efficiency gain in addition to the equity and poverty impacts (Dercon, 2011). The poverty reduction effects are more pronounced in the presence of poverty traps, whereby transfer schemes prevent individuals at the threshold from being caught in a poverty trap due to harsh blows from shocks (Dercon, 2005; Barrett et al., 2008). In other words, it is possible that such programs reduce vulnerability and can even help households to climb out of poverty through investment in assets (Holden et al., 2006).

Food aid programs affect the investment behavior of households through four channels. One, the cash benefit can directly be used for investment purposes. Two, transfer in the form of food frees expenses that could have been used for food and hence allow investments (Devereux, 2001). Three, predictable and regular transfer programs create a secure source of income for the poor and hence induce risk taking in high-return investments (Barrett et al., 2008). Four, better asset positions due to such programs improves their suitability to take credit and allows them to make larger investments (Dercon, 2011).

Another essential role played by food assistance programs is the alleviation of intergenerational poverty through the investment in children's education and health (Adato and Hoddinott, 2008; Porter and Dornan, 2010). On the one hand, the food and cash benefits from transfer schemes may directly translate into investment in human capital. On the other hand, work-fare programs requiring labor contributions from households may have negative implications on children's welfare status, as children may directly participate in the public works or substitute for their parents' work at home. The net effect depends on the households' labor endowment, the size of the public works payment and the marginal impact of this payment on child nutrition and education. In this dissertation, paper 2 assesses the effect of Ethiopia's Productive Safety Net Program (PSNP) on livestock accumulation and children's education. Paper 3 investigates whether the PSNP improves short-term child nutrition.

One of the major concerns in the literature about food assistance programs is whether they crowd out private transfers and informal insurances devised at the household or community level (Morduch, 1999; Dercon, 2000; Barrett et al., 2005; Abdulai et al., 2005). Morduch (1999), however, asserts that if public actions are well designed, they can improve and strengthen households' capacity to act independently through informal mechanisms. It is also possible that food aid programs that involve building community infrastructure, such as food-for-work programs, contribute to creating social capital via teams formed for work purposes (Barrett et al., 2005).

The disincentive effect of food aid is another issue that concerns economists and policy makers (Barrett et al., 2005). Such effects materialize when food aid results in a decline in local food production (Gelan, 2007); decline in labor supply to agriculture and off-farm activities (Barrett et al., 2005); depressed local food prices (Tadesse and Shively, 2009); and decreased incentive to invest on farmers' land (Barrett et al., 2005). On the other hand, there are empirical studies showing that food aid did not create disincentives in agricultural production (Abdulai et al., 2005) and labor supply to farming (Bezu and Holden, 2008).

Public safety nets are likely to be more effective if they are put in place before the shocks occur and if they are targeted to those who suffer most from serious shocks (Barrett et al., 2005; Skoufias, 2003). Food assistance provided in response to adverse shocks need to be timely, reaching out those who are in need (Barrett et al., 2005). Designing an effective social protection program requires the consideration of the constraints faced by the marginalized poor (von Braun and Gatzweiler, 2014). Further, safety net programs that protect the poor from falling into poverty traps, by creating the platform for better investment options and activity choice, are considered to be efficient (Dercon, 2005).

The effectiveness of food aid programs is affected by the tools of food assistance used by donors. In the past decade, the instruments of international food assistance have changed (Lentz et al., 2013a; Lentz et al., 2013b; Garg et al., 2013). New tools of food assistance include distribution of cash, vouchers and local and regional procurement (LRP). The latter component (LRP) involves procurement of food from local markets in the recipient country and distributing to recipients there (Lentz et al., 2013a).[3] Recent studies show that the new instruments improve timeliness of food aid distributions compared to direct shipment of food from donor countries (Lentz et al., 2013b). Further, LRP does not

[3] LRP consists of two-third of global food aid flow (Garg et al., 2013).

create disincentives effect on local food prices and does not affect price volatility. It also has no effect on local prices in procurement and non-procurement markets, i.e., no spatial price effect (Garg et al., 2013).

3. Food Aid Programs in Ethiopia

Ethiopia is one of the largest recipients of food aid getting 10 percent of total global food aid flows and 20-30 percent of all food aid to Sub-Saharan Africa (Bezu and Holden, 2008; Asfaw et al., 2011; Caeyers and Dercon, 2012). The country has been dependent on food aid for more than a decade (Gilligan et al., 2008). Drought and subsequent food shortages during the decade (in 1973, 1984 and 2003 and other periods with food shortages) are the causes for most of the recurrent appeal for food aid to the international community (Jayne et al., 2001; Caeyers and Dercon, 2012).

Historically, food aid provision in Ethiopia took the forms of free food and food-for-work (Jayne et al., 2001). The Food-for-work program, which is referred to as "developmental food aid" (Barrett et al., 2005; Jayne et al, 2001), involves the engagement of able-bodied individuals in community asset development such as building of roads, schools, conservation structures and dams. Participants are paid wages in the form of food or cash, which are ideally below the market price (wage).[4] Individuals who are unable to work receive free food and cash without having to work. A larger percentage of the food

[4] The main reason for making payments below the market price (wage) is to attract only the poorest. Researches however found that unintended beneficiaries benefited from the work fare programs, possibly due to the fact that the FFW wages were higher than the market wages (Caeyers and Dercon, 2012) or due to restricted access to wage employment (Holden et al., 2004).

aid distribution, accounting for 80%, is provided in the form of food-for-work (Caeyers and Dercon, 2012).

Although there was a massive transfer of food aid to Ethiopia[5], the country's emergency food aid recipients have been chronically food insecure and were unable to feed themselves even in good years (Nega et al., 2010). Moreover, the size of the vulnerable population has been increasing over time (Rahmato et al., 2013). As a result, there is a need to provide long term assistance to these households (Nega et al., 2010). To this end, the government of Ethiopia (with joint effort of donors) launched a large scale social protection program in 2005, namely the Productive Safety Net Program (PSNP).

3.1. The Productive Safety Net Program (PSNP)

The Productive Safety Net Program (PSNP) is a social protection program aimed at providing food assistance to chronically food insecure households in the country. It is the largest transfer program in Africa benefiting 8.3 million people in 319 chronically food insecure districts (*weredas*) [6] (Gilligan et al., 2008; Siyoum et al., 2012a; Rahmato et al., 2013). Four chronically food insecure regions (Tigray, Amhara, Oromiya and SNNPR) and the pastoralist areas of the country receive benefits from the program. The latter group was included as beneficiaries during the expansion of the program in 2009 (Gilligan et al., 2009; Nega et al., 2010; Siyoum et al., 2012a; Rahmato et al., 2013).

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[5] The country received about 10 million metric tons of food aid in the period between 1984 and 1998 (Jayne et al., 2001).

[6] *Wereda* is the next administrative unit above *tabia* (municipality or community). The smallest administrative unit is *kushet* (village) and there can be three to four *kushets* within each *tabia*.

The government of Ethiopia designed the country's food security program (FSP) composing four components among which the PSNP is the major one. The other components are the Complementary Community Investment (CCI), the Other Food Security Program (OFSP) which later transformed into the Household Asset Building Package (HABP) and the Resettlement Program (Berhane et al., 2011; Lavers, 2013; Rahmato et al., 2013). The PSNP aims to achieve its goals allowing households to accumulate assets and preventing likely asset depletion due to sever shocks- with the support from the complementary components of the FSP (Government of Ethiopia, 2009).

PSNP is different from the previous emergency relief program since it have a long-term feature providing predictable amounts of transfers (cash or food) for a predictable period of time (at least five years) (Bishop and Hilhorst, 2010). It has two phases; the first was between 2005 and 2009 while the second is between 2010 and 2014. Building upon the previous relief program, there are two components of the program - public works and direct support. The former involves labor contribution in community asset development (such as dams, roads, conservation structures) as a requirement to receive payment (food or cash). The latter component provides free food to individuals who are unable to supply labor and includes elderly, disabled, pregnant, lactating and orphaned teenagers (Sharp et al., 2006; Gilligan et al., 2009; Nega et al., 2010). Public works can be in the form of food-for-work or cash-for-work and accommodates able bodied household members under the age of 16. According to the labor cap rule, the maximum number of days that a household member can participate in public works is 15 days per month (Berhane et al., 2011). Beneficiaries may receive a mixture of cash and food payments in some *weredas* (Sabates-Wheeler and Devereux, 2010).

Targeting of eligible households involves Food Security Task Forces (FSTF) formed at the *kushet*, *tabia* and *wereda* levels. The task forces identify eligible households based on the criteria in the project implementation manual (Government of Ethiopia, 2009; Berhane et al., 2011). In order to become a member (beneficiary) from PSNP, households should be found in one of the chronically food insecure *weredas*; have experienced food gaps or received food aid within three years before the start of the program; have faced severe shocks that led to substantial asset depletion; or have had no other source of support (e.g. from family or other social protection programs) (Government of Ethiopia, 2009). Budget limitations at all levels might affect the targeting of households (Berhane et al., 2011; Coll-Black et al., 2011). Coll-Black et al. (2011), however, assert that PSNP is targeted well when measured at an international standard.

The program aims to assist households build their assets and eventually graduate from the PSNP. This is expected to happen by combining the PSNP with the complementary program, OFSP/HABP. Graduation requires that households are food self-sufficient, have improved asset levels and no longer require support from the program (Government of Ethiopia, 2009). The graduation performance of the program is well below expectation as only 9 percent of beneficiaries graduated in 2009 (Siyoum et al., 2012b). As a consequence, the international partners of the Ethiopian government advocate for the institutionalization of the program into the country's development objective and provide longer term social protection (van Uffelen, 2013).

4. Data and Study Sites

Data for this dissertation comes from two sources. Paper 1 uses household survey data from western Uganda while papers 2, 3 and 4 employ household survey from Northern Ethiopia. The following subsections describe the study sites and data for the two sources.

4.1. Data and study site in Uganda

The data from Uganda was collected in Masindi district. Masindi is located in west-central part of the country and borders the Democratic Republic of Congo. It is one of the poorest districts in Uganda (IFPRI, 2001) and an area where the impacts of shocks are likely to be strongly felt by households (Government of Uganda, 2007). The annual rate of population growth is 3.6 % (MDLG, 2008). Masindi district has a national forest reserve, named Budongo, which covers 793 km^2 of which 420 km^2 are Tropical High Forests (Bush et al., 2004). Although the district normally enjoys a favorable climate, adequate rainfall and fertile soils (MLDG, 2008), long droughts are increasingly becoming frequent (Government of Uganda, 2007). Other shocks in the districts include occasional occurrences of floods, wind storms and hail. Health problems are also prevalent in the district (MLDG, 2008).

Paper 1 uses a survey data conducted for 234 households in June-July 2008 in Masindi district. The survey was a follow up from a panel survey conducted in 2001 and 2005. The 2008 survey added two new villages and households from these villages were selected using simple random sampling method. Local enumerators carried out the data collection in 2008 using multipurpose household and village questionnaires. In some villages, there was a need to hire translators as migrant households spoke diverse languages. The author of this dissertation participated in the 2008 survey.

Interviews included information such as household characteristics, asset ownership, agricultural production, off-farm activities, forest income, shocks, social networks, credit and remittances. The survey in 2008 uniquely contains detailed information on shocks faced by households and coping strategies utilized. Our sample contains a total of 234 households from 13 villages. We use a subsample of households (n=70) observed in both 2005 and 2008 for a descriptive analysis and supplementary analysis in the paper.

4.2. Data and study site in Ethiopia

Located in Northern Ethiopia, Tigray region is characterized by high exposure to recurrent drought and famine, limited access to credit, narrow opportunity for off-farm employment and severe environmental degradation problem (Hagos, 2003; Bezu and Holden, 2008). The region has severe food insecurity problem (Hagos et al., 2002). Moreover, the malnutrition status of children under the age of five in Tigray is among the worst in the country (WHO, 2012). The region's annual population growth is at least 3 % (Hagos and Holden, 2002). While there are three main farming systems in Tigray- mixed crop-livestock, cereal production and pastoral systems- the dominant farming system in the highlands of Tigray is mixed crop-livestock farming system (Hagos and Holden, 2002).

This dissertation obtained its data from five waves of household survey collected in the highlands of Tigray. [7] Data collection started in 1998 and continued in the years 2001,

[7] The lowland pastoral areas of the region were not included in the survey (Hagos and Holden, 2002).

2003, 2006 and 2010 following the same households. The survey was initially carried out for a stratified random sample of 400 households in 16 villages. Sample households come from four zones of Tigray- central, eastern, western and south eastern- and are representative of population density, market access, agro-climatic conditions and access to irrigation projects (Hagos and Holden, 2002; Hagos, 2003). Figure 2 shows the map for the study site and the sampled *weredas* and villages. The 2010 data further contains an additional 119 households from two different villages. Data was collected using multipurpose household and village questionnaire which were administered by hired enumerators who spoke the local language. The author was involved during the last round of data collection (2010).

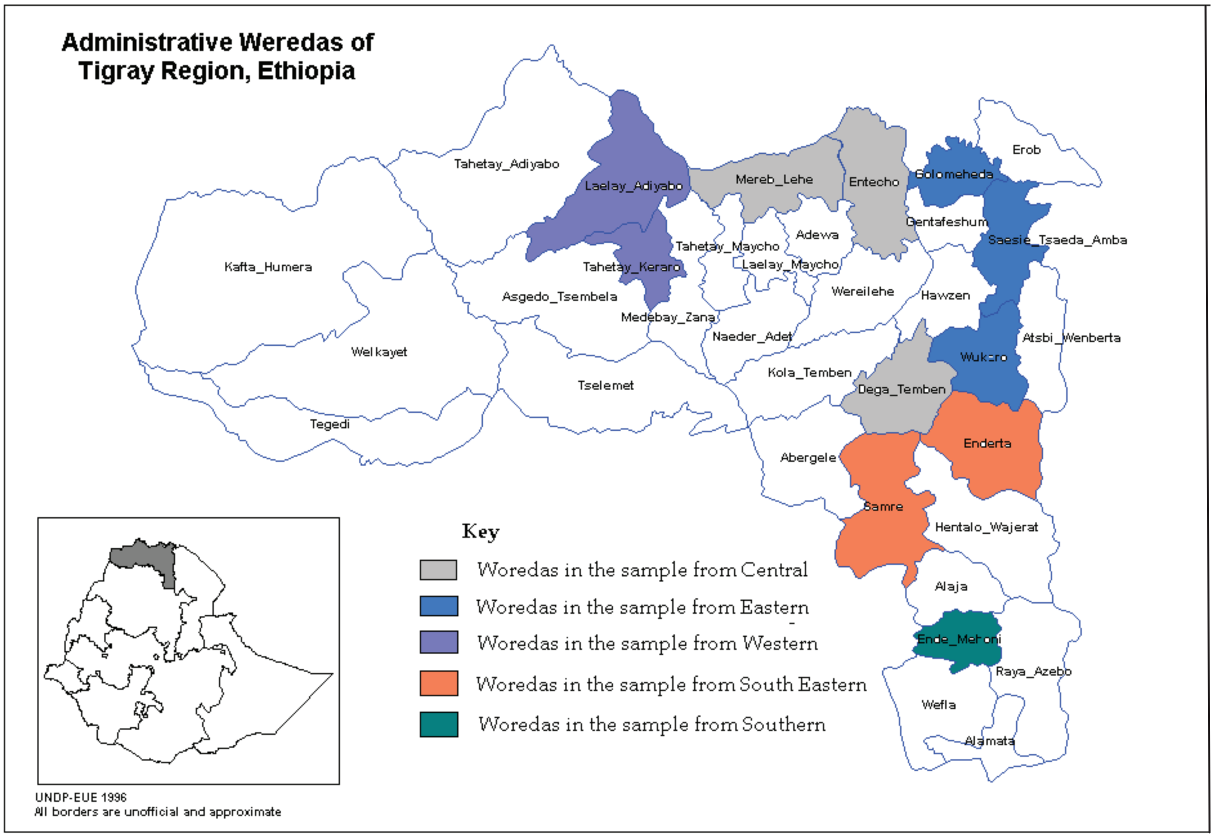

Figure 2. Map of study site in Ethiopia, Tigray region
Note: *Woredas* from Southern Tigray are used in paper 2 and are not part of the panel.

Data are comparable across the survey years since all survey rounds used standardized multi-purpose questionnaire. Respondents were asked questions concerning household characteristics, asset ownership (land, livestock and physical assets), agricultural production, non-farm income sources and consumption expenditure, among others. Survey data in 2006 and 2010 included child anthropometric measures for the first time. The surveys were carried out at a similar period of time, between May and July. Hence, seasonality is not a concern in the dataset. One of the major concerns in survey data is measurement error. The survey has minimized this problem by utilizing conservative approaches when gathering the data.

Depending on the area of focus, three papers in this dissertation use different sets of survey rounds. Table 1 summarizes the data utilization in each paper. Paper 2 uses balanced panel data from 2003 and 2010 with the aim of studying asset accumulation behavior using data right before the start of PSNP (2003) and after the end of the first phase of PSNP (2010). Paper 3 then employs 2006 and 2010 data since these were the survey years with child anthropometric measures. It undertakes child level analysis using pooled cross-section from the two years.[8] In paper 4, all survey rounds were used in order to analyze differences in livestock ownership between female- and male-headed households.

Table 1. Data utilization of papers (Data from Tigray, Ethiopia)

Papers/Years	1998	2001	2003	2006	2010
Paper 2			X		X
Paper 3				X	X
Paper 4	X	X	X	X	X

5. Methods

This dissertation uses a range of methods relevant to the contexts and research questions raised in each paper. Impact assessment methods and decomposition analysis have been applied in the empirical analyses. The major empirical bottlenecks when using survey data are endogeneity and sample selection bias. Paper 1 tackled potential selection bias by using Heckman selection model (Heckman, 1979) to examine whether forest served as a natural

[8] We treat each round as separate representative sample because only 37 children were included in both surveys.

insurance. Heckman selection was suitable because there are households that do not use forests and there is a varying degree of utilization among those who use forests. The method allows controlling for selection bias in the measurement of correlates with household forest income.

In paper 2, selection bias attributed to treatment assignment was controlled for using treatment effects model. The method is appropriate since it takes care of potential existence of unobserved factors (Brown and Mergoupis, 2010) that may determine selection in to the public works and that may be correlated with the outcome variables. Paper 3 applies exogenous switching regression which allows examining factors determining nutrition outcome in PSNP and non-PSNP households. To identify the nutrition effect of the PSNP, it builds counterfactuals based on the exogenous switching regression in which we equate nutrition returns to characteristics of member and non-member households.

When applying impact assessment methods, the major challenge has been finding the proper instrument. This has been a problem when instrumenting for participation in public works (paper 2) and checking the endogeneity of membership in PSNP in the nutrition outcome (paper 3). This dissertation dealt with this problem by carrying out relevant tests-instrumental variable approaches and log-likelihood ratio tests. Further, it applies panel data methods to control for unobserved heterogeneity.

Paper 4 utilizes a decomposition approach, Oaxaca decomposition technique, to study differences in the ownership of livestock between female-and male-headed households. The method is suitable to investigate covariates affecting gender differences in ownership of livestock by classifying those attributed to differences in observed characteristics and returns to characteristics. The decomposition analysis has an advantage over a pooled model as it allows examining coefficient effects within female- and male-headed households rather than measuring the intercept effect only. The paper benefits from panel data approach-two-way fixed effects model-when measuring average differences in livestock ownership.

6. Summary of Papers

This section provides the summary of papers included in this dissertation.

Paper 1: Economic Shocks, Diversification and Forest Use in Uganda

This paper examines household response to economic shocks using household data collected in 2008 from rural Uganda. We answer two main questions: One, were rates of subsequent diversification higher among households that encounter losses? And two, did households turn to forests in response to shocks? Patterns of income diversification are measured using constructed formal *diversification index* for each household. Using the constructed index and the forest income share as dependent variables, we run OLS regression and Heckman selection model, respectively. For both approaches, we use the estimated monetary value from self-reported losses as our indicator of shocks. Previous work focusing on the safety net role of forests has isolated a narrow range of specific shocks. Our paper contributes to the existing literature by broadening the range of shocks and examining their impact on household responses.

Findings indicate that households encountering above-average losses tend to have more diversified income portfolios subsequent to the losses. Income-poor households, those with below average land holdings and female-headed households are observed to have a more diversified income portfolio than their cohorts. Larger negative shocks are associated with greater use of the forest in subsequent periods, especially among asset poor households. Losses due to non-labor shocks precipitate forest extraction and higher rates of income diversification while shocks affecting labor in the households does not. Results have both specific and general relevance for policies related to forest protection and governance, poverty eradication and rural development.

Paper 2: How Does Ethiopia's Productive Safety Net Program Affect Livestock Accumulation and Children's Education?

Ethiopia's Productive Safety Net Program has the objectives to reduce food deficit, promote asset accumulation and prevent asset depletion. This study investigates whether the public work component of the PSNP allowed investment in two types of assets, livestock and children's education, during the first phase of the PSNP (2005-2009). The paper uses panel data from Northern Ethiopia, Tigray region. We employ treatment effects model in order to control for endogenous selection in to the program.

Several studies examined the impact of the program at the early stage of the first phase. Others that investigated after the end of the first phase either relied on recall data to form baseline for the outcome of interest or used data after the start of the program. This paper contributes to the literature by using data before the program commenced (2003) and after the completion of the first phase (2010). This way, we are able to examine program effects using "with/without" and "before/after" approach, an important strategy in the impact evaluation literature. The study also supplements previous empirical evidence which showed conflicting result concerning the effect of PSNP on livestock accumulation and children's education. Further, we investigate whether households showed strategic behavioral response in their asset accumulation to avoid recruitment for graduation, which other studies were not able to do.

We find that the program allowed beneficiaries to invest more in livestock and their children's education compared to non-beneficiaries, after controlling for sample selection and attrition bias. Participating in the public works protected households from sacrificing their children's education in response to shocks. Our conclusion on livestock accumulation remains the same after controlling for potential down-sale of livestock to avoid graduation from the program.

Paper 3: Does Ethiopia's Productive Safety Net Program Improve Child Nutrition?

A broader approach to tackle the problem of malnutrition is the provision of food aid, among other targeted interventions. Food aid programs that involve work fare program can affect a child's short-run nutritional status through multiple channels. On the one hand, the income benefit from program participation has a positive nutritional impact. On the other hand, programs that require households to provide labor could have negative implications for a child's nutritional status by shifting effort away from health provisioning. Whether a work program has deleterious impacts depends on the labor situation of the household, especially female members of the household.

This paper studies the link between Ethiopia's Productive Safety Net Program (PSNP) and short-run nutrition outcomes among children age 5 years and younger. It uses anthropometric data collected in Tigray region in 2006 and 2010. We use a pooled cross section of the two survey rounds to estimate parameters of an exogenous switching regression. This allows us to measure the differential impacts of household characteristics on weight-for-height Z-score of children in member and non-member households in PSNP. Importantly, we move beyond the traditional approach to measuring a potential impact "with" and "without" an intervention, and search for underlying conditioning mechanisms that may be driving differences in nutrition outcomes in the PSNP and non-PSNP samples.

Previous studies focusing on the relationship between food aid and child nutrition in Ethiopia have either relied on data collected before the start of the PSNP or did the analysis on districts that received transfers different from standard PSNP payment. Our study updates and complements previous works using data collected from Tigray after the introduction of the PSNP. Further, we use the new WHO growth standard, which provides the most accurate measure of child health in Ethiopia to date.

Findings show that the magnitude and significance of household covariates differ in samples of children from PSNP and non-PSNP households. We find that supply of female labor promotes child health in member households. Controlling for a set of observable features of children and households we find that children in member households have weight-for-height Z-scores that are 0.55 points higher than those of children in non-member households. We also measure program treatment effects under a set of counterfactual conditions in which we equate the nutrition returns to characteristics of member and non-member households. Those results suggest that, after controlling for the differences in the profiles of member and non-member households, children in member households have 97 percent higher WHZ, on average, than children in non-member households. We conclude that the PSNP is providing positive short-term nutritional benefits for children, especially in those households that are able to leverage underemployed female labor.

Paper 4: Female Headship and Livestock Accumulation in Northern Ethiopia

This paper investigates gender differences in livestock accumulation pattern using five waves of survey data (1998-2010) from Northern Ethiopia. It answers three research questions: (1) is there a difference in the overall amount of livestock owned by female-and male-headed households? (2) If so, what factors contribute to the observed gender gap? And (3) does this gender gap differ for big or small livestock? The empirical analysis relies on Blinder-Oaxaca decomposition technique which allows decomposing factors that contribute to the average difference in livestock ownership between female- and male-headed households. We apply two way fixed effects in order to take care of time-invariant unobserved heterogeneity.

Empirical studies focusing on gender gap in livestock ownership are scarce in the literature. Earlier researches that analyze the gender effect on livestock asset dynamics used pooled regression with a gender dummy variable, measuring only differences in the intercept effect and not in the slope coefficients. This paper contributes to the literature by identifying factors contributing to livestock accumulation behavior in female- and male-headed households, separately. Further, by employing decomposition analysis, it disentangles specific observed and unobserved factors causing differences in livestock ownership, an area less researched in the literature.

Results reveal that female-headed households own lower stock of livestock than male-headed households, on average. According to the decomposition analysis, the gap is attributed to differences in both observed and unobserved characteristics. Female-headed households' lower endowment in land area, size of male labor and number of children (aged 6 to 14) are the causes for the gender difference in livestock ownership due to observed characteristics. Differences in unobserved factors reflect that the relative vulnerability of female-headed households in the aftermath of the Ethio-Eritrea war (the year 2001) contributed to the lower stock of animals in female-headed households. Findings also reveal that the gender gap was more pronounced in the ownership of large animals compared to small ruminants.

7. Limitations

Papers in this dissertation have limitations of their own. The common limitations in papers 2 and 3 are as follows. One, we are unable to control for the indirect benefit that the PSNP generates for both beneficiaries and non-beneficiaries via the community asset development. It is therefore likely that we underestimate the total benefits from the program. Two, we did not take the effects of the complementary programs- OFSP or HABP, CCI and voluntary resettlement- into account. This is because our data does not contain information on whether households benefit from these programs. If we had controlled for these programs, we would have been able to capture the combined effect of PSNP and other food security programs. Impact evaluations by Gilligan et al. (2009) and Hoddinott et al., (2012) found that the combination of PSNP and OFSP generated greater magnitude in the outcome variables. Hence, we expect that our papers are likely to underestimate the effects of PSNP.

In paper 2, using panel data that follows the same children across time would give a better picture of the health status of children across time. Since we do not have such data, we opted to pool the data from the two years and treat each round as a separate representative sample. Further, we are unable to compare outcome with data from before the intervention since we lack nutrition data prior to the start of the PSNP. Paper 4 looks at an average effect when measuring difference in asset ownership between female-and male-headed households. This makes it difficult to disentangle policy effects of PSNP and the land certification program that has been found to have had substantial impacts in the region (Holden et al. 2009; 2011). Since this policy effect is outside the scope of the paper, it may be studied in future research.

8. General Conclusions and Policy Implications

The overall conclusion of this PhD dissertation lies in three strands. First, in the absence of government safety nets, forests provide important safety nets when households encounter unanticipated losses. Households diversify their sources of income in response to larger losses from shocks. Female-headed households and land-poor households had larger rates of diversification compared to their cohorts. Households reallocate their labor when they encounter unexpected misfortunes. In the event that shocks to labor occur, households are relatively unresponsive and vulnerable. Policy implications arising from this paper are four: (1) Development of safety nets in forested rural areas not only reduces vulnerability but also decreases forest pressure. (2) Restricting forest use in the absence of safety nets would further impoverish poor households. (3) Investment in the health sector would minimize the damage caused by labor related shocks. And (4) Strengthening income earning opportunities for female-headed households and poor households is also necessary.

Second, Ethiopia's Productive Safety Net Program has a positive effect on livestock accumulation, children's education and short-term child nutrition. Households benefiting from the program were still able to send their children to school in the event of labor related shocks compared to non-beneficiaries. Female labor supply positively influences the WHZ of children in member households which implies that there is no income-nutrition tradeoff when underemployed female labor is allocated to FFW program. A key policy implication in relation to the latter is that creation of employment opportunity for under employed females not only increases income but also improves child nutrition. Further, provision of alternative secure livelihoods on which households can rely on- upon graduation of households or the phase out of PSNP- is imperative.

Third, female-headed households own lower level of livestock compared to male-headed households. This is attributed to lower endowment of complementary assets, land and labor. Three policy implications arise. First, minimizing the land allocation bias against wives upon divorce improves the tenure security of female-headed households. This will improve the endowment of land in female-headed households and positively affect livestock ownership. Second, facilitation of well-functioning labor market allows female-headed households to hire labor and hence encourages livestock accumulation. Third, policies that aim at increasing livestock level of female-headed households should take into account the land and labor constraints that female-headed households face.

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Paper 1

Economic Shocks, Diversification, and Forest Use in Uganda

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ABSTRACT. *We investigate household outcomes arising from economic shocks in rural Uganda, focusing on patterns of income diversification and forest use, and the role of assets in shaping ex post response to shocks. Income-poor households and those with below-average landholdings are observed to have more diversified income portfolios than their cohorts. Households encountering above-average losses tend to have more diversified income portfolios subsequent to the losses. Larger negative shocks are associated with greater use of the forest in subsequent periods, especially among asset-poor households. Findings suggest that development of better safety nets would reduce both vulnerability and forest pressure.* (JEL O12, Q23)

I. INTRODUCTION

This paper examines household response to economic shocks. We study a broad set of major shocks encountered by rural Ugandan households over a retrospective three-year period (2005–2008), measuring shocks by their frequency and magnitude, and focusing our attention on those shocks that can be most clearly characterized as exogenous and unanticipated. Our sample is typical for developing regions of the world, where rural households are exposed to a wide range of idiosyncratic and covariate shocks that emanate from temporary or permanent losses in labor productivity and from partial or total crop failure. With few formal mechanisms to cope with these immiserating events, many poor households devise mechanisms to buffer their consequences. Risk management strategies include self-insurance and mutual-insurance systems; ex post strategies frequently include selling productive assets, dissaving, temporarily reducing consumption, or searching for off-farm employment or other sources of livelihood (Paxson 1992; Dercon 2000, 2005; Fafchamps 2003). In a study from Tanzania, for example, Beegle, Dehejia, and Gatti (2006) demonstrate how agricultural shocks can precipitate greater use of child labor, thereby disrupting schooling and undermining long-term investments in human capital. Some observers have argued that, in the extreme, when households cannot cope with the cumulative effects of repeated negative shocks they may become stuck in a poverty trap, escape from which may be difficult (Zimmerman and Carter 2003; Banerjee 2005; Carter and Barrett 2006).

Our data show that unanticipated shocks result in large income losses. For nearly half of the households in our sample, accumulated losses over a three-year period equaled or exceeded half a year's income. As elsewhere, financial services and other institutions that might be used to mitigate these losses are poorly developed in rural Uganda. This places a limit on the range of coping mechanisms available to households, especially those that are asset poor and headed by women (Government of Uganda 2004). In addition, because of a long history of migration into the study area (both from within Uganda and from neighboring countries) the social and economic fabric of the study area is rather weak

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(MDLG 2008). As a result, we find that forest extraction constitutes an economically significant part of many households' livelihood portfolios and that forest reliance increases in response to shortfalls elsewhere. Other research from rural Uganda has demonstrated that forests provide as much as 70% of subsistence and cash income in some areas (Kazoora, Birungi, and Dranzoa 2008). In our sample, forest income shares reach 65% for some poor households, which underscores the strong connection between rural poverty and forest use.

Our investigation of this poverty-forest link is further informed by research suggesting that in some situations households may be more vulnerable to labor shocks than agricultural shocks (see, e.g., Kochar 1995). In many settings, households combine their labor with forests and forest products in a form of "natural insurance" to weather both small and large disasters (Angelsen and Wunder 2003). This safety net role of forests has been found to be more frequently employed by households that are isolated from the market (Godoy, Jacobson, and Wilkie 1998), those that are asset poor (Takasaki, Barham, and Coomes 2004; Fisher and Shively 2007), those headed by males (Fisher and Shively 2005), and those that are at an earlier stage in the demographic cycle (McSweeney 2004). Moreover, households living in areas with easy access to forests tend to use forest resources not only to mitigate the negative consequences of income shocks ex post (Pattanayak and Sills 2001; Vedeld et al. 2004; Hegde and Bull 2008), but also to diversify their sources of income ex ante, in anticipation of income variability. Although diversification often means engaging in low-return activities (Dercon 2000), the risk reduction associated with a diversified livelihood strategy proves attractive to many rural households (Ellis 2000). Likewise, turning to the forest may not provide the most favorable returns to labor compared with normal circumstances, but may simply be the only opportunity to generate income in the wake of a shock.

Our study contributes to a small but growing empirical literature on income diversification at forest margins and household responses to shocks. Previous work focusing on the safety net role of forests has isolated a narrow range of specific shocks and examined their impact on household behavior. We expand this literature by answering two main questions: One, were rates of subsequent diversification higher, on average, among households that encountered losses? And two, did households specifically turn to forests in response to shocks? For both approaches we use the estimated monetary value from self-reported losses as our indicator of shocks. We measure the ex post response to these shocks in two ways. First, we construct a formal *diversification index* for each household based on the observed number of income sources and their contributing proportions to total income. Using this index as a dependent variable in regressions allows us to systematically quantify whether households experiencing losses in the immediate past had more or less diverse income portfolios. Second, to measure the specific role of forests in facilitating ex post responses to shocks, we study the share of total household income derived from forests following economic shocks. The forest income share is employed as a dependent variable in a two-step regression model to test the importance of asset ownership, forest access, household characteristics, and shock typology as factors conditioning household response to these events.

Findings indicate that households experiencing above-average losses tended to have more diverse sources of income in the subsequent period than their cohorts. In addition, we find that the index of diversification and the forest income share are both inversely related to farm size. This suggests diversification strategies may be more important in poor households with low agricultural capacity. Our analysis focusing on household forest use indicates that shocks precipitate greater use of the forest, confirming their apparent role as natural insurance against losses. Possession of land dampens this response, and nonland physical assets appear to effectively substitute for land in tempering forest use in response to shocks. The latter result suggests that nonagricultural assets may be as important in conditioning a household's ex post response to shocks as agricultural capacity. Results have both specific and general relevance for policies related to forest protection and governance, poverty eradication, and rural development.

II. EMPIRICAL STRATEGY AND SPECIFICATIONS

Our empirical strategy emanates from a multiple-period conceptual framework such as that of Rose (1999, 2001). The household owns specific assets, including labor, and in each period makes decisions about allocating household resources to different activities. In such a setting, households make adjustments to their portfolio of activities in response to changes in opportunities and returns, and conditional on assets available to deploy. Our primary conjecture is that unanticipated shocks alter these stocks of specific assets and produce changes in observed patterns of income generation. We therefore seek to measure empirically (1) whether household diversification patterns are correlated with past losses, (2) whether such patterns are sensitive to the types of assets held by the household, (3) whether responses differ depending on how particular assets are affected by shocks, and (4) whether such behavioral responses can be isolated for the specific case of forest resources.

Model 1: Income Diversification

We begin with the relationship between the value of shocks and patterns of income diversification. Model 1 examines the use of income diversification as a risk-coping strategy. We construct a Simpson's diversification index for the various sources of income in 2008. For household i, the diversification index D_i is defined as

$$D_i = 1 - \sum_j (p_{ij})^2, \qquad [1]$$

where p_{ij} is the proportion of income (combining both cash and the value of home consumption) originating from source j for household i. An index value of 0 indicates a single source of income, while a value of 1 indicates an infinite number of income sources of equal size (Vedeld et al. 2004). That is, as D approaches 1 it reveals an increasingly diversified income portfolio. A key virtue of this index is that it takes into account both the number of activities and the evenness of the income shares across the activities.[1] In addition, it is invariant to the household's total income. We use five categories of income: income from crops, income from livestock, income from forests, income from off-farm employment, and income from other sources (primarily remittances and land rental). With these five categories of income, a household receiving the same share of income from each would have a value of $D = 0.80$, which then is the maximum value D can take. For our sample, the mean value of D is 0.39, with a range of 0.003 to 0.73. The former is associated with a household in which 99.8% of total household income comes from crop production; the latter is the value for a household in which income comes from five categories, none of which accounts for more than one-third of total income. Shortcomings in our data preclude us from partitioning agricultural input costs to specific crops, and so we choose to treat crop production as a single category. We recognize, however, that considerable diversification in our sample takes place within agriculture itself. Unfortunately, this diversification is masked by our inability to accurately measure it.

The diversification index is the dependent variable in Model 1, which takes the form

$$D_i = \alpha_0 + \boldsymbol{\alpha}_1' \mathbf{X}_i + \alpha_2 W_i + \alpha_3 G_i + \alpha_4 SHOCK_i + \varepsilon_i, \qquad [2]$$

where $\mathbf{X}_i$ is a vector of household characteristics (age, sex, education and household size), W_i represents indices of household wealth (value of physical assets and area of land owned), G_i is a geographic control that indicates the physical distance from household i to its nearest market, and $SHOCK_i$ is the aggregate monetary value of all losses incurred between January 2005 and June 2007, expressed relative to the village average

[1] One drawback of this approach is that the Simpson index is sensitive to how finely one defines income sources. As a result, indices generally cannot be compared across studies.

household income in 2005; ε_i is an error term with expected value of zero. Regression 1A is a short regression. Variant 1B also includes a squared term for the relative loss to test for any nonlinear relationship between the relative loss and subsequent diversification. Regression 1C adds the household's total income, and variant 1D partitions the indicator of negative shocks into two components, one that includes only those losses that affected labor (defined as deaths and serious illnesses) and the other representing all other losses. Our primary empirical focus in these regressions is the point estimate for α_4. If households that experienced larger relative losses, on average, over the retrospective period tended to subsequently demonstrate more diverse income portfolios, the sign of α_4 will be positive. In part, the regressions represented by Models 1A–1D serve a diagnostic and descriptive role in this analysis, pointing to potential behavioral responses to losses encountered in the recent past. In addition, for a subsample of households we are able to control for past diversification. For the larger sample, of course, we cannot necessarily draw strong household-specific causal inferences from the regressions, since we cannot be certain that higher observed rates of diversification arise only in response to the observed shocks. In the case of the smaller sample, however, we use the temporal difference in the diversification index (i.e., $D_{2008} - D_{2005}$) as the dependent variable in an additional model (1E) to assess whether changes in the degree of diversification are correlated with shocks realized in the interim period.

Model 2: Forest Safety Nets

Our second econometric strategy is to measure the specific role of forests in the face of shocks. Because not all households in the sample use forests for subsistence or cash income, and because those that do use forests use them to different degrees, we approach the analysis using a selection model (Heckman 1979) to control for potential selection bias in the measurement of correlates with household forest income. The estimation procedure requires that we first model the decision to source income from the forest as a binary variable, using a probit model and an appropriate set of exogenous instruments for the forest-use decision. The forest income share is then modeled for those with positive forest income shares. Model 2 is therefore composed of a pair of jointly estimated regressions, a selection probit to explain the probability of forest use, and a regression to explain variation in intensity of forest use. As in the case of the diversification regressions, we estimate a series of regressions using the full cross section. These regressions take the form

$$F_i = \beta_0 + \boldsymbol{\beta}_1'\mathbf{X}_i + \beta_2 N_i + \varepsilon_{Fi}, \qquad [3]$$

$$S_i = \gamma_0 + \boldsymbol{\gamma}_1'\mathbf{W}_i + \gamma_2 SHOCK_i + \varepsilon_{Si}. \qquad [4]$$

In equations [3] and [4], F_i represents a dummy variable for forest income ($F_i = 1$ if forest income > 0 and $F_i = 0$ otherwise), S_i is our measure of the forest income share in 2008, $\mathbf{X}_i$ is a vector of household characteristics (household size and education of the household head) that determine which activities a household engages in, N_i measures nearness to the forest ($N_i = 1$ if the household lived in a village within 2 miles of the forest and $N_i = 0$ otherwise), $\mathbf{W}_i$ refers to a vector of household wealth indicators (including physical assets, livestock and land holdings). $SHOCK_i$ is the aggregate loss from shocks in the 2005–2007 period (in Ugandan shillings). The short regression is Model 2A. Model 2B adds a measure of the covariate loss incurred in household i's village, calculated as the average of the aggregate household losses in the village, exclusive of the loss experienced by household i. Model 2C adds variables for nonland assets as well as interaction terms between the household's loss and these assets. We use this model to measure whether assets matter in the context of shocks. As in the corresponding diversification regression, Model 2D partitions the loss variable into its constituent labor and nonlabor parts. Alternative (unreported) regressions that included subsets of regressors from [3] in [4], and also included second-stage variables as subset of the first-stage regression, gave similar estimates in terms of signs and significance. Utilizing the smaller sample that constitutes the balanced panel, Model 2E uses the temporal difference in the forest income share (i.e., $S_{2008} - S_{2005}$) as the dependent variable in the regression and bypasses the first-stage regression, since we observe forest shares for all but two households in this subsample. For all of the models, the error terms ε_{Fi} and ε_{Si} are associated with the selection and subsample equations, respectively. In order to ensure that our reported measures of variance are insulated from heteroskedasticity and potential spatial correlation, for all regressions we report robust standard errors, based on White's heteroskedasticity correction, which we cluster by village.

III. DATA AND STUDY SITE

Our data come from a survey of 234 households conducted in 2008 in Masindi district, Uganda. A subsample of these households ($n=70$) were also visited in 2005. As indicated above, this affords us the opportunity in the analysis to look carefully at changes in conditions and outcomes for this smaller group of households. Masindi is one of the poorest districts of Uganda (IFPRI 2001) and was purposely selected for this study because it is an area where the impacts of shocks are likely to be strongly felt by households (Government of Uganda 2007). It is located in the west-central part of the country, approximately 200 km from the capital city, Kampala, and borders the Democratic Republic of Congo. The annual rate of population growth is 3.6%, which places mounting pressure on the natural resources of the area, especially forests (MDLG 2008). The Budongo national forest reserve is located in Masindi district and is among the most biodiversity rich habitats of Uganda. It covers 793 km^2 of which 420 km^2 are Tropical High Forests (Bush et al. 2004).

Masindi district normally enjoys favorable climate, adequate annual rainfall of 1,300 mm, and fertile soils (MDLG 2008). However, data suggest long droughts may be increasing in frequency (Government of Uganda 2007). Floods, wind storms, and hail occur more occasionally. Health problems prevalent at the site include onchocerciasis, leprosy, guinea worm, iodine deficiency, malaria, cholera, and HIV/AIDS (MDLG 2008).

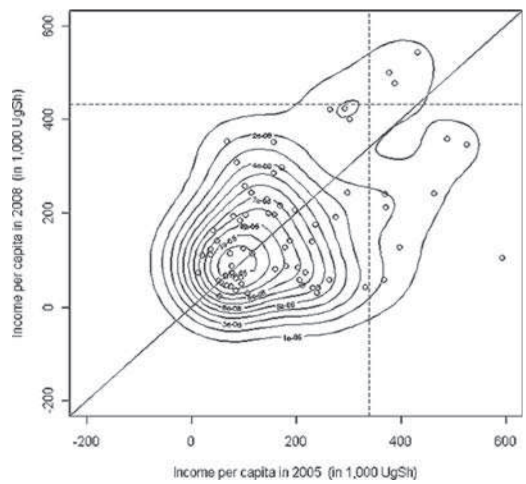

FIGURE 1
Bivariate Density of Household Income per Capita in 2005 and 2008 (See Text for Details)

Limited availability of health services coupled with inaccessible or unaffordable financial services contribute to the relative isolation of most families. Our sample of 234 households listed a total of 795 shocks during the reporting window.

In Figure 1 we use data on the balanced subset of those households observed in the two survey rounds to compare incomes in 2005 and 2008. The figure displays the bivariate kernel density contours of real income per capita (in constant 2008 Ugandan shillings). We have added to this joint-density chart dashed lines indicating the Ugandan poverty line of \$1.25 per person per day for 2005 and (in PPP-adjusted terms) for 2008.[2] During this period, the overall rate of economic growth in Uganda was positive, and so one might reasonably expect that many households in our sample would have experienced an increase in household income over the period. Such households are represented by points above the 45° line in Figure 1, but they constitute less than half of the subsample. Instead, a substantial proportion of households (54% of this subset) slipped backward over the period. In

[2] Circles indicate observed data; dashed lines indicate Ugandan poverty lines of 339,550 USh (\$1.25) per person per day in 2005 and 432,650 (CPI adjusted) USh in 2008.

TABLE 1
Household Transitions, Relative to Poverty Line (% of Households in Balanced Panel)

	Status in 2008	
Status in 2005	Below Poverty Line	Above Poverty Line
Below poverty line	83	0
Above poverty line	11	6

fact, much of the mass of the per capita income distribution lies below the 45° line *and* below the 2005 and 2008 poverty lines. As the data in Table 1 show, 11% of households moved from a position above Uganda's per capita poverty line in 2005 to a point below the poverty line in 2008. These households are represented by points in the southeast quadrant of Figure 1. Remarkably, no household in the subsample moved from a point below the 2005 poverty line to a point above the 2008 poverty line (the northwest quadrant of Figure 1).

Of course intertemporal movements of households across the income distribution can be caused by many factors, not all of them unanticipated or exogenous. To understand how households perceived their circumstances during this period, we asked them to catalog any negative shocks they had experienced between the first and second rounds of the survey. Our research design used a three-year recall for shocks because we specifically sought to pick up low-frequency events. To aid in recall, we provided respondents with a list of candidate shocks. For each shock identified, households were asked whether they experienced the shock and to estimate the total monetary cost or physical impact of the shock. We then converted any nonmonetary losses into monetary values based on reported market values of assets and crops. Figure 2 is a frequency histogram indicating the number of shocks reported by each household in our sample. The average and modal number of shocks reported was three. All households in the sample reported at least one shock of some magnitude, and more than 15% of households reported five or more shocks during the three-year recall period.

Table 2 lists the frequency with which shocks were reported. The most common shocks experienced were drought (70% of sample households), human illness (56%), and livestock loss (43%). Following Heltberg and Lund (2009) we classified the self-reported shocks listed in Table 2 into six categories for the purpose of analysis. These are (1) health related (illness or death); (2) weather related (drought, flood or hailstorm); (3) livestock or other major asset loss; (4) crop failure due to nonweather factors (such as crop raiding or pests); (5) crime, conflict, or theft; and (6) economic shocks (price shocks, loss of job, etc.). Table 3 provides data on the relative losses experienced by the sample households for each of these major categories, disaggregated by income quartile. Relative to total income in 2008, aggregate reported losses were greatest at the lowest income levels and represented a cumulative loss equal to 73% of total income in the lowest quartile. Although the absolute size of losses was positively correlated with income level, a consistent pattern displayed in the data is that, regardless of category, relative losses were smaller at higher incomes.[3]

We also asked households to report coping strategies used in response to identified shocks. These qualitative responses reveal information about the range of options available to households, especially when combined with information on household asset ownership and income-earning opportunities (Dercon 2000). The percentages of households employing different coping strategies are indicated in Figure 3. The most frequently reported response to a shock—reported by nearly half of the households that reported a shock—was a temporary reduction in consumption. Households reduced food and nonfood expenditures, the latter in some cases by withdrawing children from school and thereby avoiding school fees. This behavior accords with Beegle, Dehejia, and Gatti's (2006) em-

[3] In side regressions in which we regress relative losses on income levels, household characteristics, and asset levels, we find statistically strong patterns in which the magnitude of a relative loss is negatively correlated with income and asset levels and positively correlated with the age of the household head.

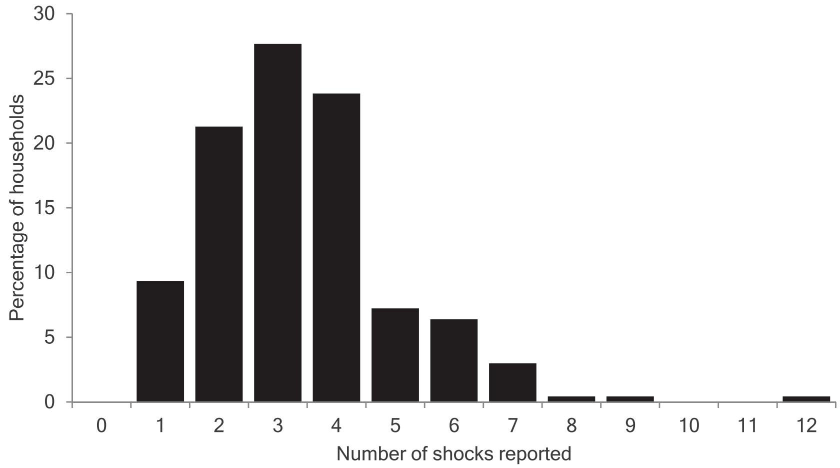

FIGURE 2
Frequency of Shocks Reported by Households in the Sample

TABLE 2
Frequency of Shocks and Percent of Households Reporting at Least One Occurrence

	Frequency	Households (%)
Labor shocks		
Serious illness	165	55.7
Death of household member/relative	75	27.7
Nonlabor shocks		
Drought	219	70.2
Livestock loss	118	43.4
Crop raiding by wild animals	88	26.8
Crop pest or diseases	32	8.5
Flood or hailstorm	28	11.9
Theft of cash or productive asset	27	11.1
Price shock	13	4.7
Crime or conflict	12	4.7
Theft of crop	7	3.0
Other asset loss	6	2.1
Loss of job of household member	3	1.3
Policy shock	2	0.9
Total number	795	234

Note: Shocks cover the period between January 2005 and June 2008.

pirical findings for Tanzania, as well as the prediction of Zimmerman and Carter's (2003) model in which poor households use consumption smoothing to buffer assets in the wake of shocks. Mutual insurance also appears in the sample: more than a third of households (37%) sought the help of friends or relatives. Among other coping strategies, households reported increasing their reliance on forest income (the combined total of cash income and the value of retained products sourced from forest, environmental, and woodland products) and off-farm income (here including all income arising from wage labor). As Figure 3 indicates, many households employed multiple coping strategies, either simultaneously or in sequence. Most forest use was for direct needs rather than cash. Fewer than 5% of households reported no response to an unanticipated event, and only 3.4% borrowed from formal financial institutions or NGOs. This latter pattern confirms a shortage of formal methods for bridging losses.

IV. RESULTS

Are Household Losses Correlated with Subsequent Diversification?

Income diversification can be both an ex ante risk management method and an ex post response to shocks. Although in practice it is difficult to isolate these strategies, we attempt to test whether diversification responds to shocks using the losses over a retrospective 30-month period as our indicator of household shock and an index of subsequent diversifi-

TABLE 3
Relative Losses for Overall and Specific Categories of Shocks, by Income Quartile

	Loss Relative to Income (%) by Income Quartile				All Households
	1	2	3	4	
All shocks	73	61	21	10	41
Health	27	24	9	4	16
Weather	21	20	6	2	12
Livestock	9	9	3	2	5
Crop	11	4	2	1	5
Theft or conflict	4	4	1	<1	2.5
Economic change	0.2	0.3	0.7	0.6	0.5
Number of observations	59	58	59	58	234

Note: See text for definitions of shocks; the loss measured relative to income is defined as the accumulated loss from shocks over a three-year period relative to annual income in the final year.

cation as the sign of a behavioral response. We recognize, however, that in the full sample we cannot control for the initial degree of diversification by the household so as to measure the impact of relative shocks on relative changes in the diversification index. Table 4 summarizes the ordinary least squares estimates of the income diversification model. The short regression (Model 1A) establishes the main empirical patterns observed, namely, that diversification—all other factors being equal—is approximately 10 percentage points higher in female-headed households, decreasing with land holdings, decreasing with distance from the market, and increasing with losses from exogenous shocks. Model 1B does not suggest any strong curvature in the shock-diversification relationship since the point estimate on the squared term is not significantly different from zero at any reasonable test level.[4] Opportunities to diversify income, at least within the range of experiences observed in this sample, appear to be relatively constant.

Model 1C adds to Model 1A total income as a regressor. Although the explanatory power of land holdings and distance to market is somewhat weaker in this model than in the shorter regressions, other patterns are robust to the inclusion of total income in the regression. Results suggest that diversification decreases slightly as one moves up the income distribution, consistent with the view that higher incomes accompany specialization. Even controlling for income, however, households that faced larger relative losses from shocks still had substantially greater measures of diversification in subsequent periods.

To gain additional understanding regarding whether the specific form of shocks might matter in shaping diversification, our final income diversification regression with the full sample (Model 1D) replaces the relative loss variables with two variables that segment the total loss into two constituent parts: those affecting family labor supply and those not affecting labor supply. Overall, we find point estimates for other variables in the regression that are roughly similar in sign, magnitude, and significance to those of previous models. Looking specifically at the point estimates for our disaggregated loss variables, it appears that nonlabor losses are more highly and strongly correlated with subsequent diversification than losses to labor. We find no statistically robust correlation between losses to labor and the degree of subsequent diversification. An intuitive interpretation of this result is that labor is the most easily reallocated asset within the household. For this reason, when nonlabor losses occur, households can reallocate labor to new activities. In contrast, when the household receives a labor shock, it is constrained in its ability to respond.

To summarize the results from the first four diversification regressions, we find patterns that are consistent with information obtained in village discussions that indicated that households searched for off-farm employment

[4] We find similar results when we restrict the period covered by losses to the immediately preceding 12 months.

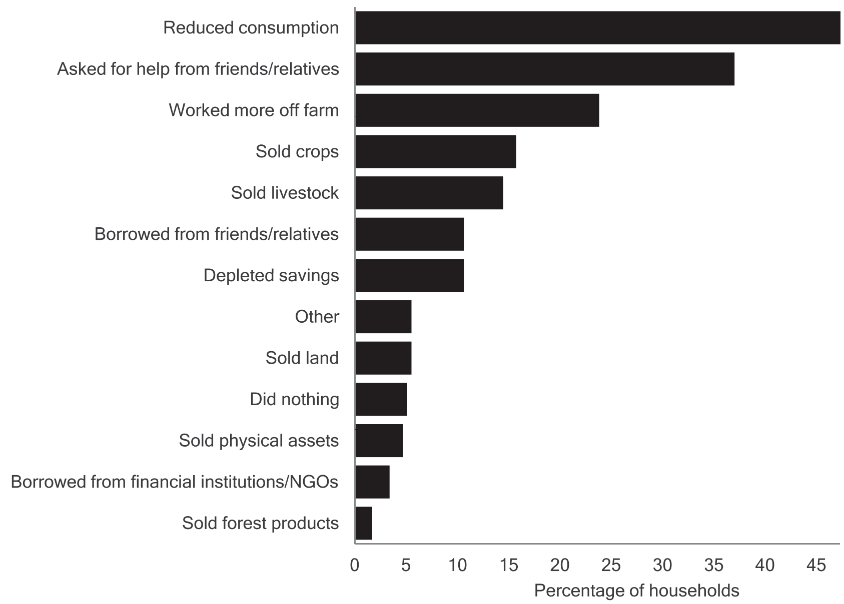

FIGURE 3
Coping Strategies Reported by Households in the Sample

at times of adversity. For example, in Busingiro village, focus groups reported that households left the village to fish or engage in casual labor during floods and droughts.[5] Although income diversification can be an ex ante strategy to mitigate the negative consequences from shocks, findings indicate that it also constitutes an important ex post strategy to deal with shocks. Put differently, the extent to which households are able to deal with shocks is highly correlated with their ability to diversify their income sources (Pattanayak and Sills 2001). In this sense, our results are consistent with households using diversification to cope with shocks.

For the full sample we find a statistically strong negative correlation between absolute income and diversification. This suggests that poor households tend to diversify more than rich households. In our sample, households in the highest income quartile derive around 80% of their income from crop production, on average. A similar pattern is reported by Vedeld et al. (2004) for meta-analysis of 54 case studies. In contrast, Abdulai and CroleRees (2001) report that poor households in southern Mali have less-diversified income sources than rich households. An explanation for our finding is that, broadly speaking, the wide variety of income earning opportunities in the study area mainly constitute low-return activities.

Larger land holdings are associated with a higher agricultural income, which itself may be related to households' specialization in agricultural production (Reardon et al. 1992; McSweeney 2004). Consistent with this view, our findings indicate that land holdings are negatively and significantly correlated with diversification of income sources. Households that focus efforts on crop production tend to have less diversity in their income-earning activities. A consistent finding from these models is that households headed by women have more diversified income portfolios than those headed by men. Tripp (2004) argues that female-headed households have less income from agriculture because they have more limited access to land, and therefore a greater

[5] Lake Albert is 25 km from the location of focus group discussions. Other types of on-farm and off-farm employment were mentioned in other villages.

TABLE 4
Income Diversification Regressions

Variable	Model 1A	Model 1B	Model 1C	Model 1D	Model 1E
Constant	57.34 (5.96)***	57.28 (5.93)***	54.99 (5.89)***	55.57 (5.96)***	0.47 (0.06)***
Household Characteristics					
Age of household head (years)	− 0.04 (0.09)	− 0.04 (0.09)	− 0.01 (0.08)	− 0.02 (0.09)	—
Female household head (0/1)	11.36 (3.14)***	11.50 (3.19)***	11.89 (3.14)***	11.83 (3.14)***	—
Household size (number of persons)	− 0.14 (0.35)	− 0.12 (0.36)	− 0.28 (0.35)	− 0.30 (0.35)	—
Education of head (years)	− 0.32 (0.42)	− 0.31 (0.42)	− 0.10 (0.43)	− 0.17 (0.42)	—
Household Wealth					
Land area owned (acres)	− 0.35 (0.11)***	− 0.36 (0.12)**	− 0.21 (0.10)**	− 0.18 (0.10)**	—
Value of physical assets (100,000 USh)	0.05 (0.07)	0.05 (0.07)	0.06 (0.06)	0.05 (0.06)	—
Total income (1,000,000 USh)	—	—	− 0.09 (0.03)***	− 0.10 (0.03)***	− 0.04 (0.02)**
Geographic Control					
Distance from the market (miles)	− 1.44 (0.82)*	− 1.41 (0.83)*	− 0.89 (0.83)	− 0.96 (0.83)	—
Shocks					
Loss/village average income (2005 USh)	3.50 (1.94)*	1.29 (6.29)	2.90 (1.82)*	—	—
Squared loss divided by village average income	—	0.61 (1.30)	—	—	—
Loss (to labor only) divided by income	—	—	—	1.29 (2.28)	− 0.02 (0.04)
Loss (to nonlabor) divided by income	—	—	—	11.18 (6.31)**	− 0.026 (0.04)
Diversification index (2005 value)	—	—	—	—	− 0.98 (0.14)***
Number of observations	230	230	230	230	70
R^2	0.16	0.16	0.20	0.20	0.53
F-test	8.90	8.28	8.27	7.59	—
p-value (F)	0.00	0.00	0.00	0.00	—

Note: Robust standard errors, clustered at village level, in parentheses. For Models 1A–1D the dependent variable is the diversification index (× 100); Model 1E uses the absolute *change* in the diversification index ($D_{2008} - D_{2005}$).
*, **, *** Coefficient is significantly different from zero at the 90%, 95%, and 99% confidence levels, respectively.

need to diversify their income sources. However, we find that even after controlling for land availability, female-headed households diversify more. Many women in the study area engage in brewing and other small business activities, although these are often relatively unremunerative.

Shifting attention to the small sample regression, Model 1E, we find it difficult to draw strong conclusions regarding the link between shocks and changes in diversification. On average, the measured value of D in this small sample fell approximately 20% between 2005 and 2008, from 0.51 to 0.42. The decline in diversification was considerably more pronounced for households that started out with higher rates of diversification, in reflection of the fact that a household that received a nonhomothetic income shock and did nothing would, on average, experience a decline in its value of D.[6] Overall, we find smaller diver-

[6] From a measurement perspective, it is possible to create scenarios in which, given an initial set of income sources, a particular shock or set of shocks could produce a higher value of D, even in the absence of behavioral changes. In most cases, however, the pure effect of an income shock is, ceteris paribus, to reduce household diversification vis-à-vis the household's initial value of D.

sification changes at higher incomes, although our inability to measure diversification within agriculture prevents us from providing a comprehensive view of risk exposure in the sample.

Do Households Use Forests as a Safety Net?

We now examine whether households specifically use forests to cope with shocks. Results for four variants of the jointly estimated maximum likelihood regressions of Model 2 are presented in Table 5.[7] We identify the first-stage forest-use decision using proximity to the forest, education of the household head, and household size.[8] In the context of the study area, these household characteristics are those most likely to influence the household's ability and choice to include forest use as an income-generating activity. Households closer to the forest are simply more likely to use forests due to lower costs of access. Moreover, since forest use in Uganda requires no formal education, and other available activities better capitalize on knowledge, we expect formal education to reduce the probability of forest use. Finally, because most forest activities are among the most labor intensive activities in this area, larger households are more likely to consider adding forest activities to their standard portfolio of livelihood strategies. Although the structure of Model 2 does not provide a straightforward method of testing for overidentification, we note that our point estimates are invariant in signs, significance, and magnitude to including subsets of our three candidate instruments in the second-stage regression. In addition, when we estimate the model using a pair of linear regressions and a standard instrumental variables approach, the results of postestimation overidentification tests support our two-step approach.

The probit model shows that larger households (with greater labor capacity) and those located closer to forests are more likely to engage in forest use, regardless of motivation. The probability of forest use declines with the educational level of the household head, which is consistent with the view that most forest-income opportunities require only unskilled labor, and that returns to education are higher in other rural activities. All point estimates from this first-stage regression are individually and jointly significant.

Shifting attention to the percentage of income derived from the forest, which in this framework should be understood to be measured conditional on the latent characteristics of forest use, we initially focus on the short regressions 2A and 2B. These results establish a basic pattern that is replicated in subsequent regressions, namely, that (1) the correlation between the forest income share and land holding is negative; (2) higher absolute losses from shocks (none of which correspond directly to forests) are positively correlated with forest reliance; and (3) the relationship between losses and forest use are best understood as responses to both idiosyncratic and covariate shocks, but idiosyncratic shocks probably play a stronger role in pushing households toward forest use. The latter reasoning is based on the inclusion in Model 2B of a control variable computed as the village average loss, exclusive of the household-specific loss for each observation. Although results provide some evidence that household forest use is positively associated with the size of a village-level shock, the result is not robust across specifications. This leads us to conclude that idiosyncratic losses are the primary drivers of shock-related forest pressure in this sample.

Our initial finding from these short regressions, therefore, is that larger absolute losses from shocks lead households to rely more on forests to cover their subsistence and cash needs. This finding is consistent with previous empirical studies that have identified a safety net role of forests (Godoy, Jacobson, and Wilkie 1998; Pattanayak and Sills 2001;

[7] The list of regressors used here is broadly similar to that for the diversification model, with a few exceptions. Most importantly, we use the household's total loss from shocks as an explanatory variable for the forest share, rather than the relative loss, since we want to avoid introducing into the regression any correlation that might exist between the relative loss variable and the income share as a result of forces affecting the denominator of both. This concern does not arise in the case of the diversification index.

[8] Although we find gender of the household head to be correlated with diversification in the regressions for Model 1, we observe no correlation between gender of the household head and forest use, and therefore do not include this variable in the regressions for Model 2.

TABLE 5
Forest Income Share Regressions

Variable	Model 2A	Model 2B	Model 2C	Model 2D	Model 2E
Forest Use (0/1)					
Constant	1.32 (0.52)**	1.29 (0.51)**	1.22 (0.53)**	1.23 (0.51)**	—
Proximity to forest (<2 miles from forest = 1)	1.48 (0.52)***	1.39 (0.57)**	1.39 (0.57)**	1.41 (0.54)***	—
Education of household head (years)	− 0.15 (0.04)***	− 0.14 (0.04)***	− 0.13 (0.03)***	− 0.13 (0.03)***	—
Household size (number of members)	0.13 (0.05)***	0.13 (0.05)***	0.13 (0.05)***	0.14 (0.05)***	—
Forest Income Share					
Constant	21.54 (1.73)***	2.88 (11.97)	16.26 (14.21)	21.15 (2.02)***	0.131 (0.022)***
Land area owned[a] (acres)	− 5.39 (1.33)***	− 4.96 (1.55)***	− 2.19 (1.59)	− 2.18 (1.46)	− 0.001 (0.008)
Physical assets[a] (100,000 USh)	—	—	− 2.88 (0.91)***	− 2.37 (0.95)**	− 0.012 (0.006)**
Livestock[a] (100,000 USh)	—	—	− 0.87 (1.36)	− 2.64 (1.42)*	− 0.002 (0.001)**
Loss from shocks[a] (USh)	0.39 (0.16)**	0.38 (0.15)**	0.52 (0.24)**	—	—
Village loss[a] (average excluding household *i*)		1.21 (0.71)*	0.18 (0.90)	—	—
Loss × physical asset value (100,000 USh)	—	—	0.08 (0.12)	—	—
Loss × livestock value (100,000 USh)	—	—	− 0.25 (0.16)	—	—
Value of loss to labor[a] (USh)	—	—	—	− 0.01 (0.14)	0.002 (0.003)
Value of nonlabor loss[a] (USh)	—	—	—	0.28 (0.12)**	0.007 (0.002)***
Forest income share (2005)	—	—	—	—	− 0.837 (0.037)***
Number of observations	219	219	219	219	70
Log-likelihood (R^2 for 2E)	− 887.2	− 886.5	− 878.7	− 879.5	0.58
Wald χ^2 (*p*-value)	10.4 (0.00)	6.9 (0.01)	2.7 (0.10)	3.2 (0.07)	

Note: Robust standard errors, clustered at the village level, in parentheses. For Models 2A–2D the dependent variable is the forest income share; Model 2E uses the absolute *change* in the forest income share ($F_{2008} - F_{2005}$).
[a] Variables measured in natural logarithm forms; at the time of the survey 1 USD was equivalent to 1,638 USh, on average.
*, **, *** Coefficient is significantly different from zero at 90%, 95%, and 99% confidence levels, respectively.

McSweeney 2004; Takasaki, Barham, and Coomes 2004; Fisher and Shively 2007; Khundi et al. 2011). The patterns are also consistent with discussions with focus groups in the villages of Kinogozi and Karongo. In the former, respondents pointed to charcoal production as the way some households responded to poor crops in 2007. In the latter village, a number of residents were migrants who had fled civil war in northern Uganda. These households indicated very weak social networks and difficulty accessing labor markets. Aside from cutting sugar cane on a nearby plantation, their main response to crop loss was to utilize forests.

Model 2C adds to the specification two additional household asset variables: physical assets other than land and the value of livestock. The general pattern suggests that accounting for these other assets weakens in both magnitude and statistical significance the explanatory power of land holdings. Those with larger landholdings still appear less likely to rely on forests, but other physical assets and livestock dampen household reliance on forests.

Model 2D is designed to focus on the specific form of assets held by a household, while at the same time splitting the observed shock into its labor and nonlabor components. Regarding the role of assets, the results are highly consistent with those from diversification regression Model 1C. We find that nonland physical assets and livestock both buffer forest use, and that their inclusion in the regression tends to weaken the explanatory power of land. These findings are in accordance with those found for livestock assets in Malawi (Fisher and Shively 2007) and fishing assets in Peru (Takasaki, Barham, and Coomes 2004). Although agricultural capacity matters for the use of forest products as an income source, we find land to be less important in shaping forest use in this sample than Fisher and Shively (2007) suggest for Malawi. Observed patterns confirm less reliance on forests at higher levels of wealth, but also indicate that small farm size may not necessarily precipitate high rates of forest use.

In the case of the specific form of shocks observed, patterns in the forest share regression are consistent with those of diversification Model 1D. Focusing attention on point estimates for the disaggregated loss variables, we again see that nonlabor losses are highly and strongly correlated with subsequent intensity of forest use. When losses are associated with labor, patterns of forest use are unchanged. Consistent with our interpretation that labor is more easily reallocated than other assets, we believe this strongly supports the conjecture that when nonlabor losses occur, households reallocate labor to the forest in order to compensate. In contrast, when losses are specific to household labor, households are constrained in their ability to reallocate labor to forest uses. While inference in this case is theoretical rather than econometric (since Model 2D does not control for what forest use may have been before the shock), these results are broadly consistent with those of Shively and Pagiola (2004), who argue that finding ways to gainfully employ rural labor outside of forests is likely to be the most robust strategy for reducing forest pressure.

An additional perspective comes from the results from Model 2E, in which we use the change in the forest income share as the dependent variable in a regression for our subsample. Among these households, only two had forest shares equal to zero, and therefore we skip the first-stage probit regression for forest use. Over the period studied, the overall forest income share declined approximately 4 percentage points, from 0.22 to 0.18. Results suggest this reduction was greatest for households with the largest forest income shares in the initial period, which perhaps corroborates reports of shrinking forest resources in the vicinity of some villages. We find no statistical support for a hypothesis that changes in forest income shares are related to the availability of land resources, but we find a small but statistically strong association between the stock of physical assets and changes in forest use that indicates a decline in forest reliance among households with relatively larger stocks of physical assets. When considering the loss variables, we find patterns broadly consistent with those of the diversification regressions. Shocks to labor are uncorrelated with increased forest pressure, consistent with the view that labor is the primary resource available for reallocation. In addition, shocks to nonlabor assets precipitate a reallocation of effort toward forest activities. As a complement to the cross-section regressions, therefore, we find these results to be suggestive of a causal impact of losses on forest use.

V. CONCLUSIONS AND POLICY IMPLICATIONS

We studied behaviors and outcomes for rural households living in forested areas of Uganda. We measured diversification of income sources in the face of unanticipated shocks and the specific role of forest resources in mitigating economic losses. We found that average rates of diversification, as measured by an index that incorporates both the number of income sources and their relative importance in total income, were larger for households that received proportionately larger income shocks in previous periods. Compared to their cohorts, female-headed households and those with below-average land holdings used a more diverse set of income sources.

Forests appear to provide important safety nets for rural households, especially when households encounter unanticipated losses. Not surprisingly, forests are used at higher rates by households nearer to the forest. Forest use is also more likely in larger households, presumably in a reflection of greater labor capacity for engaging in the labor-intensive activities associated with forest use. Levels of education are negatively correlated with forest use. Greater stocks of assets are correlated with lower rates of forest reliance in the sample. Importantly, stocks of nonland physical assets seem to serve as a relatively close substitute for land in reducing forest pressure. Although initial evidence suggested that individual use of forests is higher in the face of larger village-level shocks (perhaps confirming the existence of local safety nets), the result was not robust, leading us to conclude that idiosyncratic losses are the primary drivers of shock-related forest pressure in this sample. Controlling for past levels of forest use, we found that households experiencing shocks specific to nonlabor assets increased their use of forests. Our overall conclusion is that labor is the resource most easily reallocated in response to shocks. As a result, households are relatively unresponsive and especially vulnerable to labor shocks.

Important policy implications arise from these results. First, we see poor and female-headed households diversifying more than their cohorts. Therefore, to the extent some forms of diversification could improve household welfare—a conjecture that remains unproven here but is widely held—policies that create and strengthen alternative income-earning opportunities targeted at these groups might better enable them to withstand shocks. However, to the extent specialization leads to higher incomes—a pattern that seems broadly consistent with our data—policy makers must ultimately aim to help poor households realize the benefits from specialization (e.g., in off-farm activities or cash crops), while at the same time protecting them from the risks that may be inherent in some specialization strategies.

Second, development of better safety nets in forested rural areas would not only decrease vulnerability of households to shocks but also decrease forest pressure. Local market establishment and strengthening that supports diversification opportunities would be another means to reduce forest pressure, provided local markets do not promote sales of forest products harvested in an unsustainable manner.

Third, our results indicate that restricting access to forests without the parallel development of formal safety nets would further impoverish poor households that lack access to other coping mechanisms. Finally, we find that diversification and forest use respond to nonlabor shocks but not to labor shocks. This confirms that households do not routinely reallocate effort when losses arrive in the form of a shock to household labor. In such cases, asset-fixity predominates, and the primary household strategy appears to be to engage in "more of the same." For this reason, efforts to reduce shocks to labor, for example, through investments in health services, could be potentially welfare-enhancing for households, not just by improving labor productivity, but also by facilitating a greater range of responses when shocks to other assets occur. Given an adequate set of data on household time allocation, future efforts might fruitfully explore this issue in greater detail, for example by examining the link between economic losses, labor capacity, and forest use using more direct indicators of behavioral response, such as time allocation before, during, and after shocks.

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Paper 2

How Does Ethiopia's Productive Safety Net Program Affect Livestock Accumulation and Children's Education?*

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Abstract

We use panel data from Northern Ethiopia to investigate the welfare impact of Ethiopia's Productive Safety Net Program. We assess whether the program raised livestock asset levels and children's education among participant households. Using treatment effects models, we find that participants in the public work component invested more in livestock and children's education than non-participant households after controlling for selection into the program. Participation in the program helps to protect beneficiaries from sacrificing their children's education in response to shocks. Our conclusion remains the same when we control for the extent of down sale of livestock to avoid graduation from the program.

Keywords: Social protection, safety net, asset accumulation, education, Ethiopia, Africa

JEL codes: I32, I38

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1. Introduction

This paper examines the effect of a social protection program on asset accumulation behavior of rural households in Northern Ethiopia. Ethiopia has been heavily dependent on emergency food aid programs for more than a decade (Gilligan et al., 2008). Recurrent droughts and food shortages in the country were the main reasons causing appeals for relief interventions (Jayne et al., 2001). The country's emergency food aid recipients have been chronically food insecure and were unable to feed themselves even in good years. As a result, there was a need to provide long term assistance to these households (Nega et al., 2010). To this end, the government of Ethiopia (with joint effort of donors) launched a large scale social protection program in 2005, namely the Productive Safety Net Program (PSNP). It is different from the previous program as it provides predictable transfers to eligible households for a predictable period of time (Gilligan et al., 2008; Gilligan et al., 2009; Andersson et al., 2011; Government of Ethiopia, 2009; Bishop and Hilhorst, 2010). The program has two components: public works involving food-for-work and cash-for-work as well as direct support providing free food and cash. The main objectives of the PSNP are to reduce the food deficit of households, promote asset accumulation and prevent asset depletion (Government of Ethiopia, 2009).

We use panel data from Northern Ethiopia, Tigray region, to investigate whether the public work component of the PSNP allowed investment in two types of assets: livestock and children's education. To control for endogenous selection, we employ treatment effects model and estimate the average treatment effects on beneficiary households.

A growing body of literature examines the welfare implications of workfare programs operating at scale such as the PSNP. Earlier studies of the impacts of Ethiopia's PSNP suggest that PSNP increased consumption (Gilligan et al., 2009), improved tree holdings and had no effect on livestock holding (Andersson et al., 2011), decreased labor allocated to farm work (Siyoum, 2012), improved food security status and raised livestock holdings (Berhane et al., 2011b). Others have reported that the PSNP resulted in a decrease in children's time spent on domestic work (Woldehanna, 2009), decrease in child labor hours on public works (Hoddinott et al., 2009) and time spent in school (Tafere and Woldehanna, 2013).

Previous studies have either measured early impact prior to the maturity of the first phase of PSNP or relied on recall data to form baseline to examine asset accumulation effects of the program. Others that investigated outcomes after the end of the first phase either used recall data or outcomes after the start of the program. This paper contributes to the existing literature in three ways. One, it uses data prior to the start of PNSP (2003) as a baseline and compares it with outcome after the end of the first phase (2010). Two, it captures the situation at towards the end of the first five year period of PSNP when some behavioral responses are likely to occur given the uncertainty about continued participation in the program. We assess the potential terminal effect by using two alternative periods (2009-2003 and 2010-2003) in our econometric analysis. This allows us to detect potential strategic responses in households' livestock accumulation behavior to avoid exclusion or graduation from the program, which other studies were unable to do. Three, since the effect of the program on livestock accumulation and children's education is mixed in the literature, this study supplements the empirical evidence by combining “before/after” and “with/without” approach while controlling for selection in to the program.

Our econometric results suggest that the program has a positive effect on livestock holdings of participant households. Participant households show significantly larger average increase in livestock holding of 2.68-2.69 tropical livestock units than non-participant households in the first five year period of the PSNP, after controlling for sample selection and attrition bias. Furthermore, children within participant households achieve significantly greater level of education than children in non-participant households. In the face of labor related shocks (illness and death), participant households are able to invest more in their children’s schooling than non-participant households, although shocks negatively affect investment in children’s education. The tendency among some households to sell their livestock towards the end of the five year period, perhaps to reduce the probability of being graduated from the program, does not significantly affect our conclusions. Our findings demonstrate the safety net effects of the program for households that were able to participate in the public works.

2. The Productive Safety Net Program (PSNP) – Overview and Related Literature

2.1. Overview of the program

Ethiopia’s Productive Safety Net Program is a development oriented social protection program aimed at solving the chronic food needs of rural households in the country. In 2005, the program commenced by covering four regions of the country (Tigray, Amhara, Oromiya and SNNPR) aiming to reach more than 1.6 million households (5 million people) in 263 *woredas* [1](districts) identified as chronically food insecure areas (Legovini, 2006; Gilligan et al., 2009; Siyoum, 2012). It is the largest social protection program in Sub Saharan Africa (excluding South Africa) and initially took up an annual budget amounting to 500 million USD[2] (Legovini, 2006; Gilligan et al., 2008). Currently, the pastoralist areas of the country are included in the program and the size of the beneficiaries has increased to 8.3 million people in 319 *weredas* (Siyoum, 2012; Rahmato et al., 2013). The first phase of PSNP operated between 2005 and 2009. The second phase of the program is runs for an additional five years (2010- 2014).

Participation in the two components of the program, public works and direct support, depends on the labor endowments within the household. The public works component of the PSNP targets households endowed with labor capacity and involves contribution of labor by adult household members-over the age of 16-for building community assets (e.g. conservation structures, dams, roads, schools). The direct support component does not require labor input and it is for the elderly, disabled, sick or mentally challenged, pregnant women, lactating women and orphaned teenagers In return, beneficiaries get cash and/or food, mainly wheat and cooking oil (Berhane et al., 2011a). The public works component takes a greater share than the direct support component of the PSNP (Gilligan et al., 2008). In Tigray region, for example, 90 percent of the beneficiaries participate in the public work component while 10 percent receive direct support (Tigray Food Security Coordination office, 2009).

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[1] *Wereda* (district) is the next administrative unit above the *tabia* (villages) level. Within each *tabia* there can be three to four *kushets* (communities).

[2] 1.3% of GDP in 2010

The public works, in the form of either food-for-work (FFW) or cash-for-work (CFW), requires beneficiaries to work five days per month per household member for the period the PSNP is operational (usually six months in the agricultural slack season) (Sharp et al., 2006). The maximum number of days that a household member can work is 15 days per month (Berhane et al., 2011a). [3] The payment for the public work participants was initially 6 Ethiopian Birr per day in the case of CFW and 3 kg of cereals in the case of FFW. Adjustments were made for inflation over the period of the program and CFW participants received 8 birr and 10 birr per day in 2008 and 2010, respectively (Hoddinott et al., 2012). In some *weredas*, beneficiaries received a mixture of cash and food payments (Sabates-Wheeler and Devereux, 2010). Payments are not always timely or complete such that households get paid more than one month after the work (Berhane et al., 2011a). According to a report by Berhane et al. (2011a), receipt of entitled payment –calculated based on the family size and the maximum number of days entitled to work- varies by region and family size. In our study area, Tigray region, small families received up to 79 percent of their entitlement while large families received up to 60 percent (Berhane et al., 2011a).

Targeting takes place at multiple stages and the methods include both administrative and community components (Berhane et al., 2011a). Food Security Task Forces formed at the *tabia* (village) and *woreda* (district) levels together with the *tabia* and *woreda* councils undertake targeting of the PSNP beneficiaries. Eligible households are those found in the chronically food insecure *woredas;* that faced food gaps and received food aid in the three years before the start of the program; faced shocks that

[3] This labor cap rule implies that an able bodied individual can work on behalf of another household member provided that it does not exceed a maximum of 15 days in a month (Berhane et al., 2011).

caused significant depletion of assets and are without any support from family or other social protection programs (Government of Ethiopia, 2009). Additional criteria for targeting include endowment of household assets (land size, food stock, and labor availability); agricultural and non agricultural income; and specific conditions of households (female-headed households, households with chronically ill members and elderly-headed households looking after orphans) (Berhane et al., 2011a).

PSNP is part of the country's Food Security Program (FSP) and its goals are to reduce the food gap of households, promote asset accumulation and prevent asset depletion (Government of Ethiopia, 2009). It is expected that the program eliminates distress sale of assets at times of shocks and hence prevent asset depletion. Further, the program plans to bring asset accumulation through its combination with another component of the FSP, namely the Other Food Security Program (OFSP). The OFSP was transformed into Household Asset Building Program (HABP) in January 2010. It includes provision of credit and extension services to PSNP beneficiaries and aims to enhance agricultural productivity, food security and support asset accumulation (Berhane et al., 2011a; Hoddinott et al., 2012). Once PSNP beneficiaries achieve improved livelihoods, in terms of consumption and asset accumulation, they are expected to graduate from the program. Graduation therefore implies that participant households exit the program once they have attained better livelihoods and become food sufficient.[4] The enabling factors that are complementary for households' graduation are the support from the extension workers and financial institutions combined with the benefits from the community assets built by PSNP (Government of Ethiopia, 2009, Berhane et al., 2011a).

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[4] In some villages, there is self-graduation of households when they gain better income earning opportunities elsewhere. However, this is a rare phenomenon.

2.2. Theoretical links and recent literature on impacts of the program

Work fare programs such as the Productive Safety Net Program, involving FFW and CFW, can have a direct impact on the investment behavior of rural households. Particularly, the income benefit from the program can translate into investment in productive assets (such as livestock) and human capital (children's education). One, the cash income from CFW can be used to purchase livestock and pay for school. Two, the food benefit under FFW frees expenses that could have been used for food and hence allows investments. Further, households are able to maintain their stocks of productive assets in form of livestock, since such programs decrease the need to sell livestock at times of shocks. Put differently, it is possible that such programs reduce vulnerability and can even help households to climb out of poverty through investment in assets (Holden et al., 2006).

Public works programs may also have an indirect effect on investment in children's education since such programs require labor contribution. On the one hand, there may be negative effect on children's schooling outcome as children may be required to take care of their parent's work at home while adults participate in the public works. On the other hand, the income effect due to the program can promote sending of children to school. If the positive outcome outweighs the negative effect, public works can alleviate intergenerational poverty by enhancing investment in human capital (Porter and Dornan, 2010).

Impact of public works programs therefore ranges from protection of households from negative consequences of shocks to crowding-in of investment and reducing vulnerability. But, the size and even direction of some of these effects are highly context-and design-specific (Barrett et al., 2005; Hagos and Holden, 2006; Holden et al., 2006; Barrett et al., 2008).

There is a growing body of literature that investigates the impacts of Ethiopia's PSNP. One study that examined the early impacts of the PSNP was Gilligan et al. (2009) who used survey data collected in 2006 in four major PSNP regions (Tigray, Amhara, Oromiya and SNNPR). They used a retrospective approach to collect data prior to the start of the program. Their findings indicated that the program increased in consumption, prevented depletion of assets and had no effect on rates of asset growth. In relation to asset holdings, a study by Andersson et al. (2011) showed that the participation in PSNP did not increase livestock holding while the program induced greater tree planting. They based their analysis on panel data collected in 2002, 2005, 2007 and 2008 in South Wollo, Amhara Region, covering up to three years after the introduction of the program.

Berhane et al. (2011b) examined the effect of public works participation on food security, assets, transfers and non-farm activities using data from all PSNP beneficiary regions. Authors find that the program improved households' food security status, raised livestock holdings (except Tigray region), and had no effect on private transfers and start up of non-farm business. A qualitative study by Siyoum et al. (2012) described a positive link between labor availability with in public work participant households and effect on their livelihood. They found that greater percentage of labor-rich households used PSNP transfers to smooth their consumption compared to labor-sufficient and labor-poor households. Labor-rich households were able to protect their assets and invest in livestock using PSNP transfers. The study based its analysis on survey data from 2009/2010 for one of the chronically food insecure districts in Amhara region.

Another direction of research has been on the links between PSNP and children's education and time spent on public works. Using the Young Lives survey data for the years 2002 and 2006, Woldehanna (2009) found that the program significantly reduced children's time spent on domestic work and increased girls' time spent on their studies. He also found that the public works component of the PSNP significantly increased children's time spent on paid work. In another study, Hoddinott et al. (2009) provided evidence of reduction in child labor hours spent on public works. They assessed impacts using survey data from 2006 collected in four major PSNP regions of the country (one and a half years after PSNP started). Tafere and Woldehanna (2013) used Young Lives survey data in 2002, 2006 and 2009 and found that the public work component of the PSNP decreased the time spent in school and had a positive effect of school grade for age.

Most of the above studies carried out early impact assessments, i.e., before the end of the first phase of the program. The studies that carried out impact assessment after the end of the first phase do not use baseline data to compare with outcomes after the program's implementation. This study contributes new evidence to the literature by using baseline data to compare outcomes and measure impacts from the first full phase of the program. Our data allows us to combine with-without and before-after analysis while controlling for selection into the program. In addition, this paper uniquely tries to identify the potential influence on households' potential down-sale of livestock at the end of the first phase lest graduating from PSNP. Moreover, previous studies show mixed results concerning the effect of PSNP on livestock accumulation and children's education. This merits further empirical investigation and this paper contributes to this by examining program effects after controlling for selection.

3. Data and Descriptive Analysis

3.1. Field site and data

Data for this study comes from a household panel data survey in Northern Ethiopia, Tigray region - one of the chronically food insecure regions of the country. The defining characteristics of Tigray region include occurrences of frequent droughts, limited off-farm employment opportunities, and low credit availability (Bezu and Holden, 2008). The region has a population growth rate of 2.5 percent. Approximately one third (33 percent) of the region's population and 31 out of 34 *woredas* directly benefit from PSNP (Tigray Food Security Coordination Office, 2009).

This paper extracts its data from a five round household panel survey carried out in the period 1998-2010, with two to four years intervals in between. Initially, the survey in 1998 covered a stratified random sample of 400 households in 16 villages with 25 households in each village. In 2001, 2003, 2006 and 2010, there were follow-up surveys tracking the same households. The survey included information such as basic household characteristics, land and non-land assets, land use, livestock and crop selling activities, other income sources, PSNP membership and participation, shocks and household coping strategies. More detailed shock information was collected in the 2010 survey. The entire sample for our analysis contains a balanced panel of 333 households in the years 2003 and 2010. This allows us to carry out a pre- and post-program analysis. We tested for attrition bias based on Moffit et al. (1999) and found evidence of its existence.[5] [6] In section four, we describe how we corrected for it.

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[5] One out of the 16 communities (25 households) had to be dropped due to lack of cooperation in the survey. Additional attrition was due to more household-specific conditions such as migration, death and other reasons for non-availability.

[6] Table A1 in the appendix contains the results from the attrition bias test.

Our main variables of interest in this study are livestock holdings (measured in tropical livestock units-TLU) and children's education. The education variable is constructed as follows: First, we took the education level of children (age between 7 and 14) relative to the age-specific average education in our sample for 2003 and 2010.[7] Second, we took the variable constructed in the first step and generated average education of all children within each household for each year.

3.2. Participation in public works and direct support at study sites

Table 1 shows participation of sample households in the public works component of the PSNP (FFW and CFW) in each village. Levels of participation showed variation across study communities as it ranged from 17 percent (in Kihen village) to 75 percent (in Adi Selam village). On average, 47 percent of the sample households participate in public works. Participation in direct support is low with only 43 households (13 percent) participating. The highest village level participation in the direct support component is 25 percent (May Alem village).

In table 2, we present the distribution of public works participation by the gender of household head. Female-headed participant households are 37 in number comprising 39 percent of all female-headed households and 23 percent of the participant households. The male participants on the other hand take up 51 percent of male-headed households and 77 percent of the participant households. This implies that male-headed

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[7] There are five categories of education level. These are illiterate; able to read and write or church education; elementary; junior and secondary; and others. The categories took values from one to five, respectively. We used these categories in order to harmonize the differences in the way education was measured in the two survey years (2003 and 2010). We computed the age-specific average education by taking the mean of the education categories for a specific age group. For example, the average education for children aged seven in our sample (for 2003) is 1.49. If a seven year old child in a household is illiterate (taking value=1); then the relative education for the child is 0.67(1/1.49).

households are more likely to be participants in public works than female-headed households. Sharp et al. (2006) state that gender difference in the level of participation in the public works is due to the fact that female-headed households are more labor-poor and have fewer livelihood options. In conformity with this, our data indicate that a greater share of female-headed households have access to direct support which targets labor-poor households (see table 3). 22 percent of the female-headed households benefit from direct support while it is only nine percent of the male-headed households that receive free support.

This paper focuses on the effect of the public works component of the PSNP. PSNP public works participation appears to be cut in both ends of the wealth scale, with those too well-off on one side and those too labor-poor on the other side (direct support participants). Since it potentially leaves us with a problem of having a very heterogeneous counterfactual, we dropped direct support participants (43 households) in the empirical analysis.[8]

3.3. Are public works participant households different in characteristics and endowments?

Tables 4 and 5 contain the results of a two sample t-test for differences between participant and non-participant households.[9] Table 4 reports test results for major variables in the base year (2003) while table 5 shows results for 2010 (five years after the program started). Our data seem to suggest that participation mainly relates to labor

[8] Another line of reasoning is that investment decisions between public work participants and direct support beneficiaries are also likely to be different due to: (1) the former receive an earned income while the latter get free benefit, (2) the fact that the inherent characteristics between the two groups are distinct. Hence, including direct support beneficiaries in the main sample may bias our empirical result.

[9] Here, non-participants do not include direct support participants since they are dropped for the empirical analysis.

force endowment, household size, number of children and asset endowments. In 2003, households that later became members of the PSNP public works program are significantly younger and have more children than non-participants (see table 4). In terms of asset endowments, non-participant households on average own larger land area and are better endowed with livestock assets than participant households. The significant difference in livestock ownership, however, disappears when livestock holding is divided by land area; probably because land limits how much livestock households can accumulate. Geographical location variables do not seem to indicate significant differences between the two groups.

In 2010, the differences in the number of children and age of household head are similar to the year 2003 (see table 5). On the other hand, other demographic variables such as household size and number of literate children are significantly higher for participant households. Non-participant households continue to have significantly greater asset endowment (land and livestock) than the participants, like in 2003.

One can observe in Tables 4 and 5 that the changes in the major variables of interest (livestock and average children's education) between the two periods are not significantly higher for participant than non-participant households. We should not, however, conclude that the PSNP has no significant effect on these variables as we have not yet controlled for other variables possibly influencing these changes; selection bias and attrition bias in the sample. [10]

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[10] Kernel density distributions of change in TLU (not reported) indicates that participation in PSNP has contributed to stabilize the livestock holding of participant households as compared to non-participants (less variation in change).

3.4. How do public works participants perceive the benefits from PSNP?

We asked public works participants to report the benefits they obtained from PSNP. They cataloged benefits from a list we provided. Figure 1 shows the list of benefits as well as the number and percentage of public works participants that obtain the benefits. Among the 158 participant households, more than 60 percent (96 in number) reported a combination of at least three of the benefits. The majority of the participants (around 87 percent) indicated that the PSNP increased the food availability for consumption in the household. This relates to the fact that PSNP provides cereals and oil under the food-for-work program (Government of Ethiopia, 2009). As reported by 63 percent of the participants, the program reduced the need to migrate during agricultural slack periods. This is probably because the program's operational period is the agricultural slack period and household members stay within villages to participate in the developmental safety net projects. Respondents also indicated that the program reduced the need to sell livestock at times of harvest failure (56 percent of participants). This is consistent with one of the objectives of the PSNP, i.e., to prevent distress sale of assets at times of shocks (Government of Ethiopia, 2009). In one of the villages (Kihen), the village development agent pointed out that PSNP has minimized the sale of livestock and migration. Ability to send children to school due to the program is reported by 44 percent of the participant households. Other benefits mentioned include increased purchase of other goods and purchase of livestock (32 and 31 percent of participant households, respectively).

4. Empirical Strategy

4.1. Empirical Model

In order to investigate whether the PSNP induced investment in assets, we apply an endogenous treatment effects model using full maximum-likelihood. The treatment effects model, based on Heckman's selection model (Heckman, 1979), controls for selection bias attributed to treatment assignment when estimating the average treatment effect. This method is suitable as our econometric approach due to the potential existence of unobserved factors (Brown and Mergoupis, 2010) that may determine selection into the program and that may also be correlated with outcome variables that are used to identify impacts of the program. Our modeling approach involves assessing the impact of a binary endogenous treatment variable, conditioned by a set of exogenous variables (Cong and Drukker, 2000), on the outcome variable Y (livestock endowment and children's education). We specify the model in the following form:

$$D_{it2}^{*}= \alpha_0 + \alpha_1\mathbf{X}_{it1} + \alpha_2 L_{it1} + \alpha_3 G_{it1} + \alpha_4 Z_{it1}+ v_i \tag{1}$$

$$D_{it2}= \begin{cases} 1 & \text{if } D_{it2}^{*} > 0 \\ 0 & \text{if } D_{it2}^{*} = 0 \end{cases} \tag{2}$$

$$Y_{it2}- Y_{it1}= \beta_0 + Y_{it1}+\beta_1\mathbf{X}_{it1} + \beta_2 L_{it1} + \beta_3 G_{it1} + \beta_4 S_i + \beta_5\widehat{D_{it2}}+ \beta_4 C_i +\varepsilon_i \tag{3}$$

Equations (1) and (2) model the treatment assignment. D_{it2}^{*} in equation (1) is a latent variable conditioned by a vector of regressors that determine participation in the program. The observed value of D_{it2}^{*} is represented by D_{it2} in equation (2). It renders 1 for non-negative values of D_{it2}^{*} and zero otherwise (equation 2). The variable Y_i is our outcome variable (livestock endowment or children education) and forms the dependent variable in the second stage [equation (3)]. The dependent variable is the change in livestock ownership or children education (Y_{it2}- Y_{it1}) between 2010 (t2=end of first five year period of PSNP) and 2003 (t1=before implementation of PSNP). In the livestock model, we alternated the end years between 2010 and 2009 to check the variation in livestock dynamics caused by the potential down sale of livestock towards the end of the first phase of the program (to avoid graduation). $\mathbf{X}_{it1}$ is a vector containing household characteristics in 2003 (age, gender and education of the household head; endowment of female and male adult labor force; and a binary variable for any off farm income other than PSNP). [11] L_{it1} represent farm size in 2003 (in *tsimdi)*[12]; G_{it1} represents geographic variables including a dummy variable for market access in 2003 and regional dummies[13]; and S_i refers to a binary variable representing whether the household faced any severe shock between 2007 and 2010.

In the model for children's education, we include labor related shocks (illness and death of a household member) to assess its effect on human capital formation. The model also has an interaction term between participation in PSNP and labor related shocks which allow assessing whether PSNP buffers the negative consequences of shocks. G_{it1} in the children's education model adds distance from the household dwelling to primary school in 2003 (in minutes).The predicted probability of participation ($\widehat{D_{it2}}$), which enters the second stage in equation 3, is the variable of interest. Positive and significant values of β_5 imply accumulation of livestock and enhanced investment in children's education attributable to the PSNP after controlling for selection bias.

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[11] We used 2003 variables as explanatory variables in order to be able to control for pre-treatment characteristics.

[12] 1 *tsimdi*=2500 meter square

[13] Regional dummies refer to four zones from which the sample was taken.

To make sure that our results do not suffer from attrition bias- due to those households that dropped out when forming the balanced panel, we corrected for it following Moffit et al. (1999). First, we ran an attrition probit model where the dependent variable takes value one for those that stayed in the sample and zero otherwise. Second, we calculated the inverse mills ratio from the attrition probit and included it in the second stage. C_i in equation (3) denotes the attrition bias correction variable (inverse mills ratio). The attrition probit results showed that households with smaller land area and no off-farm income sources have higher chance to leave the sample (see table A1 in the appendix). This is probably because little land available is a push factor and access to off-farm income is a pull factor that may have caused some households to have given up their rural base and have left the village. [14]

One of the limitations in our analysis is that we are unable to control for effects of PSNP's community asset developments. The community asset developed via the PSNP generates an indirect benefit for both participants and non-participants. Our study assesses only the direct benefit for targeted beneficiaries versus non-beneficiaries. This implies that we are likely to underestimate the total benefits from the program. Another limitation in this paper is that we do not control for complementary programs (OFSP/HABP). Studies carried out by Gilligan et al. (2009) and Hoddinott et al. (2012) showed that the combination of the PSNP with OFSP increases the magnitude of the program effect. Hence, we expect that our findings underestimate the effect of the program.

[14] We rely on the non-linearity of the attrition probit model to identify it in the outcome equation since we lack instruments. Our results showed that the attrition bias correction variable (inverse mills ratio) is statistically insignificant in the outcome models. Hence, we are less concerned about the attrition problem.

4.2. Identification strategy

The treatment effects model requires an identifying variable that affects the probability of being treated (participation in the public works component of the PSNP) but does not directly influence the outcome variables. We include Z_{it1} in equation (1) as an instrumental variable to identify the second stage regression. In the livestock model, Z_{it1} represents agro-ecological zones in the sampled villages. We argue that this variable affects the likelihood of households' participation in the program but does not directly affect investment in livestock. Livestock are equally important in all agro-ecological zones while the program is likely to include more households in locations with more adverse agro-climatic conditions. Z_{it1} in the children's education model is the age of the household head in the base year (2003). While the head's age affects the probability of participation, we assume it does not directly influence the decision to invest in children's education. We carried out likelihood ratio tests to check the validity of the exclusion restrictions by taking the following steps. First, we estimated the main model; second, we included the instrument in the second stage of the main model and ran a second regression; and third, we employed the likelihood ratio test. The instruments satisfied the exclusion restriction, i.e., the equations are identified and the likelihood ratio test did not detect any significant correlation between the instruments and the outcome errors.[15]

5. Results

5.1. Does the PSNP help households to accumulate more livestock?

Table 6 summarizes the results from the treatment effects model with change in livestock holding as the dependent variable. Models 1A and 1B in the table test whether

[15] See table A2 in the appendix.

the program allowed households to accumulate livestock at the end of the first phase of the PSNP. While Model 1A uses 2009 as an end year, Model 1B uses 2010 as an end year.

Results in the first stage probit regression (measuring the probability of participation) indicate that households headed by older individuals are less likely to participate in the program. The coefficient is significant at 10 percent level of significance. A plausible explanation is that as the age of the household head increases, chances are that the individual becomes less able to participate in the public work component of the program. This is consistent with the targeting criteria in the public works. Old age may also mean asset accumulation and hence less dependence on the support overall.

The second stage estimates in Table 6 portray that participation in the public works component of the PSNP enhanced accumulation of productive assets in the form of livestock. The positive and significant coefficient (at 10% level) for the predicted value of public works participation demonstrates this. As can be seen in Models 1A and 1B, participant households had 2.68-2.69 TLU larger increase in livestock holding compared to the non-participant households over the period under consideration after correcting for selection bias and attrition bias. Our results are significantly different from a study conducted by Andersson et al. (2011) using panel data from South Wollo zones of Amhara Region in Ethiopia. They found no significant improvement from PSNP participation on livestock holdings in their study area. Berhane et al. (2011b) also reported that the program did not enhance livestock accumulation in Tigray region. The different finding in our analysis may be due to the differences across locations or the fact that we are able to control for selection bias due to unobservable factors.

One noticeable finding in Models 1A and 1B is that one TLU unit increase in the initial livestock endowment in 2003 reduced the growth in the livestock endowment by 0.48-0.57 TLU in the period 2003-2009/10. This is probably due to the diminishing returns to investment in livestock attributed to the land/fodder constraint. Households with larger male labor force had a significantly higher growth in their livestock holding (Model 1B). On the other hand, larger female labor force endowment (Model 1A and 1B) and female-headship (Model 1B) did not seem to encourage livestock accumulation. It may be that male labor is more involved in rearing livestock while females are more involved in other activities such as household chores, collection of water and firewood.

Information about graduation plans for PSNP spread in 2010. This may have resulted in some strategic reactions among PSNP participants in their livestock accumulation behavior in order to avoid graduation from the program. In our survey, we observed that 17 households had sold substantial amounts of livestock from 2009 to 2010, of which 13 are participants in PSNP. This constitutes four percent of the sample households and eight percent of PSNP participant households (13 out of 158). [16] We expected results to be different when considering the two time periods in Models 1A and 1B. Contrary to our expectation, it was not sufficient to change the basic effect of the PSNP on livestock accumulation since findings are consistent in Models 1A and 1B. The negligible difference in the coefficient for predicted public work participation in the two models shows that the extent of down sale did not significantly affect the conclusion of our study.

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[16] In order to see if this affected our econometric analysis, we checked whether those that sold significant number dropped out of our sample in forming balanced panel. Our data indicates that most of these households (17 out of 21 households) still appear in our balanced panel.

In order to investigate the livestock accumulation pattern closely, we ran separate regressions for participant and non-participant households. [17] We then plotted the predictions from the regression for the two groups. For this part of the analysis, we included the initial survey year (1998) and formed a balanced panel for the three periods (1998, 2003 and 2010). Figure 2 shows the livestock endowment pattern for participants and non-participants in the years 1998, 2003 and 2010. In conformity with the regression results in table 6, the figure indicates that participant households showed better accumulation of livestock assets, after joining the PSNP. In sum, findings suggest that the program allowed households to accumulate livestock assets and/or protected against distress sales of livestock over the period under consideration.

5.2. Has the PSNP led to more investment in children's education?

We test the impact of the PSNP on children's education in Model 2. Table 7 contains results for Models 2A and 2B by taking the change in the average education level of children (age group of 7-14) within the household as a dependent variable. Model 2A forms the initial model without including an interaction term. Model 2B expands from Model 2A by incorporating an interaction term between labor shock and PSNP participation. Estimation results in both models are consistent in terms of sign and significance of the other variables.

Results in Table 7 reveal that PSNP beneficiaries invest more on their children's education than non-beneficiaries. The point estimate for PSNP participation, which is significant at 10% level, shows that the average children's education increased more for the participant households than for the non-participant households. Children in participant households have 0.43-0.48 units larger increase in their average education

[17] Regression results can be obtained from authors upon request.

level compared to children in the non-participant households, on average. This finding suggests that beneficiary households are enabled to send their children to school, indicating an indirect benefit that public works participants obtain. Our result is consistent with findings in a previous study by Hoddinott et al. (2009). Their study, which focuses on the four major PSNP regions (Tigray, Amhara, Oromiya and SNNP), finds that the program decreased child labor hours spent on public works. In our data, approximately 44 percent of the participant households reported that they were able to send their children to school due to the PSNP.

A notable finding is that the increment in educational investment is lower for households with higher initial education level of children in 2003. The negative and highly significant coefficient (at 1% level of significance) for average children's education in 2003 confirms this finding. PSNP therefore appears to particularly have encouraged children's education in households with more education-poor children. This may be associated with the limits to how much more education can be obtained for children in this age group. Results also indicate a positive correlation between the maximum education level achieved by adults in the households and the level of investment in children's education. The more educated the adults are, the higher average education of children within the household.

One would expect lower schooling outcomes as a result of labor shocks (such as illness and death). In line with this, our findings in table 7 indicate that households that faced labor shock (illness and death) showed a lower increase in the average education of children, *ceteris paribus*. This, however, was to a less extent the case for participant households. The coefficient estimate for the interaction term between program participation and labor shock dummy, which is positive and significant at five percent level, demonstrates this. Participant households showed significantly less negative effect (-0.35+0.25=-0.10) on children's education in the face of labor shocks compared to the non-participant households that experienced the same type of shocks. An implication is that the program to a large extent neutralized the negative impact of labor-related shocks on investment in children's education. This finding is similar to the finding of de Janvry et al. (2006) showing that a conditional cash transfer program in Mexico reduced the need to take children out of school at times of shocks. [18]

To closely inspect the change in children's average education, we plotted the predictions of separate regressions for participants and non-participants (see Figure 3). [19] Again, we included the initial survey year (1998) to examine the pattern of change. One can clearly observe that participants showed an improvement in the children's average education compared to the non-participants. In general, participant households seem to have invested significantly more on children's education than non-participants after the introduction of PSNP.

6. Conclusion

This study examined the impact of Ethiopia's Productive Safety Net Program on livestock asset accumulation and investment in children's education during the first five years of the program. It used two rounds of panel data from rural households in Northern Ethiopia, Tigray region. By using treatment effects model, which controls for selection bias due to unobservable factors, we found that the program stimulated livestock accumulation among PSNP beneficiary households as compared to non-

[18] Since the decisions to invest in children's education and livestock are potentially interdependent, we carried out an additional robustness test by including livestock holding (2003) in both stages of Model 2 (not reported). The estimates for children's education did not change significantly and TLU was statistically insignificant.

[19] Regression results can be obtained from authors upon request.

beneficiary households, after correcting for attrition bias in the sample. Results show diminishing returns to livestock accumulation since households with low initial livestock endowments accumulate more livestock. An explanation for this is the scarcity of land and/or fodder that is mostly obtained from households' private land. Importantly, results show that the potential down sale of livestock- to avoid graduation from the program-did not significantly reduce the positive impact of the program on livestock accumulation.

Findings reveal that participant households invested more on their children's education than the non-participants, after controlling for selection into the program and the level of children's education before entering the program. There seems to be an indirect benefit gained from participating in public works in terms of the promotion of human capital formation and particularly so for households with children lagging behind in their level of education. Study results also showed that labor-related shocks like illness and death are negatively correlated with investment in children's education. Public work participant households who faced these shocks, however, were significantly less negatively affected in terms of children's education than non-participant households, also demonstrating the safety net effect of the program. This indicates that the negative consequence of the shocks to a less extent hindered participant households from sending their children to school.

In general, the program has allowed asset accumulation and served as a safety net for participant households who would have become worse off without the program. Given the findings that the program buffered households against shocks (in terms of reduced destocking of livestock and lower need to take children out of school), an issue of concern is the sustainability of the effectiveness of the program in terms of providing long-term investment opportunities to the participants when the program phases out. At the time when the program phases out or households graduate from the program, there is a need to ensure that supporting schemes such as credit access and non-farm employment opportunities are created which then create investment opportunities to vulnerable poor rural households.

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Table 1: Participation in public works by village

	Public Works				
	Non-Participants				
Village			Participants		Total
	#	%	#	%	#
Adi Menabir	15	71	6	29	21
Adi Selam	6	25	18	75	24
Asmena	9	39	14	61	23
Dibdibo	13	59	9	41	22
Genfel	13	62	8	38	21
Hadegti	14	67	7	33	21
Hagereselam	14	58	10	42	24
Kihen	19	83	4	17	23
Mahbere Genet	8	32	17	68	25
May Adrasha	12	71	5	29	17
May Alem	6	30	14	70	20
May Keyahat	6	26	17	74	23
Samre	13	59	9	41	22
Seret	12	50	12	50	24
Tseada Ambora	15	65	8	35	23
Total	175	53	158	47	333

Note: Participation variable is for the survey year 2010 which is considered as a measure of participation between the years 2005-2010(i.e., the first phase).

Table 2: Participation in public works by gender

Sex of Household Head	Public works participation				
	Non-Participants		Participants		Total
	#	%	#	%	#
Male	117	49	121	51	238
Female	58	61	37	39	95
Total	175		158		333

Table 3: Participation in direct support by gender

Sex of Household Head	Direct Support participation				
	Non-Participants		Participants		Total
	#	%	#	%	#
Male	216	91	22	9	238
Female	74	78	21	22	95
Total	290		43		333

Table 4: Mean values of household characteristics and endowments (2003) for public works participants and non participants (2010)

Variables(2003)	Non-Participants	Participants	t-tests
Household Characteristics			
Household head age	53.9 (1.24)	50.8 (1.09)	**1.91**
Household head sex(1=female)	0.27 (0.04)	0.28 (0.04)	-0.11
Head's education(1=literate)	0.37 (0.04)	0.35 (0.04)	0.41
Household size	5.30 (0.20)	5.65 (0.18)	-1.32
Number of children	2.31 (0.13)	2.70 (0.13)	**-2.09**
Number of adult females	1.26 (0.06)	1.39 (0.06)	-1.42
Number of adult males	1.42 (0.10)	1.32 (0.08)	0.74
Number of educated children	0.81 (0.08)	0.85 (0.07)	-0.33
Average education of children	1.03 (0.04)	1.01 (0.04)	0.33
Endowments			
Land area(*tsimdi*)[a]	5.43 (0.33)	4.32 (0.23)	**2.83**
Number of oxen	1.01 (0.09)	0.78 (0.07)	**2.10**
Number of oxen per land area	0.23 (0.03)	0.23 (0.03)	-0.14
TLU	3.14 (0.30)	2.33 (0.20)	**2.32**
TLU per land area	0.69 (0.08)	0.66 (0.07)	0.31
Geographical Location(walking minutes)			
Distance from primary school	36.5 (3.25)	30.8 (2.09)	1.53
Distance from secondary school	131.6 (8.55)	121.1 (8.30)	0.88
Number of observations	132	158	

[a] 1*tsimdi*=0.25 ha. [b] Note: Standard errors in parenthesis.

Table 5: Mean values of household characteristics and endowments (2010) for public work participants and non-participants (2010) (After completion of first phase of PSNP)

Variables(2010)	Non-Participants	Participants	t-tests
Household Characteristics			
Household head age	56.2 (1.16)	54.0 (1.09)	1.42
Household head sex (1=female)	0.28 (0.04)	0.23 (0.03)	0.90
Head's education (1=literate)	0.33 (0.04)	0.29 (0.04)	0.63
Household size	5.11 (0.22)	5.70 (0.16)	**-2.19**
Number of children	1.90 (0.15)	2.25 (0.13)	**-1.74**
Number of adult females	1.42(0.07)	1.56 (0.07)	-1.34
Number of adult males	1.49 (0.10)	1.59 (0.10)	-0.71
Number of literate children	0.98 (0.09)	1.26 (0.08)	**-2.29**
Average children's education	1.01 (0.03)	1.06 (0.02)	-1.21
Endowments			
Land area(*tsimdi*)[a]	5.19 (0.33)	3.87 (0.23)	**3.36**
Number of oxen (2010)	1.23 (0.09)	0.95 (0.07)	**2.55**
Number of oxen per land area (2010)	0.34 (0.04)	0.32 (0.03)	0.53
TLU (2010)	3.70 (0.27)	2.53 (0.16)	**3.83**
TLU per land area (2010)	1.05 (0.11)	0.86 (0.07)	1.44
Number of oxen (2009)[c]	1.53 (0.12)	1.17 (0.08)	**2.56**
Number of oxen per land area (2009) [c]	0.44 (0.05)	0.39 (0.04)	0.90
TLU (2009) [c]	4.45 (0.31)	3.19 (0.21)	**3.45**
TLU per land area (2009) [c]	1.31 (0.16)	1.11 (0.09)	1.11
Geographical Location (walking minutes)			
Distance from primary school	28.5 (1.58)	29.4 (2.00)	-0.34
Distance from secondary school	107.6 (7.29)	103.2 (6.59)	0.45
Shocks in past years			
Any severe shock (2007-2010)	0.62 (0.04)	0.63 (0.04)	-0.20
Any labor related shock (2007-2010)	0.11 (0.03)	0.18 (0.03)	**-1.72**
Number of observations	132	159	

[a] 1*tsimdi*=0.25 ha. [b] Note: Standard errors in parenthesis. [c] Livestock endowment for 2009 based on recall.

Table 6: Impact of PSNP Public Works on Livestock Holdings

	Model 1A (2009-2003)	Model 1B (2010-2003)
Change in Tropical Livestock Units		
Tropical Livestock Unit 2003	-0.48	-0.57
	(0.10)***	(0.09)***
Age of Household Head 2003	0.02	0.01
	(0.02)	(0.02)
Female-headed household 2003	-0.58	-0.79
	(0.57)	(0.44)*
Education of head 2003 (1=literate)	-0.07	0.26
	(0.42)	(0.36)
Land area in Tsimdi 2003 [a]	0.11	0.09
	(0.08)	(0.08)
Number of adult females 2003	-0.55	-0.71
	(0.29)*	(0.21)***
Number of adult males 2003	0.30	0.37
	(0.21)	(0.16)**
Number of children 2003	0.24	0.13
	(0.15)	(0.13)
Any very severe shock 2007-2010 (1=Yes)	-0.58	-0.50
	(0.40)	(0.37)
Any off-farm income 2003 (1=Yes) [b]	0.06	-0.13
	(0.51)	(0.39)
Access to a major market 2003 (1=Distant)	-0.60	-0.54
	(0.49)	(0.37)
Public works participant	**2.69**	**2.68**
	(1.54)*	**(1.60)***
Zone 1	-2.38	-2.10
	(0.89)***	(0.85)**
Zone 2	-0.96	-1.43
	(0.62)	(0.52)***
Zone 3	-1.03	-1.63
	(0.84)	(0.70)**
Constant	1.63	2.27
	(1.95)	(1.65)
Public Works Participation 2010 (1=Participant)		
Age of Household Head 2003	-0.01	-0.01
	(0.01)	(0.01)*
Female-headed household 2003	-0.07	-0.09
	(0.24)	(0.23)
Education of head 2003 (1=literate)	-0.08	-0.18
	(0.21)	(0.20)
Land area in Tsimdi 2003 [a]	-0.01	-0.02
	(0.04)	(0.04)

Table 6 continued		
Number of adult females 2003	0.13	0.16
	(0.12)	(0.12)
Number of adult males 2003	-0.08	-0.06
	(0.09)	(0.09)
Number of children 2003	0.04	0.05
	(0.07)	(0.07)
Any very severe shock 2007-2010 (1=Yes) [c]	0.30	0.33
	(0.20)	(0.21)
Any off-farm income 2003 (1=Yes) [b]	-0.15	-0.14
	(0.21)	(0.20)
Access to a major market 2003 (1=Distant)	-0.13	-0.07
	(0.19)	(0.18)
Tropical Livestock Unit 2003	-0.03	-0.04
	(0.04)	(0.04)
Zone 1	1.13	1.15
	(0.29)***	(0.33)***
Zone 2	0.61	0.62
	(0.26)**	(0.26)**
Zone 3	0.85	0.87
	(0.26)***	(0.27)***
Agro ecological zones [1=kola (dry)] [d]	-0.62	-0.53
	(0.24)***	(0.21)**
Constant	0.29	0.31
	(0.62)	(0.59)
Observations	290	290
Log likelihood	-839.87	-763.69
Wald chi2	9.40	18.88
P-value	0.00	0.00
Anthro [e]	-0.97	-1.30
	(0.49)**	(0.63)**
Lnsigma	1.08	0.91
	(0.11)***	(0.10)***
Attrition bias correction (Inverse Mills Ratio)[f]	-1.65	-1.22
	(2.41)	(2.02)

* Significant at 10%; ** significant at 5%; *** significant at 1% Note: Bootstrapped standard errors in parentheses (400 replications) [a] 1*tsimdi*=0.25 ha [b] Off farm income excludes FFW/CFW income, [c] Second stage variables included as a control, [d] Instrument [e]Anthrho is the variable that tests and corrects for standard selection bias, [f] Attrition bias correction for households that dropped out of the sample.

Table 7: Impact of PSNP Public Works on Children's Education

	Model 2A	Model 2B
Change in average children's education (2010-2003)		
Average children education 2003	-0.97	-0.97
	(0.06)***	(0.07)***
Female-headed household 2003	-0.21	-0.21
	(0.12)*	(0.11)*
Education of head 2003 (1=literate)	-0.03	-0.04
	(0.06)	(0.06)
Maximum level of adults' education 2003 [a]	0.03	0.03
	(0.01)**	(0.01)**
Land area in Tsimdi 2003 [b]	0.01	0.01
	(0.01)	(0.01)
Number of adult females 2003	0.00	0.01
	(0.03)	(0.04)
Number of adult males 2003	-0.05	-0.05
	(0.03)	(0.03)
Number of children 2003	-0.05	-0.05
	(0.03)*	(0.03)*
Any labor shock 2007-2010 (1=Yes)	-0.18	-0.35
	(0.08)**	(0.11)***
Any labor shock*public work participation		0.25
		(0.11)**
Any off-farm income 2003 (1=Yes) [c]	0.08	0.07
	(0.07)	(0.07)
Access to a major market 2003 (1=Distant)	-0.07	-0.07
	(0.06)	(0.06)
Distance from primary school 2003 (hours)	-0.04	-0.05
	(0.07)	(0.07)
Zone 1	-0.03	-0.02
	(0.11)	(0.10)
Zone 2	0.18	0.17
	(0.06)***	(0.07)***
Zone 3	-0.05	-0.05
	(0.11)	(0.10)
Public works participant	**0.48**	**0.43**
	(0.25)*	**(0.21)****
Constant	1.02	1.07
	(0.23)***	(0.23)***
Public work participation (1=Participant)		
Age of Household Head 2003	-0.03	-0.03
	(0.02)*	(0.02)*
Female-headed household 2003	0.63	0.61
	(4.17)	(0.66)

Table 7 continued		
Education of head 2003 (1=literate, 0=otherwise)	-0.20	-0.25
	(0.37)	(0.40)
Land area in Tsimdi 2003 [b]	-0.03	-0.03
	(0.06)	(0.05)
Number of adult females 2003	0.27	0.28
	(0.23)	(0.22)
Number of adult males 2003	0.04	0.06
	(0.16)	(0.16)
Number of children 2003	0.13	0.13
	(0.14)	(0.12)
Zone 1	0.79	0.82
	(0.58)	(0.56)
Zone 2	0.21	0.21
	(0.45)	(0.42)
Zone 3	0.98	0.98
	(0.49)**	(0.47)**
Any labor shock 2007-2010 (1=Yes) [d]	0.70	0.82
	(0.51)	(0.48)*
Any off-farm income 2003 (1=Yes) [c]	-0.36	-0.35
	(0.31)	(0.30)
Access to a major market 2003 (1=Distant)	-0.30	-0.29
	(0.36)	(0.37)
Constant	0.95	1.07
	(1.18)	(1.26)
Observations	162	162
Log likelihood	-89.80	-87.56
Wald chi2	5.55	5.45
P-value	0.02	0.02
Anthro [e]	-1.28	-1.23
	(0.82)	(0.73)*
Lnsigma	-1.15	-1.18
	(0.13)***	(0.13)***
Attrition bias correction (Inverse Mills Ratio) [f]	-0.10	-0.12
	(0.33)	(0.41)

* Significant at 10%; ** significant at 5%; *** significant at 1% Note: Bootstrapped standard errors in parentheses (400 replications). The number of observations shrank to 162 because there were households that did not have children (between age 7 and 14) in both periods (2003 and 2010). Average education, distance from primary school and maximum level of adult education are included in the first stage so that the same variables are controlled for in both stages (except the instrument).

[a] The education level categories are illiterate; able to read and write or church education; elementary; junior and secondary; and others. The categories took values from one to five, respectively. [c] Off farm income excludes FFW/CFW income, [b] 1*tsimdi*=0.25 ha [d] Second stage variables included as a control,

[e] Anthrho is the variable that tests and corrects for standard selection bias [f] Attrition bias correction for households that dropped out

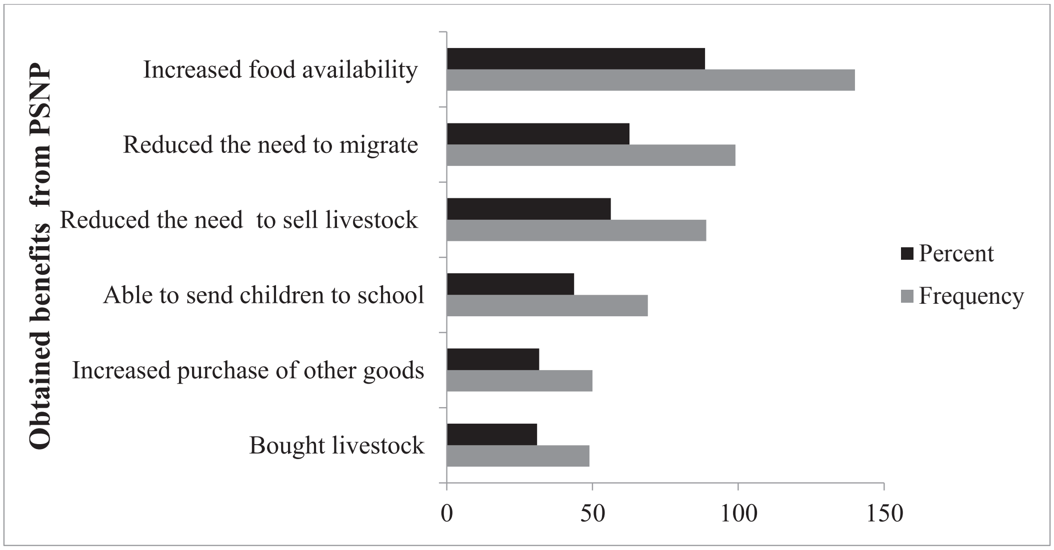

Figure 1: Obtained benefits from PSNP among public work participant households

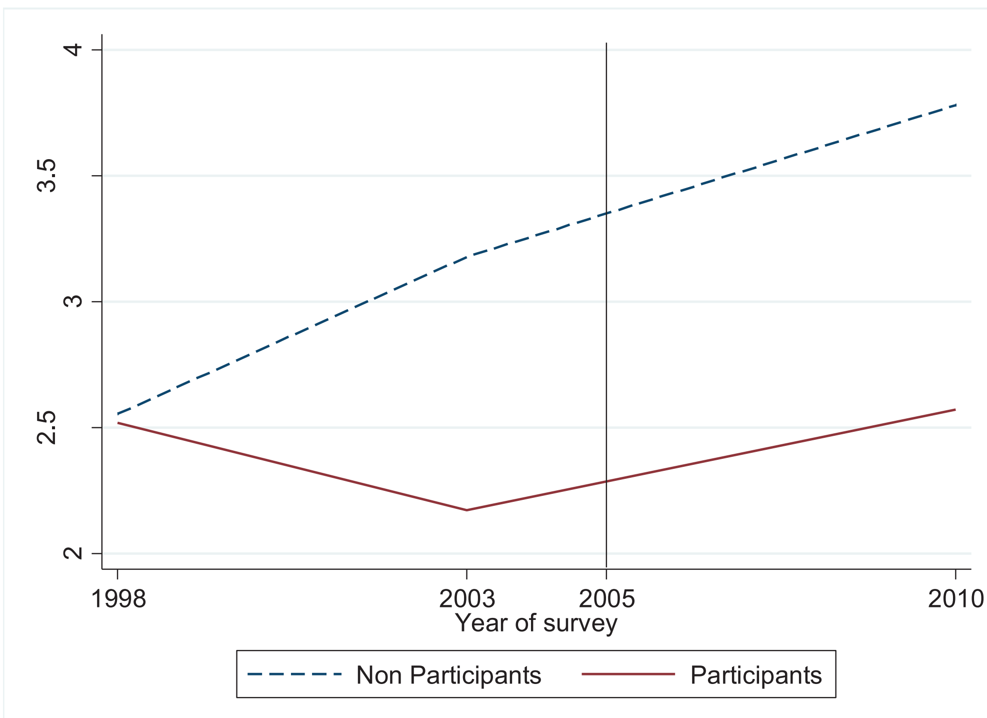

Figure 2: Predicted TLU (1998, 2003 and 2010) for participants versus non-participants

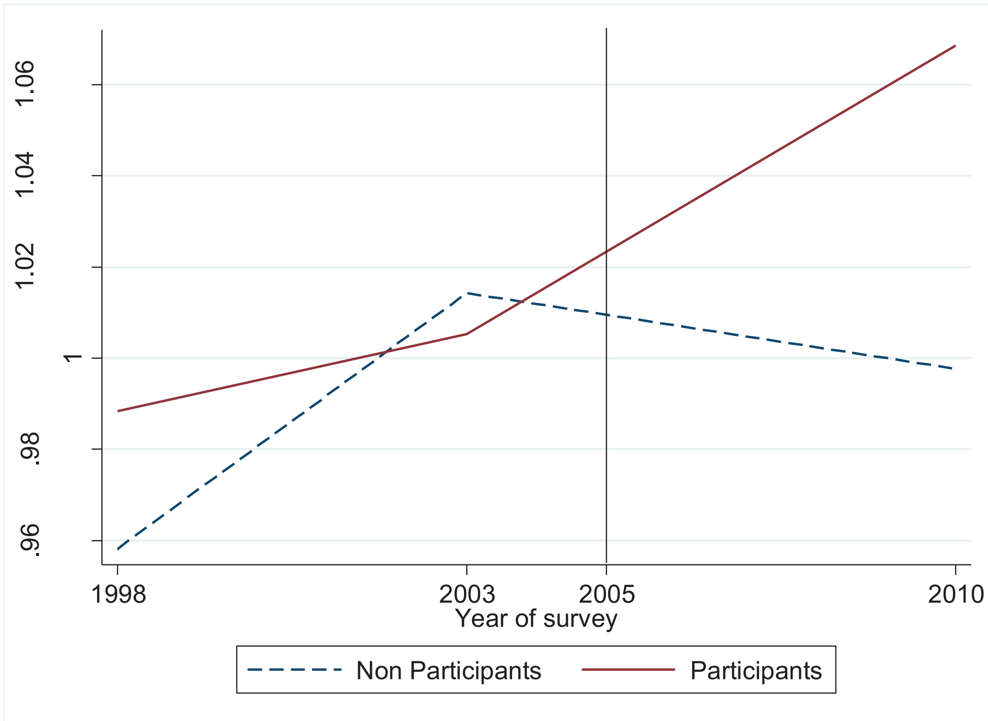

Figure 3: Predicted average children education (1998, 2003 and 2010) for participants versus non-participants

Appendix

Table A1: Test for Attrition bias

	Probit Model
Attrition Dummy(1=stayers)	
Tropical Livestock Unit 2003	- 0.04(0.04)
Age of Household Head 2003	0.01(0.01)
Female-headed household 2003	0.46(0.34)
Household head's any education (1=literate) 2003	0.17(0.28)
Household size 2003	0.07(0.11)
Number of children 2003	0.01(0.15)
Land Area on certicifate in *tsimdi*(log) 2003	- 0.43(0.24)*
Any off farm income [a](1/0) 2003	- 0.44(0.25)*
Zone 1	0.53(0.34)
Zone 2	0.86(0.37)**
Zone 3	0.70(0.35)**
Observations	353
Log likelihood	-67.03
LR chi2	19.61
P-value	0.05

* Significant at 10%; ** significant at 5%; *** significant at 1% [a] Standard errors in parentheses
This regression does not contain one village where survey respondents refused to be interviewed due to religious reasons.

Table A2: Likelihood ratio test results for exclusion restrictions

Models	LR chi2	P-value
Model 1		
Model 1A	1.50	0.47
Model 1B	0.45	0.50
Model 2		
Model 2A	0.08	0.78
Model 2B	0.13	0.72

Note: These test results are for the models presented in Table 6(Model 1) and Table 7 (Model 2).

Paper 3

Does Ethiopia's Productive Safety Net Program Improve Child Nutrition? *

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Abstract

We study the link between membership in Ethiopia's Productive Safety Net Program (PSNP) and short-run nutrition outcomes among children age 5 years and younger. We use 2006 and 2010 survey data from Northern Ethiopia to estimate parameters of an exogenous switching regression. This allows us to measure the differential impacts of household characteristics on the weight-for-height Z-scores of children in member and non-member households. We find that the magnitude and significance of household covariates differ in samples of children from PSNP and non-PSNP households. Controlling for a set of observable features of children and households we find that children in member households have weight-for-height Z-scores that are 0.55 points higher than those of children in non-member households. We conclude that the PSNP is providing positive short-term nutritional benefits for children, especially in those households that are able to leverage underemployed female labor.

Key words: anthropometry; Ethiopia; food security; nutrition; safety net

JEL codes: I15, I38

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1. Introduction

In this paper, we use data from Northern Ethiopia to study the links between a social protection program and child nutrition.[1] Child malnutrition is one of the many challenges that pose a threat to economic growth in developing countries. It undermines educational attainment, lowers non-cognitive skills, leads to low labor productivity during adulthood, and diverts attention and resources away from other development objectives (Kimhi, 2003; World Bank, 2010; Save the Children, 2012; Dercon and Sanchez, 2013). Ultimately, under-nutrition during childhood can lead to intergenerational poverty (World Bank, 2010). To tackle the problem of malnutrition in poor nations, a number of targeted interventions have emerged. These include school feeding programs and micro-nutrient and vitamin supplementation programs for women and young children (Save the Children, 2012). A broader approach is the provision of food aid. Ethiopia has a long history of receiving food aid (Gilligan et al., 2009a), yet the country's record of child malnourishment remains poor and rates of malnutrition are among the highest in Africa (Christiaensen and Alderman, 2004). In 2005, the government of Ethiopia established the largest social protection program in Sub-Saharan Africa to date (outside of South Africa). The Productive Safety Net Program (PSNP) builds on a previous emergency food aid program and includes as components food-for-work (FFW) and cash-for-work (CFW) as well as direct support through free food. However, the PSNP differs from Ethiopia's previous interventions by providing individual member households a guaranteed source of income for at least five consecutive years (2005-2009), and in a majority of cases guaranteed income for an additional five years (2010-2014) (Government of Ethiopia, 2009).

[1] We use the terms "health" and "nutrition" interchangeably here.

To examine the impacts of the PSNP on child nutrition, we use anthropometric data collected in the Tigray region among children five years and younger in 2006 and 2010. We conduct empirical analysis using pooled cross section data from the two survey rounds. Our outcome indicator is weight-for-height Z-score (WHZ), a short-term indicator which we construct using the WHO's newly developed child growth standard. Two research questions motivate the analysis. First, we ask whether the determinants of WHZ differ between the population of children in PSNP households and those in non-PSNP households. Second, we test whether PSNP membership was associated with subsequently higher Z-scores for children in beneficiary households. Importantly, we move beyond the traditional approach to measuring a potential impact "with" and "without" an intervention, and search for underlying conditioning mechanisms that may be driving differences in nutrition outcomes in the PSNP and non-PSNP samples. Such a refocusing of effort for impact evaluation has been most clearly articulated by Deaton (2010). We find, for example, that a household's supply of female labor is one such factor that conditions nutritional response to the food-for-work opportunity. This is probably because the economic and nutritional cost of participating is low for females because they have few other off-farm opportunities.

Impact evaluation studies have documented that PSNP resulted in an increase in consumption (Gilligan et al., 2009a; Berhane et al., 2011b) and tree holding (Andersen et al., 2011); decrease in children's time spent on domestic work (Woldehanna, 2009) and child labor hours on public works (Hodinott et al., 2009); and mixed effect on livestock holdings (Andersen et al., 2011; Gilligan et al., 2009b; Berhane et al., 2011b). Past studies focusing on the relationship between food aid and child nutrition in Ethiopia have suggested a positive impact of food aid on weight-for-height (Quisumbing, 2003) and linear growth (Yamano et al., 2005). These earlier studies relied on data collected between 1994 and 1996, well before the start of the PSNP. Gilligan et al. (2009b) examined the impact of the PSNP on child anthropometry in selected *weredas* (districts) from Amhara region in the period between 2005 and 2008. They found that the program did not have an influence on child nutrition. Authors however base their analysis on *weredas* (districts) in Amhara receiving High Valued Food Basket (HVFB), different from standard PSNP payment. Authors indicate that results are partly affected by data limitations. Our study updates and complements previous works using data collected from Tigray after the introduction of the PSNP. Further, we use the new WHO growth standard, which provides the most accurate measure of child health in Ethiopia to date.

We use an exogenous switching regression framework to answer our research questions. Findings reveal that the determinants of short-run anthropometric outcomes differ between member and non-member households. In particular, the supply of female labor seems to matter for promoting child health in member households. We also find that while nutrition outcomes are better for female children in our sample of member households, vis-à-vis their non-PSNP cohorts, male children appear to do better in non-member households. We use our regression results to examine difference in WHZ in member and non-member households, finding an average difference in WHZ of approximately 0.55 points, or roughly 31 percent of a standard deviation. We also measure program treatment effects under a set of counterfactual conditions in which we equate the nutrition returns to characteristics of member and non-member households. Those results suggest that, after controlling for the differences in the profiles of member and non-member households, children in member households had 97 percent higher WHZ, on average, than children in non-member households. We conclude that short-run nutrition outcomes, as measured by WHZ, have been responsive to PSNP membership and associated interventions.

2. Theoretical Framework

At the outset, it is necessary to clarify key temporal considerations for our analysis because we have available both short-run and long-run nutritional indicators but are only well-positioned to measure program impacts arising in the recent wake of PSNP enrollment. Clearly, given a long enough observational history, it would be possible to isolate the long-term impacts of PSNP membership on child health, as expressed through a long-term indicator such as height-for-age Z-score (HAZ). In our case, however, we strongly believe that HAZ is highly correlated with household status at the start of the PSNP, and therefore negatively correlated with program participation. Indeed, the data confirm that average HAZ is lower among PSNP members than non-members, suggesting the households selected for inclusion in the program contained children who were, at enrolment in the PSNP, no better-nourished than those who were not included in the program, despite somewhat higher WHZ. In fact, if one acknowledges that stunting is a biological response to sustained health and nutrition insults, then higher WHZ in a stunted population is not unexpected.

In the absence of a realistic opportunity to separately identify the drivers of long-run malnutrition and program participation predicated on poverty, we set aside the notion of linking the PSNP to long-term nutrition outcomes. Instead, we focus our attention on WHZ, the more immediate nutrition indicator, as this is more likely to be sensitive to short-term program impacts and less likely to be contaminated by initial conditions influencing program enrollment. From a short-run perspective, a program such as Ethiopia's PSNP can affect a child's short-run nutritional status through multiple channels. First, if the program involves distribution of food (as in the case of the FFW and free food program components of the PSNP), it may directly increase household's short-run food availability, with potential immediate benefits to mothers and children

(Yamano et al., 2005). Second, in cases where the program provides wages or cash transfers, a household's income will rise, thereby improving the household's ability to purchase food and nutrition-enhancing items (Alderman et al., 2006). Nevertheless, while a positive nutritional impact from a rise in income seems possible and even likely, the degree to which such transfers might boost nutrition depends upon several factors. These include the overall magnitude of the increase in income, the marginal propensity to consume calories or other health and nutrition goods and services out of cash income, and the extent to which actual expenditures are transformed into positive increments in health and nutrition. On the other hand, a work program that requires households to provide labor could have negative implications for a child's nutritional status by shifting effort away from health provisioning. Whether a work program has deleterious impacts depends on the labor situation of the household, especially female members of the household. To the extent a household has "surplus" labor, and hence a low opportunity cost of effort, work opportunities may not displace nutrition-producing activities. However, if household labor is scarce, if the overall nutritional demands of work are high, or if off-farm work leads household members to redirect labor away from activities that produce adult and child nutrition, negative impacts may arise. In short, since labor is an input to child health, but public works programs require labor contributions from household members, such programs introduce the potential for an income-nutrition tradeoff.

PSNP can therefore increase or decrease health production and hence have either a positive or negative effect on child nutrition. A dynamic model of household production and consumption can be solved to show the relationship between PSNP and children's health outcome (see Appendix A). A decline in health may occur if labor allocated to health provisioning falls in response to a reallocation of labor to other activities, thereby reducing health production by an amount more than the health improvements provided by income arising from the competing activity. On the other hand, an improvement in health could result from an increase in FFW income if it does not require substantial "cost" in terms of reallocation of labor from health production. Because labor market rigidities preclude off-farm work for women, one might expect the shadow value of female labor to be artificially low inside the household. That is, the endogenous wage (implicit value) for their work within the household is low. In such a setting, a FFW program that makes use of female labor provides a potential means to generate gains for the household by reallocating small quantities of female labor. That is, outcomes may vary depending on whether new activities require the (re)allocation of male or female labor. Hence, the household's supply of female labor may influence the marginal nutrition benefit of a FFW program, providing a mechanism by which program impacts might differ across otherwise similar households (see Appendix A for the optimization result).

Whether, on net, FFW has a short-run positive or negative effect on child health depends on the deleterious effects of the reallocation of labor, the household's labor endowment, the size of the public works payment, and the marginal impact of this payment on child nutrition and health. If a household uses the payment on health production (either in terms of consuming food or consuming health and medical attention) children in PSNP households may enjoy better health than those in non-PSNP households, even when FFW labor requirements crowd out some agricultural or home activities. In this case, the benefit from PSNP may outweigh the deleterious effect of reallocation of labor. If, on the other hand, the household uses public works income for purposes unrelated to child health, this potentially undermines health production by displacing labor from health production without a compensatory expenditure on health provisioning. Moreover, the outcome may critically depend on whether it is male or female labor that is devoted to FFW, and whether that labor is relatively scarce in the household. The overall impact is, *a priori*, ambiguous.

Based on the theoretical framework, we pose two hypotheses. First, we hypothesize that determinants of nutritional outcomes will differ between households that are members of the PSNP and those that are not. Second, we hypothesize that children residing in PSNP households will have better nutritional outcomes because the opportunity cost of allocating labor to public works is likely to be low and the nutritional or cash income benefits obtained from participating in the program are likely to be high. Our subsequent investigation makes use of data observed over two periods to reveal empirical regularities between WHZ and membership in the PSNP.[2]

3. Study Context and Data

3.1. *Child malnutrition in Ethiopia*

It has long been recognized that under-nutrition is the major cause of child mortality (World Bank, 2011). In Ethiopia, child malnutrition contributed to an estimated 57 percent of under-five mortality as of 2001 (Mekonnen et al., 2005), with boys having higher mortality rate than girls (WHO, 2011). Between 2000 and 2011, the country ranked third in Africa in terms of high under-five mortality, after Nigeria and the Democratic Republic of Congo (WHO, 2013). A recent estimate of the country's malnutrition status indicates that 44.2, 10.1 and 29.2 percent of children under five

[2] As argued elsewhere, we do not include a longer-term measure of malnutrition (e.g. height-for-age) in this study primarily because a long-term indicator is not likely to pick up the short-term benefits of the PSNP as measured at the time of the study. Instead, height-for-age scores are more likely to reflect underlying levels of deprivation in the sample, and for this reason are likely to be positively correlated with PSNP eligibility.

years of age were stunted, wasted and underweight in 2011 (WHO, 2013).[3] Compared to data from 2005 (WHO, 2012), these rates have improved somewhat (by 6.5, 2.2 and 5.4 points for stunting, wasting and underweight), although improvements have not been sufficient for Ethiopia to reach the Millennium Development Goals (World Bank, 2011).

3.2. *The Productive Safety Net Program*

The Productive Safety Net Program (PSNP) is a development-oriented social protection program launched in Ethiopia in 2005. It was introduced by joint efforts of the Government of Ethiopia and donors in an attempt to provide a long-term solution to the chronically food insecure households found in chronically food insecure regions of the country. The program has two phases. The first phase was between 2005 and 2009 while the second phase is between 2010 and 2014. Initially, it aimed to cover more than 263 *weredas* (districts) and 5 million people in four major regions of the country, namely Tigray, Amhara, Oromiya and SNNP (Legovini, 2006, Gilligan et al., 2009a; Porter and Dornan, 2010; Nega et al., 2010; Siyoum, 2012). In 2009, the program expanded and covered 8.3 million people in 319 *weredas* by reaching out for pastoralist areas of the country (Siyoum, 2012; Rahmato et al., 2013). While the program builds on the experiences of the earlier emergency relief program, it has distinct characteristics in its long term nature. It provides a predictable amount of transfers (cash or food) for a predictable period of time (at least five years) (Bishop and Hilhorst, 2010).

Able-bodied adults are required to work five days per month in community infrastructure development in return for food (mainly wheat and cooking oil) or cash. Elderly, disabled, sick or mentally challenged individuals; pregnant and lactating

[3] A child is considered stunted, wasted or underweight if the calculated Z-score for height-for-age, weight-for-height and weight-for-age, respectively, is 2 standard deviations below the median of a reference population. The Z-score is calculated as:
$Z = \frac{\text{observed value} - \text{median reference value}}{\text{standard deviation of reference population}}$.

women; and orphaned teenagers receive free food or cash without a work requirement. The former is the public work (food-for-work or cash-for-work) component and the latter is the direct support component (Sharp et al., 2006). Under the public work component, an able bodied household member can work a maximum of 15 days - referred to as the labor cap rule (Berhane et al., 2011a). Payments maybe a combination of cash and food in some *weredas* while only one form of payment in others (Sabates-Wheeler and Devereux, 2010).

In the first phase of the program, an adult household member shared his/her transfer from the public works among other members who cannot work. In June 2010, full family targeting rule (FFT) was introduced which considers all family members of PSNP households as beneficiaries of the program. The aim is to increase the benefits gained from the program by taking into account of household size. The rule requires that able-bodied household members additionally cover the work requirement of other members who are unable to work, subject to labor cap rule of 20 days (Berhane et al., 2011a).

Program eligibility depends on whether a household is found in one of the chronically food insecure *weredas*; whether it faced food gaps or received food aid within three years of the start of the program; whether it faced severe shocks that led to substantial asset depletion; or whether the household had no other source of support (e.g. from family or other social protection programs). Food security task forces (FSTF) and councils formed at community, *tabia* and *wereda* levels select eligible households in the program (Government of Ethiopia, 2009; Berhane *et al*., 2011a). At community level, community food security task forces are formed for each community (sub-*tabia*). These task forces identify households that qualify for the program based on the criteria (poverty status), given the allocated quota for the community. [4] Public meeting is organized to inform the community members and accommodate complaints before the beneficiary list is transferred to the *tabia* FSTF. The tabia FSTF reviews the list and submits it to the *wereda* FSTF. Then, the *wereda* FSTF transfers the list to the regional and the regional to the federal office (Berhane et al., 2011a). Eligible households are then registered as members of the program for a consecutive five year period (first phase) and possibly for an additional five years (second phase). [5] The FSTF at each level generally follow the criteria in the project implementation manual, although targeting might be affected by limited budget at all levels (Berhane et al., 2011a; Coll-Black et al., 2011). According to Coll-Black et al. (2011), the main criterion used by local officials in targeting public works beneficiaries is their poverty status. There is a little evidence of favoritism at community level. The authors report that PSNP is targeted well when measured at an international standard.

PSNP is the core among the four components of the country's food security program (FSP). FSP also includes Complementary Community Investment (CCI) which involves building infrastructure; Other Food Security Program (OFSP) [later transformed in to Household Asset Building Package (HABP)] which provides extension services and credit; and resettlement program which involves voluntary relocation of households in search for better agricultural production (Berhane et al., 2011a; Lavers, 2013; Rahmato et al., 2013). Along with the HABP, the PSNP aims to allow households to accumulate assets and prevent likely asset depletion due to severe shocks. It is together with these complementary programs that the PSNP aims to achieve graduation of

[4] In our study context, a Development Agent in *Kihen tabia* indicated that community members are informed about households that faced severe shocks and who are in need of support.
[5] Households that participate in the public works component of the PSNP do not necessarily participate in the community asset development component.

beneficiary households. Successful participants that graduate out of the program need to show sufficient improvement in food security status and asset accumulation (Government of Ethiopia, 2009).

3.3. *Study site and data*

Data for this study come from household surveys collected in Tigray region. Located in Northern Ethiopia, Tigray is typically characterized by high exposure to recurrent drought and famine (Hagos, 2003). Further, most households have limited access to credit and off-farm opportunities (Bezu and Holden, 2008). The malnutrition status of children under five in Tigray is among the worst in the country. In 2000, 61.3 percent of children were stunted in the region, the second largest percentage in the nation after the Amhara region (62.9%). During the same period, the percentages of wasted and underweight children were 12.9 and 42.3, respectively (WHO, 2012).

Our data were collected in 2006 and 2010. The data are part of a follow up survey that initially visited 400 rural households in 1998 and then revisited them in 2001 and 2003. The initial sample was collected using stratified random sampling method from 16 villages, 25 households within each village. Selected villages were representative of the region in terms of agro-climatic conditions, agricultural potential, population density and market access (Hagos, 2003). Data was collected by hired enumerators who speak the local language. The main instruments used in the survey are multipurpose household questionnaire and village questionnaire. The household questionnaire contained topics on household characteristics; asset ownership (livestock, land and physical assets); membership in the PSNP; income from agriculture and non agriculture sources; exposure to shocks and anthropometric measures for children and parents. Survey data in 2006 and 2010 included child anthropometric measures for the first time. The 2010 data further contains height and weight of the parents and an additional 119 households from two different villages. [6] We use pooled cross-section data from 2006 and 2010 at child level. Only 37 of the children were included in both surveys, so we treat each round as a separate representative sample.[7]

We generated Z-score values for weight-for-height of children under five using WHO's latest child growth standard (2006). The newly developed growth standard incorporates the growth pattern of children with different ethnic and cultural backgrounds which makes it suitable for data coming from developing countries. This is unlike the earlier National Center for Health Statistics (NCHS)/WHO growth standard (O'Donnell et al., 2008). The Z-score values reflect the standard deviation from the median height or weight of WHO's well-nourished reference population (with same age and gender).[8] Anthropometric surveys of children typically suffer from problems of missing data or mismeasurement. After removing missing and outlier observations, our sample includes 383 children less than five years of age, 187 for 2006 and 196 for 2010.

Table 1 presents the proportions of malnourished children by age category, gender and membership in the PSNP. Acute malnutrition (wasting), which is indicated by low WHZ, seems to be more of a problem for children above two years (see column 1). In our sample, approximately 16 percent of children below two years and 19 percent of children above two years are wasted (WHZ<-2.0). Overall, 18 percent of children in our sample are wasted. In terms of sex, our sample indicates a greater share of boys with

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[6] Parent's heights and weights were measured only in the 2010 survey. This precludes us from using these variables in the empirical analysis.

[7] Ideally, using panel data that follows the same children across time would give a better picture of the health status of children across time. Since we do not have such data, we opted to pool the data from the two years.

[8] We used the WHO's STATA package (2011) to compute Z scores. When biologically implausible values are encountered, these are recoded to missing. In our dataset, 11 per cent of WHZ scores exceeded the WHO cutoff values.

WHZ scores lower than 2 standard deviations below the reference population (see column 1 in Table 1). This is in line with the study by Christiaensen and Alderman (2004) who found that boys were more malnourished than girls in Ethiopia. Table 1 also shows the percentages of children who are malnourished within households that are members and non-members in the PSNP. The proportion of wasted children in member households (16%) is lower than in non-member households (23%). Columns 3 and 4 show similar trend for 2006 and 2010, respectively (see Table 1). An exception is that the proportion of wasted boys is higher than the proportion of wasted girls in 2006.

Table 2 summarizes average WHZ among children in PSNP and non-PSNP households. Short-term nutritional status worsened in both groups between 2006 and 2010, declining from 0.17 in 2006 to -0.66 in 2010. Figure 1 illustrates the pattern. The worsening of WHZ occurred for both member and non-member households. On average, children in PSNP households exhibited higher WHZ than children in non-beneficiary households. Figure 2 compares the Z-score distributions for members and non-members. Cumulative density functions for WHZ are plotted in Figure 3. These underscore that the distribution for PSNP households is shifted to the right, and dominates the non-PSNP distribution at nearly all points.

4. Empirical Strategy

Our main focus in this paper is to examine differences in the nutritional outcome of children in households that are members in the PSNP and those that are not. We first examine the differences in the determinants of WHZ within PSNP and non-PSNP households. Then, we measure the impact of the PSNP on member households' child nutrition outcome. Membership in the PSNP is beyond the control of households, which makes an exogenous switching regression suitable for our purposes.[9]

The theoretical framework suggests labor reallocation decisions of member households may differ from non-member households. An implication is that child health may differ in member and non-member households. A Chow test in our sample rejects the null hypothesis of coefficient equality for members and non-members (at a 0.1% test level). This confirms that an exogenous switching regression, which allows coefficient estimates to differ across the sub-samples, is appropriate. Estimating separate slope coefficients for the two groups also enables us to measure the differential impacts of child and household covariates on the outcome variable of interest.

Using the child as the unit of analysis, the regression models for the two groups are defined as follows:

$$Z_{Mi} = \beta_0 + \beta_1' X_{Mi} + \beta_2' X_{Mh} + \beta_3' A_{Mh} + \beta_4 T + \varepsilon_{Mi} \quad [1]$$

$$Z_{Ni} = \gamma_0 + \gamma_1' X_{Ni} + \gamma_2' X_{Nh} + \gamma_3' A_{Nh} + \gamma_4 T + \varepsilon_{Ni} \quad [2]$$

where subscripts M and N for the dependent and the explanatory variables represent PSNP membership and non-membership. Subscript i denotes child level variables and subscript h denotes household level variables. Z_i denotes anthropometric measures of the child (weight-for-height Z-score) ; X_i is a vector of child characteristics (gender and age of the child); X_h is a vector of household characteristics (age, gender and education

[9] Following Duflo (2003), we focus on membership, rather than participation. We tested exogeneity of membership in two ways. First, following a similar approach used by Yamano et al. (2005) we employed 2SLS using the deflated village average income from FFW in 1998 as our identifying instrument for PSNP membership. Although the instrument was weak, the test recommended rejecting the hypothesis that membership is endogenous in the Z-score regression. Second, we used the same instrument in an endogenous switching regression, subsequently checking the significance of the correlation between the error term in the membership equation and the error term in the Z-score regression. The estimated coefficient was not statistically different from zero, again suggesting that PSNP membership is exogenous to nutrition outcomes. Tables B.1and B.2 in Appendix B show the results.

of the household head; number of female and male adult labor; number of other siblings under five); A_h refers to a vector of productive assets (including land area and livestock holdings); T is a year dummy variable ($T = 1$ if the year is 2010 and zero if the year is 2006); and ε_i is an error term with expected value of zero. In the estimation, ε_{Mi} and ε_{Ni} are assumed to be uncorrelated with unobservable factors affecting membership in PSNP, a requirement in an exogenous switching regression model (Maddala, 1983). In order to control for time-invariant unobservable characteristics, we use household fixed effects. White's hetroskedasticity corrected standard errors are clustered by *wereda*.

In order to directly examine if membership in PSNP contributed to child nutrition, we use two approaches. First, we use predictions from the separate regressions and test differences in predicted outcomes between members and non-members. Kernel density graphs, Kolmogorov Smirnov tests and t-tests were applied. Second, we adopt the approach of Kassie et al. (2014) who compute treatment effects after carrying out an exogenous switching regression. In our case this involves generating the average value of the observed outcome (WHZ) for PSNP and non-PSNP sub-samples, as well as those derived under plausible counterfactual conditions. A reasonable counterfactual for PSNP member households is one in which the nutrition outcomes of children reflect the aggregated effects of the observed household characteristics but the marginal nutrition effects for each characteristic observed in the non-member sample regression. Table 3 shows the relations of the observed and counterfactual expected values of health outcomes for PSNP and non-PSNP households. Cells [1] and [5] represent the expectations that are observed for member and non-member households, respectively. *P* refers to a binary variable taking the value of one for members and zero otherwise. Cells [2] and [4] are the respective counterfactual expected health outcomes. For example, cell [2] is equivalent to the average WHZ of member households if returns to their characteristics are the same as non-member households.

Average treatment on the treated (ATT) is computed as the difference between the average of the observed WHZs and the average of the constructed counterfactual WHZs for member households. This shows the effect of the program on member households and is represented in Cell [3]. Analogously, Cell [6] refers to the average treatment on the untreated (ATU) which is equivalent to effect of membership on non-member households if they had the same returns to their characteristics as member households. Heterogeneity effects, which are defined in cells [7] and [8], measure differences in health outcomes due to unobserved factors.

This paper only focuses on PSNP membership and does not take into account of the complementary programs of HABP, CCI and voluntary resettlement. Controlling for these variables would have captured the combined asset building and labor requirement implications of these programs on child nutrition. An impact evaluation by Gilligan et al. (2009) showed that combination of the PSNP and OFSP generated a greater magnitude of asset accumulation and food security compared to the benefit gained only from PSNP. Further, a study by Hodinott et al. (2012) found that higher payments from PSNP promoted fertilizer use and investment in agriculture when the program is combined with OFSP. On this basis, we expect that findings in this paper are likely to under estimate the impact of the PSNP on child nutrition.

5. Results

Prior to examining the impact of PSNP on child health, we first discuss the factors that influence the weight-for-height Z-score of children in PSNP and non-PSNP households. Table 4 gives a description of the variables that are used in the regression analysis and

Table 5 provides the summary statistics for PSNP and non-PSNP households in each survey round.

5.1. Determinants of weight-for-height Z-score

Tables 6 and 7 report the determinants of children's WHZ in member and non-member households. The parameter estimates in the regressions measure the short-term nutritional status of children (WHZ) attributable to the explanatory variables within the two groups. Models 1A, 1B and 1C contain results for member households and Models 2A, 2B and 2C show results for non-member households. Models 1B and 2B include the number of other under five children in the household. Models 1C and 2C disaggregate the number of other under five children by gender. As the theoretical model predicts, the set of covariates that explain variation in WHZ differ in the PSNP and non-PSNP sub-samples.

Findings suggest that a lower WHZ for older children in member households while the age of a child does not seem to matter in non-member households. Gender of a child has an impact on WHZ in non-member households. Results indicate that boys in non-member households have 0.89-1.88 higher WHZ than girls, on average. Non-member households seem to favor boys than girls in the distribution of food within the households. On the other hand, the estimate in Model 1C and signs in Models 1A and 1B show that in member households girls have better WHZ outcomes, on average, than boys. This finding is similar to those from a study by Webb and Block (2004) showing higher WHZ for girls than boys in Indonesia. Using a sample of Ethiopian children, Outes and Porter (2013) also find that girls have higher catchup growth than boys in terms of height-for-age Z-score.

Female headship seems to be negatively associated with WHZ in non-member households. This may indicate that female-headed households are resource poor and hence less able to generate health improvements than male-headed households. The point estimate for this variable is not statistically significant in the member sample, probably because female-headed households benefit more and are more able to provide food for children. As the age of non-member households head increases by one year, short term health outcome (WHZ) decreases by 0.28-0.32 (significant at 1% level). This potentially relates to the decline in the ability to foster children's better nutritional outcome as one gets old. In the regression for member households, we find no evidence that household head age is correlated with WHZ.

Results show that children in non-member households with uneducated household heads have higher WHZ, ceteris paribus. This is contrary to findings in previous studies such as Lavy et al. (1996) and Christiaensen and Alderman (2004). Our results are on the other hand similar with Webb and Block (2004) who argue that responses to education vary depending on whether one considers short-term or long-term nutrition indicator. In member households, coefficient estimates for household head education are not statistically significant.

In member households one additional female worker is associated with 1.09-1.31 higher WHZ, on average. A plausible explanation is that member households with greater number of adult female labor are in a better situation to allocate labor to the public works in the PSNP as well as health production. This is in line with our theoretical model which states that the increase in income from FFW can bring positive health outcome if labor reallocation from health production is not costly. It seems like FFW is particularly important for mobilizing idle female labor while males may have better off-farm opportunities without access to FFW. Put differently, FFW enhances value of the female labor force in the household and this leads to more investment in child health through their FFW income. Endowment of labor does not seem to matter in determining child nutrition in non-member households (see Table 7). [10]

Children who have greater number of siblings under the age of five seem to have higher WHZ in both member and non-member households (see Models 1B and 2B in Tables 6 and 7, respectively). The marginal effect is higher for non-member households (0.76) than member households (0.52). As can be seen in Models 1C and 2C, effects differ depending on whether the siblings are boys or girls. The number of brothers positively affects WHZ in non-member households while number of sisters is positively linked with higher WHZ in member households. This is in line with our results on gender which show that members favor girls and non-members favor boys in health production. In the setting of our study area, girls tend to stay with their mothers while boys are around their fathers. Girls therefore get direct food benefit from their mothers since mothers are responsible for preparing food. In PSNP households, where food payments are available and adult females get direct payments, girls have significantly higher tendency to be better nourished than boys. Further, the value of female children is probably higher in member households due to the ability of adult females to generate income. On the other hand, male children may be better nourished in non-member households since it is mostly the male adults that support the family and investing in boys' health may be more rewarding in the future.

One can observe that WHZ has generally declined for all households between 2006 and 2010. This is possibly due to the high food prices experienced in 2008

[10] Figure B.1 in Appendix B show the observed distribution of adult female labor in member and non-member households. Figure B.2 shows the predicted WHZ versus number of adult female labor. It can clearly be seen that the predicted value of WHZ increases with number of adult females in member households confirming the statistically significant result in Models 1A- 1C.

(Gilligan et al., 2009b). Findings are consistent with Gilligan et al. (2009b) who studied the prevalence of wasting in Amhara region from 2005 and 2008. Thomas et al. (1996) also found that higher food prices led to a significant decline in the short-run health indicator in Cote d'Ivoire. However, the point estimate for the year indicator is significantly different from zero only in the regression for member households.

5.2. Impact of PSNP on weight-for-height Z-score

Is the average WHZ higher for children living in member households than for those in non-member households? Table 8 summarizes the result for a two sample t-test between the predicted values of the separate regressions for the two groups.[11] Results indicate that the average predicted WHZ is significantly higher for children in PSNP households than their non-PSNP cohorts. Tables 6 and 7 showed that the year dummy in member households is significant while it is insignificant in non-member households (though the coefficient is higher in non-member households). An implication from the prediction result is that even after controlling for the time effect, children in member households still have higher WHZ than in non-member households. [12]A two-sample Kolmogorov-Smirnov test for equality of distribution functions for member and non-member households reveals a statistically significant difference in the conditional distributions (p-value=0.06) (see Table 8).

Table 9 presents results for treatment effects of membership. Cells 1 and 5 contain observed WHZ for children of PSNP and non-PSNP households. Cell 2 shows the

[11] We use models 1A and 2A to derive predicted values and compute treatment effects.

[12] We used a more conservative approach in predicting the outcome by generating the predictions using only the significant variables. This way, we are able to take into account of variables that only matter to the outcome variable in each regression. Test results using the new predictions gave an even stronger result showing children in member households have better nutritional status.

counterfactual condition for members, i.e. the WHZ value that would have been obtained had members' responses to observed characteristics been the same as that of non-members. Similarly, cell 4 shows the counterfactual value for non-members. Findings reveal that average treatment effect on the treated (ATT) is positive and significant at a 1% level (cell 3). This implies that average WHZ for members is higher than it would have been if the marginal return to their characteristics had been the same as for non-members. Results also show that average treatment effect on the untreated (ATU) is statistically insignificant (cell 6). The heterogeneity effects, which are shown in cells 7 and 8, indicate that unobserved factors also contribute to the differences in WHZ between member and non-member households. In general, results show that nutrition outcomes have been responsive to PSNP membership in the short run.

6. Conclusion

Using 2006 and 2010 survey data from Northern Ethiopia, we investigated whether the determinants of short-run nutrition outcomes, as measured by weight-for-height, differ between PSNP and non-PSNP households. We also examined whether the PSNP has improved child nutrition in households benefiting from the program. Findings indicate that both the magnitude and significance of covariates influencing WHZ differ across the member and non-member samples. We find that female labor supply is positively correlated with WHZ in member households but exhibits no correlation with WHZ in non-member households. We conclude that there is no observable income-nutrition tradeoff when "underutilized" female labor is allocated to a FFW program. Although this result is highly-specific to Ethiopia, given its low baseline female labor force participation rate, it nevertheless underscores the potential for FFW programs to improve, not jeopardize, the short-run nutrition outcomes of children. . We find that girls are better nourished in member households and boys have higher average WHZ in non-member households. This result, its causes and implications warrant further study. Results from predictions after exogenous switching regressions show that children in member households have higher WHZ than those in non-member households. We also measured the treatment effect by comparing mean of actual WHZ and counterfactual WHZ constructed from the regression. Results confirm that the PSNP has positively influenced short-term nutrition of children.

Our findings contribute to the impact evaluation literature in two ways. First, we demonstrated not only the existence of a short-run PSNP impact on child nutrition, but also cast light on one potential mechanism that seems to drive the result. As Deaton (2010) argues, uncovering the factors that explain why an impact exists is a necessary task to inform policy. In this paper we have suggested one way to do so, providing evidence that female labor supply, which is an input to the FFW component of the PSNP, influences the marginal benefit of membership.

One of the key policy implications that emerge from our findings, therefore, is that employment opportunities for under-employed women not only improve their incomes, but also improve child nutrition in the short run. Whether long-term nutrition impacts can be generated through continued participation in the program remains an important, but unanswered question.

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Table 1. Percentages of wasted children by gender, age and household PSNP status

	Percentage of children wasted (WHZ < -2)		
	All years	2006	2010
Gender of child			
Girls	17.5 (194)	14.6 (96)	20.4 (98)
Boys	19.1 (189)	13.2 (91)	24.5 (98)
Age of child			
0-24 Months	16.4 (134)	11.4 (70)	21.9 (64)
25-60 Months	19.3 (249)	15.4 (117)	22.7 (132)
Membership in PSNP			
PSNP=1	15.5 (239)	11.0 (127)	20.5 (112)
PSNP=0	22.9 (144)	20.0 (60)	25.0 (84)
All children	18.3 (383)	13.9 (187)	22.5 (196)

Note: Number of observations in parentheses

Table 2. Mean weight-for height Z-score by year and membership in PSNP

		All	Members	Non-members	t-test
Average Weight-for-height Z-score(WHZ)	All years	-0.25 (383)	-0.05 (239)	-0.60 (144)	2.53
	2006	0.17 (187)	0.30 (127)	-0.10 (60)	1.25
	2010	-0.66 (196)	-0.45 (112)	-0.95 (84)	1.77

Note: Number of observations in parentheses

Table 3. Treatment effects and heterogeneity effects

Groups	Member households' response to characteristics	Non-member households' responses to characteristics	Treatment effects (Column 2- column 3)
Member households' characteristics	[1] $E(Z_M\|P=1)$	[2] $E(Z_N\|P=1)$	[3] ATT=[1]-[2]
Non-member households' characteristics	[4] $E(Z_M\|P=0)$	[5] $E(Z_N\|P=0)$	[6] ATU=[4]-[5]
Heterogeneity effects (Row 2- row 3)	[7] H_M=[1]-[4]	[8] H_N=[2]-[5]	

Table 4. Description of variables

Variable	Description
Female child	Gender of the child (1=female, 0=male)
Age of child(in months)	Age of child in months
Female headed household	Gender of the household head (1=female, 0=male)
Age of Household Head	Age of household head (years)
Education of Household Head	1=any education, 0=illiterate
Number of adult female labour	Number of female members aged >=15 &<=65 years
Number of adult male labour	Number of female members aged >=15 &<=65 years
Tropical Livestock Unit current	Livestock ownership in tropical livestock units
Land area owned in Tsimdi	Land size owned (1Tsimdi=0.25 hectare)
Year Dummy (1=2010, 0=2006)	1=2010, 0=2006
Number of other children	Number of other children aged <=5
Number of other female children	Number of other female children aged <=5
Number of other male children	Number of other male children aged <=5

Table 5. Descriptive statistics comparing PSNP and non-PSNP households by year

Variable	Mean values-Year 2006			Mean values- Year 2010		
	PSNP	Non-PSNP	T-test	PSNP	Non-PSNP	T-test
Female child	0.50 (0.50)	0.55 (0.50)	0.69	0.53 (0.50)	0.46 (0.50)	0.86
Age of child(in months)	36.6 (18.6)	36.7 (16.9)	0.06	41.1 (16.8)	38.5 (17.2)	1.07
Female headed household	0.24 (0.43)	0.10 (0.30)	2.22	0.13 (0.33)	0.14 (0.35)	0.36
Age of Household Head	47.1 (11.7)	48.6 (12.1)	0.78	46.4 (11.3)	44.3 (11.1)	1.29
Education of Household Head	0.46 (0.50)	0.53 (0.50)	0.88	0.38 (0.49)	0.44 (0.50)	0.79
Number of adult female labour	1.54 (0.71)	1.35 (0.94)	1.56	1.38 (0.69)	1.32 (0.64)	0.65
Number of adult male labour	1.52 (1.00)	1.57 (0.96)	0.30	1.42 (0.96)	1.61 (1.18)	1.22
Tropical Livestock Unit current	2.81 (2.12)	3.54 (1.95)	2.24	3.10 (2.61)	5.44 (3.92)	5.01
Land area owned in Tsimdi	3.72 (2.54)	3.41 (2.48)	0.77	4.37 (2.88)	5.51 (4.20)	2.25
Number of other children	0.89 (0.75)	0.87 (0.70)	0.20	0.78 (0.84)	0.62 (0.64)	1.44
Number of other female children	0.44 (0.54)	0.48 (0.60)	0.48	0.46 (0.75)	0.27 (0.45)	2.07
Number of other male children	0.45 (0.68)	0.38 (0.56)	0.65	0.31 (0.48)	0.35 (0.50)	0.46
Observations	127	60		112	84	

Note: Standard deviations in parentheses

Table 6. Determinants of weight-for-height Z-score (WHZ) of children in member households

	Model 1A	Model 1B	Model 1C
Sex of child (1=female, 0=male)	0.51	0.50	1.23
	(0.36)	(0.38)	(0.45)**
Age of child(in months)	-0.02	-0.02	-0.02
	(0.01)*	(0.01)**	(0.01)**
Female headed household	-0.87	-0.75	-0.56
	(0.53)	(0.59)	(0.58)
Age of Household Head	-0.01	-0.01	0.01
	(0.04)	(0.03)	(0.03)
Education of Household Head	-0.64	-0.85	-1.09
	(0.70)	(0.70)	(0.66)
Number of adult female labour	1.17	1.09	1.31
	(0.33)***	(0.33)***	(0.35)***
Number of adult male labour	-0.06	-0.13	-0.01
	(0.33)	(0.31)	(0.26)
Tropical Livestock Unit current	-0.26	-0.21	-0.23
	(0.16)	(0.18)	(0.20)
Land area owned in Tsimdi [c]	0.10	0.17	0.17
	(0.16)	(0.12)	(0.11)
Year Dummy (1=2010, 0=2006)	-0.64	-0.55	-0.67
	(0.32)*	(0.24)**	(0.24)**
Number of other children		0.51	
		(0.23)**	
Number of other female children			0.84
			(0.22)***
Number of other male children			-0.04
			(0.21)
Constant	0.22	-0.16	-1.64
	(1.73)	(1.63)	(1.62)
Observations	239	239	239
Number of Household ID	129	129	129
R-squared	0.17	0.20	0.22
Household fixed effect	Yes	Yes	Yes

[a] Robust standard errors clustered by *wereda* in parentheses
[b] * significant at 10%; ** significant at 5%; *** significant at 1%
[c] 1Tsimdi=0.25 hectare

Table 7. Determinants of weight-for-height Z-score (WHZ) of children in non-member households

	Model 2A	Model 2B	Model 2C
Sex of child (1=female, 0=male)	-0.96	-0.89	-1.88
	(0.36)**	(0.36)**	(0.87)*
Age of child(in months)	0.00	-0.00	0.00
	(0.01)	(0.00)	(0.00)
Female headed household	-5.49	-4.83	-5.41
	(0.62)***	(0.67)***	(1.54)***
Age of Household Head	-0.32	-0.30	-0.28
	(0.10)***	(0.09)***	(0.07)***
Education of Household Head	-1.99	-1.72	-1.73
	(0.62)***	(0.62)**	(0.70)**
Number of adult female labour	-0.52	-0.44	-0.65
	(0.36)	(0.32)	(0.47)
Number of adult male labour	-0.19	-0.31	-0.09
	(0.46)	(0.47)	(0.49)
Tropical Livestock Unit current	0.20	0.18	0.16
	(0.25)	(0.26)	(0.25)
Land area owned in Tsimdi [c]	0.15	0.05	0.08
	(0.17)	(0.11)	(0.19)
Year Dummy (1=2010, 0=2006)	-0.89	-0.55	-0.97
	(0.60)	(0.55)	(0.74)
Number of other children		0.76	
		(0.40)*	
Number of other female children			-0.10
			(0.86)
Number of other male children			1.14
			(0.48)**
Constant	16.06	14.82	14.61
	(3.78)***	(3.35)***	(3.49)***
Observations	144	144	144
Number of Household ID	79	79	79
R-squared	0.39	0.42	0.45
Household fixed effect	Yes	Yes	Yes

[a] Robust standard errors clustered by *wereda* in parentheses
[b] * significant at 10%; ** significant at 5%; *** significant at 1% [c] 1Tsimdi=0.25 hectare

Table 8. Kolmogorov-Smirnov test and t-test on predicted values for members and non-members

	Kolmogorov-Smirnov test		T-test		Number of observations
Group	D	P-value	Mean	t-value	
Members	-0.01		-0.05		239
Non-members	0.15		-0.60		144
Combined	0.15	0.03	-0.25	2.90	383

Note: Models 1A and 2A are used to generate these results

Table 9.Treatment effects-average weight-for-height Z-score

Groups	Member households' response to characteristics	Non-member households' responses to characteristics	Treatment effects (Column 2- column 3)
Member households' characteristics	[1] -0.05	[2] -1.43	[3] 1.38 (0.27) ***
Non-member households' characteristics	[4] -0.64	[5] -0.60	[6] -0.04 (0.40)
Heterogeneity effects (Row 2- row 3)	[7] 0.59 (0.13) ***	[8] -0.84 (0.42)**	

Standard errors in parenthesis ** significant at 5% and *** significant at 1%

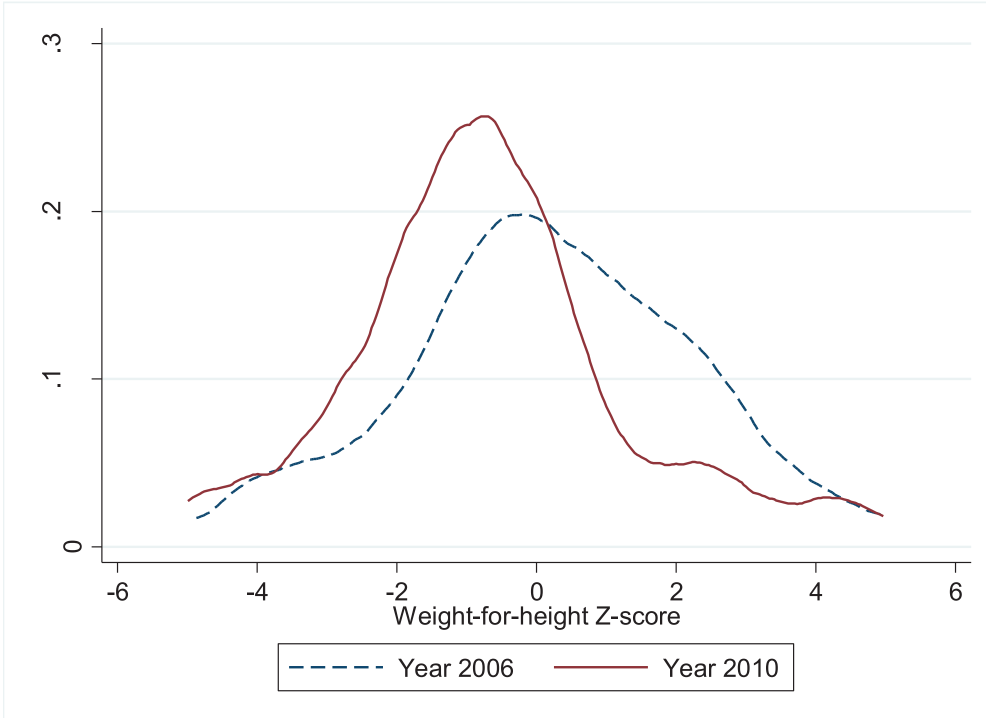

Figure 1. Kernel Density of WHZ, by year.

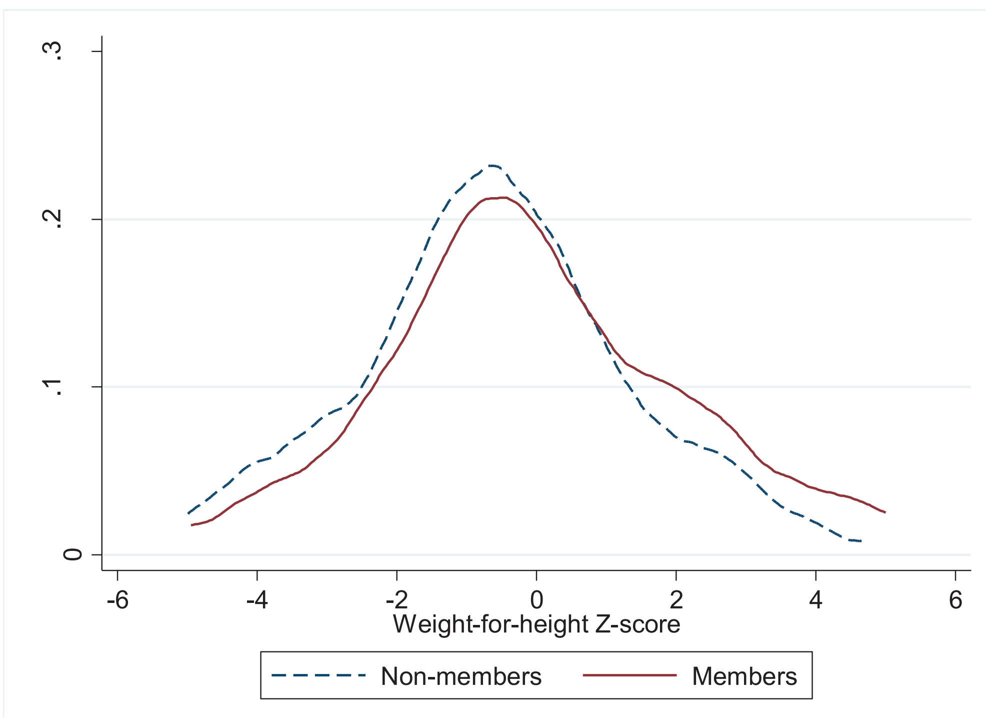

Figure 2. Kernel Density of WHZ by PSNP status.

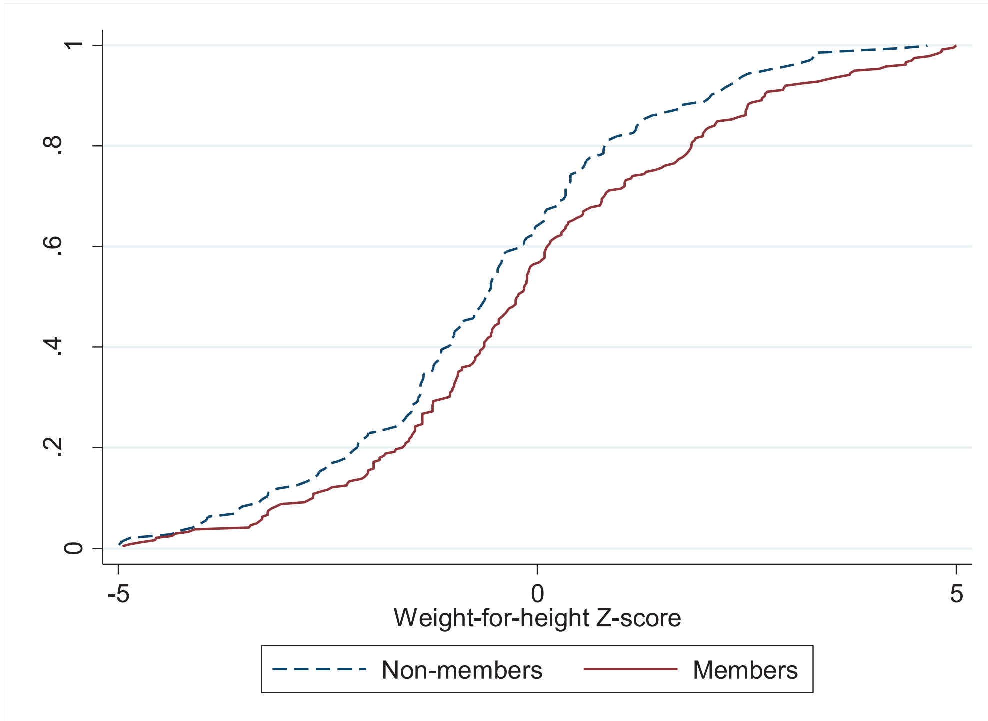

Figure 3. Cumulative density function of WHZ by PSNP status.

Appendices

Appendix A

Theoretical Model

This section presents the theoretical model which underpins the logic outlined in the theoretical framework. We begin by developing a multi-period dynamic model of household production and consumption in which household health evolves as a stock. As a simple starting point, we assume a unitary household in which household members make decisions, including those that affect child nutrition, jointly.[13] The representative household maximizes a discounted stream of utility, defined over consumption, subject to the technology of production and the evolution in stocks of human and physical capital. The problem can be written as:

$$\text{Max}\sum_{t=0}^{T} \beta^{t}\ U(C_t) \qquad [A.1]$$

Subject to

$$C_t = I_t - S_t \qquad [A.2]$$

$$\bar{L}_b = L_{tb}^{G} + L_{tb}^{o} + L_{tb}^{F} + L_{tb}^{H} \qquad [A.3]$$

$$\bar{L}_d = L_{td}^{G} + L_{td}^{F} + L_{td}^{H} \qquad [A.4]$$

$$Q_t = q\left(L_{tb}^{G}, L_{td}^{G}, A_t, \eta\right) \qquad [A.5]$$

$$I_t = P_t Q_t + w_t^{o} L_{tb}^{o} + w_t^{F} L_{tb}^{F} + w_t^{F} L_{td}^{F} \qquad [A.6]$$

$$A_t = (1+r)\ A_{t-1} + S_t \qquad [A.7]$$

$$H_t = h\ (L_{tb}^{H}, L_{td}^{H}, C_t) + H_{t-1} \qquad [A.8]$$

[13] The assumption of unitary household is a strong one. However, using bargaining household model would quickly complicate our modelling approach and will not enable us to easily show the mechanism through which PSNP affects child nutrition.

where C_t is a vector containing consumption of food, manufactured goods and health; I_t is the income of the household; and S_t represents savings. Equations [A.3] and [A.4] represent labor constraints for each gender category where subscripts *b* and *d* refer to male and female labor, respectively. $\bar{L}$ is the total labor endowment; L_t^G, L_t^o, L_t^F and L_t^H represent labor allocated to agricultural production, off-farm work, food-for-work (FFW) and health, respectively. Gender disaggregation of the labor force endowment is important because household health outcomes may vary depending on whether new activities require the (re)allocation of male or female labor. Since off-farm employment is generally unavailable or greatly limited for women in Tigray, we assume in equation [A.4] that female labor cannot be allocated to off-farm employment. Q_t is an agricultural production function which is increasing in labor and stock of land and non-land productive assets (A_t) and decreasing in negative shocks that affect production (η); P_t refers to the price of a composite agricultural product; w_t^o and w_t^F are wages from off-farm employment and food-for-work, respectively.

The dynamic system is governed by two equations of motion, one for physical capital (equation [A.7]) and one for human capital (equation [A.8]). A_t appreciates at the rate *r* and can be augmented through savings. Of course, the stock of land may depreciate from degradation and the stock of animals may depreciate from disease. The household's stock of human capital is represented as an aggregate index of health, H_t, which evolves subject to previous health status (H_{t-1}) and improvements in health generated through the health production function [$h(\bullet)$]. We assume the health production function is concave in its arguments and depends on the labor allocated to health (child care) and the current level of consumption (C_t). In subsequent modeling, we consider child health to be part of H_t.

Substitution of equation [A.5] into equation [A.6]; equation [A.6] into equation [A.2] and equation [A.2] into the objective function yields the following fixed-horizon optimization problem:

$$\mathrm{Max}\sum_{t=0}^{T}\beta^{t}\ U[P_t(q(L_{tb}^{G}, L_{td}^{G}, A_t, \eta)) + w_t^{o}L_{tb}^{o} + w_t^{F}L_{tb}^{F} + w_t^{F}L_{td}^{F} - S_t] \qquad [A.9]$$

Subject to: $\bar{L}_b = L_{tb}^{G} + L_{tb}^{o} + L_{tb}^{F} + L_{tb}^{H}$ [A.10]

$$\bar{L}_d = L_{td}^{G} + L_{td}^{F} + L_{td}^{H} \qquad [A.11]$$

$$A_t - A_{t-1} = r\,A_{t-1} + S_t \qquad [A.12]$$

$$H_t - H_{t-1} = h\,(L_{tb}^{H}, L_{td}^{H}, C_t) \qquad [A.13]$$

The choice variables in the problem are $L_{tb}^{G}, L_{td}^{G}, L_{tb}^{o}, L_{tb}^{F}, L_{td}^{F}, L_{tb}^{H}$ and L_{td}^{H} while the state variables are A_t and H_t. We assume that initial conditions for the state variables are given as $A\ (0) = A_0$ and $H\ (0) = H_0$ where $A_0 = \bar{A} > 0$ and $H_0 = \bar{H} > 0$. With a fixed terminal time T, transversality conditions for the state variables (with initial values $\bar{A}$ and $\bar{H}$) imply that the values of physical and human capital may vary at the terminal time depending on the shadow values of increments to these stocks compared with the cost of further improvements.

Accounting for the constraints on the choice variables, the dynamic Lagrangian associated with the problem is:

$$\mathcal{L} = \beta^{t}\ U[P_t(q(L_{ta}^{G}, L_{tb}^{G}, A_t, \eta)) + w_t^{o}L_{tb}^{o} + w_t^{F}L_{tb}^{F} + w_t^{F}L_{td}^{F} - S_t] + \theta_t(r\,A_{t-1} + S_t)$$
$$+\delta_t[h\,(\bar{L}_b - L_{tb}^{G} - L_{tb}^{o} - L_{tb}^{F}, \bar{L}_d - L_{td}^{G} - L_{td}^{F}, C_t)\,]$$
$$+\lambda_t(\bar{L}_b - L_{tb}^{G} - L_{tb}^{o} - L_{tb}^{F} - L_{tb}^{H}) + \gamma_t\,(\bar{L}_d - L_{td}^{G} - L_{td}^{F} - L_{td}^{H}) \qquad [A.14]$$

The first-order necessary conditions (FOC) with respect to labor allocated to health and FFW for male labor are given by equation [A.15] and equation [A.16].

$$\frac{\partial \mathcal{L}}{\partial L_{tb}^{F}} = \beta^{t} \frac{\partial U}{\partial C_t} \frac{\partial C_t}{\partial L_{tb}^{F}} + \delta_t \frac{\partial h}{\partial L_{tb}^{F}} - \lambda_t = 0 \longrightarrow \beta^{t} \frac{\partial U}{\partial C_t} w_t^{F} + \delta_t \frac{\partial h}{\partial L_{tb}^{F}} - \lambda_t = 0$$

$$\longrightarrow \lambda_t = \beta^{t} \frac{\partial U}{\partial C_t} w_t^{F} + \delta_t \frac{\partial h}{\partial L_{tb}^{F}} \qquad [A.15]$$

$$\frac{\partial \mathcal{L}}{\partial L_{tb}^{H}} = \delta_t \frac{\partial h}{\partial L_{tb}^{H}} - \lambda_t = 0 \longrightarrow \lambda_t = \delta_t \frac{\partial h}{\partial L_{tb}^{H}} \qquad [A.16]$$

Analogously, the FOC with respect to the choice variables of interest (labor allocated to health and FFW) for female labor are presented in equation [A.17] and equation [A.18].

$$\gamma_t = \beta^{t} \frac{\partial U}{\partial C_t} w_t^{F} + \delta_t \frac{\partial h}{\partial L_{td}^{F}} \qquad [A.17]$$

$$\gamma_t = \delta_t \frac{\partial h}{\partial L_{td}^{H}} \qquad [A.18]$$

Solving equations [A.15] and [A.16] for male labor and equations [A.17] and [A.18] for female labor results in a pair of equations that illustrate the potential connections between a program like Ethiopia's PSNP and nutrition outcomes. Equations [A.19] and [A.20] show these links.

$$\beta^{t} \frac{\partial U}{\partial C_t} w_t^{F} + \delta_t \frac{\partial h}{\partial L_{tb}^{F}} = \delta_t \frac{\partial h}{\partial L_{tb}^{H}} \longrightarrow \delta_t \frac{\partial h}{\partial L_{tb}^{F}} = \delta_t \frac{\partial h}{\partial L_{tb}^{H}} - \beta^{t} \frac{\partial U}{\partial C_t} w_t^{F} \qquad [A.19]$$

$$\beta^{t} \frac{\partial U}{\partial C_t} w_t^{F} + \delta_t \frac{\partial h}{\partial L_{td}^{F}} = \delta_t \frac{\partial h}{\partial L_{td}^{H}} \longrightarrow \delta_t \frac{\partial h}{\partial L_{td}^{F}} = \delta_t \frac{\partial h}{\partial L_{td}^{H}} - \beta^{t} \frac{\partial U}{\partial C_t} w_t^{F} \qquad [A.20]$$

Appendix B

Table B.1.Instrumental variable regression (second stage)

	IV-WHZ
Membership in PSNP	1.96
	(2.10)
Girls=1,Boys=0	-0.12
	(0.25)
Age in months	-0.01
	(0.01)*
Sex of Household Head	0.36
	(0.38)
Age of Household Head	-0.01
	(0.01)
Education of Household Head	-0.41
	(0.26)
Number of adult female labour	-0.14
	(0.19)
Number of adult male labour	0.01
	(0.16)
Land area owned in Tsimdi	-0.00
	(0.10)
Tropical Livestock Unit current	0.11
	(0.10)
Year 2010=1 and 2006=0	-0.66
	(0.29)**
Sahsamre	-0.32
	(1.46)
Enderta	-0.78
	(1.61)
Wukro	-1.33
	(2.03)
Deguatembien	-1.04
	(0.78)
Saesetseada	0.25
	(1.47)
Gulomekda	-2.41
	(1.42)*
Ahferom	-0.54
	(1.35)
Merbleke	0.21
	(1.58)
Laelayadyabo	-0.83
	(1.57)
Constant	0.63
	(1.24)
Number of obs.	303
R-squared	0.06
Post-estimation tests	
Endogeniety test	0.77 (P-value=0.38)
F-test	2.98 (P-value=0.09)

[a] Robust standard errors clustered by household ID in parentheses

[b] * significant at 10%; ** significant at 5%; *** significant at 1%

[c] 1Tsimdi=0.25 hectare [d] Variables Sahsamre-Laelayadyabo are *wereda* dummies

Table B.2. Endogenous switching regression for testing endogeneity of membership

	WHZ
Members	
Girls=1,Boys=0	0.36
	(0.30)
Age in months	-0.02
	(0.01)**
Sex of Household Head	0.24
	(0.44)
Age of Household Head	-0.03
	(0.02)**
Education of Household Head	-0.77
	(0.35)**
Number of adult female labour	0.14
	(0.23)
Number of adult male labour	0.02
	(0.20)
Tropical Livestock Unit current	0.11
	(0.12)
Year 2010=1 and 2006=0	-0.39
	(0.32)
Region 2	-0.27
	(0.44)
Region 3	-0.45
	(0.52)
Region 4	-0.33
	(0.71)
Constant	2.23
	(0.87)**
Non-members	
Girls=1,Boys=0	-1.19
	(0.41)***
Age in months	0.01
	(0.01)
Sex of Household Head	0.72
	(1.54)
Age of Household Head	-0.01
	(0.04)
Education of Household Head	0.11
	(1.22)
Number of adult female labour	-0.50
	(0.40)
Number of adult male labour	0.12
	(0.72)
Tropical Livestock Unit current	0.14
	(0.25)
Year 2010=1 and 2006=0	-1.19
	(1.30)
Region 2	-1.54
	(4.28)

Table B.2 continued	
Region 3	0.96
	(1.02)
Region 4	0.21
	(3.22)
Constant	-1.32
	(8.42)
Membership in PSNP	
Girls=1,Boys=0	0.01
	(0.20)
Age in months	0.01
	(0.01)
Sex of Household Head	0.08
	(0.36)
Age of Household Head	-0.02
	(0.01)
Education of Household Head	0.04
	(0.42)
Number of adult female labour	-0.02
	(0.19)
Number of adult male labour	0.07
	(0.25)
Tropical Livestock Unit current	-0.12
	(0.07)*
Year 2010=1 and 2006=0	0.07
	(0.44)
Region 2	0.66
	(0.37)*
Region 3	-0.68
	(0.35)*
Region 4	-0.77
	(0.34)**
Village average FFW income in 1998 [a]	0.002
	(0.00)**
Constant	1.14
	(0.99)
Lnsigma 1	0.67
	(0.03)***
Lnsigma 2	0.84
	(1.71)
Rho 1	**0.09**
	(0.50)
Rho 2	**-1.28**
	(5.58)
Number of households	303
Wald Chi 2 (Overall equation)	27.4
P-value- Chi 2 (Overall equation)	0.01
Wald test of independent equations	338.04
P-value independent equations	0.00

[a] Village average deflated FFW income in 1998(deflated to 2006)
[b] * significant at 10%; ** significant at 5%; *** significant at 1%
[c] 1Tsimdi=0.25 hectare

Table B.3. Determinants of weight-for-height (WHZ) with squared term for household head age

	WHZ-Members	WHZ-Non-members
Girls=1,Boys=0	0.53	-0.85
	(0.39)	(0.31)**
Age in months	-0.02	-0.00
	(0.01)*	(0.01)
Sex of Household Head	-0.86	-8.08
	(0.54)	(1.72)***
Age of Household Head	0.08	-1.52
	(0.19)	(0.56)**
Age of Household Head Squared	-0.00	0.01
	(0.00)	(0.00)**
Education of Household Head	-0.70	-3.21
	(0.65)	(0.73)***
Number of adult female labour	1.14	-0.47
	(0.34)***	(0.35)
Number of adult male labour	-0.06	-0.30
	(0.32)	(0.48)
Tropical Livestock Unit current	-0.27	0.31
	(0.17)	(0.25)
Land area owned in Tsimdi	0.12	0.10
	(0.17)	(0.20)
Year 2010=1 and 2006=0	-0.67	-0.37
	(0.34)*	(0.41)
Constant	-1.72	46.11
	(4.73)	(14.65)**
Number of obs.	239	144
Number of households	129	79
R-squared	0.17	0.44

[a] Robust standard errors clustered by *wereda* in parentheses
[b] * significant at 10%; ** significant at 5%; *** significant at 1%
[c] 1Tsimdi=0.25 hectare

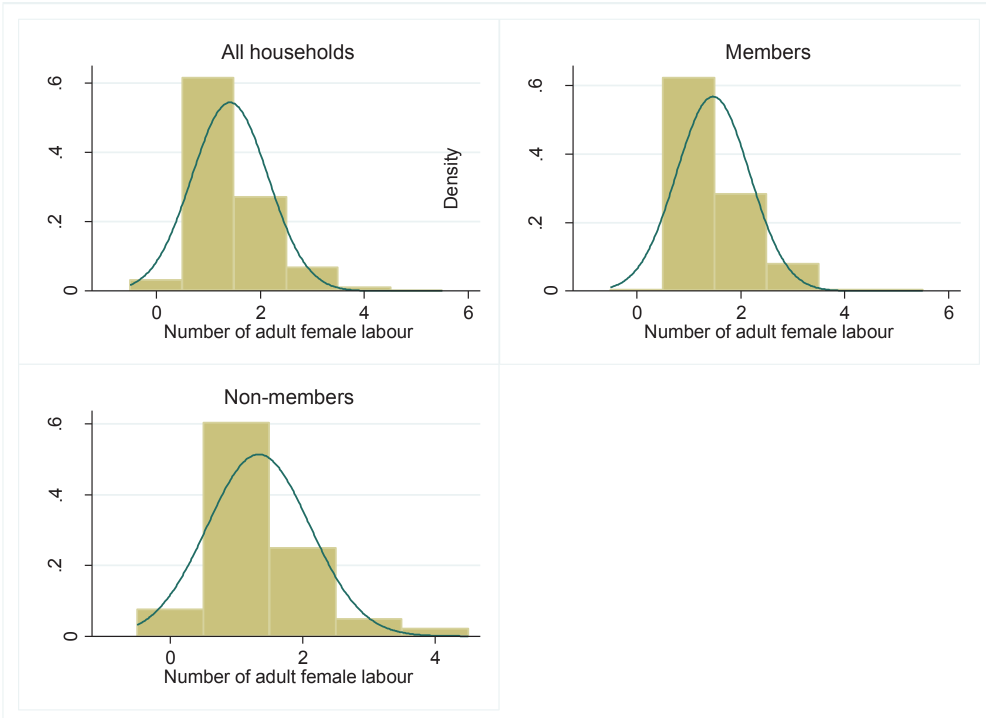

Figure B.1. Distribution of adult females.

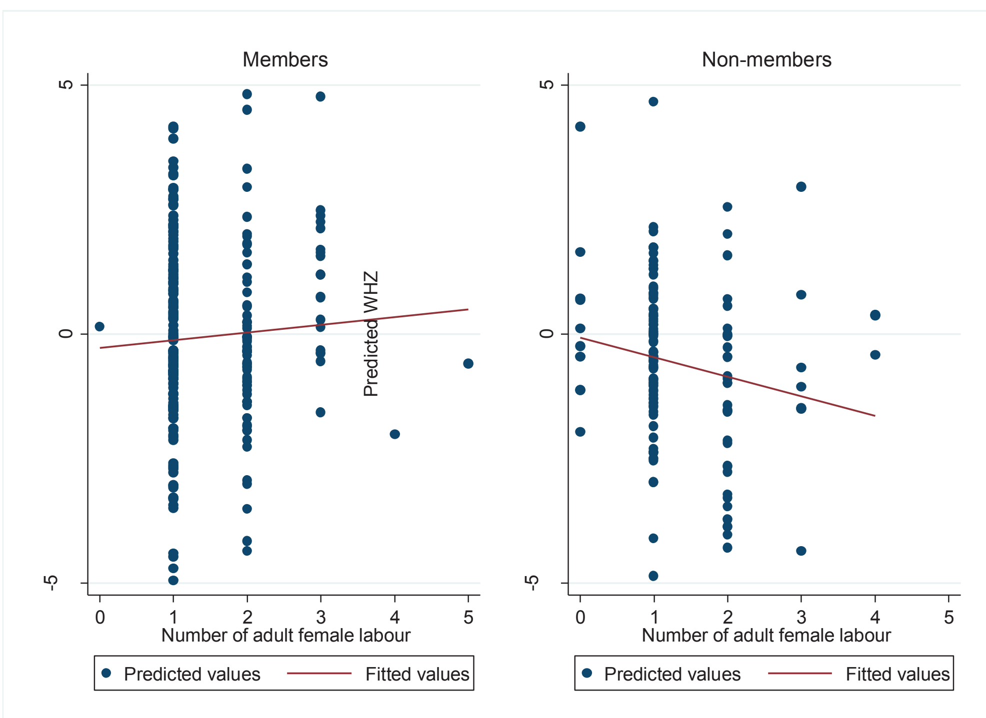

Figure B.2. Predicted WHZ versus number of adult female.

Paper 4

Female Headship and Livestock Accumulation in Northern Ethiopia

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Abstract

This paper investigates gender differences in livestock dynamics using five waves of survey data (1998-2010) from Northern Ethiopia. By employing decomposition analysis, we find that female-headed households own significantly lower livestock compared to male-headed households. Differences in observed characteristics and returns to characteristics account for 29 and 51 percent of the gender difference, respectively. Lower endowment of land area, male labor and children between age of 6 and 14 in female-headed households are the observed factors causing the disparity. Gender difference is more pronounced in the ownership of big animals than small animals. Findings are relevant for gender sensitive public interventions that aim to promote livestock accumulation.

Keywords: Ethiopia; female-headed household; livestock accumulation

JEL Codes: I21, I32, J16

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1. Introduction

In this paper, we examine differences in livestock ownership between female and male-headed households using data collected in Northern Ethiopia. Asset measures have received recent attention in defining chronic poverty (Carter and Barrett, 2006). A growing body of literature shows that building of assets is one of the pathways through which rural households move out of poverty (Carter and Barrett, 2006; Meinzen-Dick et al., 2011). Among the portfolio of assets at the disposal of households, livestock is an important source of agricultural wealth in rural livelihoods (FAO, 2011a). It can produce nutritious food; serve as a source of traction power; provide manure that can enhance land productivity; serve as a buffer stock to smooth consumption; build social capital; and serve as a store of wealth (Rosenzweig and Wolpin, 1993; Njuki and Miller, 2012). In Ethiopia, where livestock takes 90 percent share of the value of assets in the country (Campenhout and Dercon, 2012), livestock ownership reflects agricultural capacity, ability to get credit and wealth status of rural households. Oxen ownership is also important for participation in land rental market (Holden et al., 2008). Female-headed households' ownership of such an important asset-livestock- is essential for food security, child nutrition, education and women's wellbeing (Meinzen-Dick et al., 2011; Njuki and Miller, 2012). However, female-headed households are often more constrained in terms of access to assets (including livestock), labor, credit and extension services (Kassie et al., 2014). This has implications for female-headed households' livestock accumulation strategy and hence poverty.

We aim to answer three research questions: One, is there a difference in the overall amount of livestock owned between female-headed and male-headed households? Two, if so, what factors contribute to the observed gender gap in livestock asset dynamics? And three, does this gender gap depend on whether households accumulate big or small livestock? Data comes from a household panel survey with five rounds of data for the period 1998-2010 in Northern Ethiopia, Tigray region. We employ Blinder-Oaxaca decomposition technique, a method that decomposes causes of gender differences into differences in observed characteristics and coefficients.

Empirical researches that analyze the gender gap in livestock ownership in a dynamic set up are scarce in the literature. Earlier studies with this focus (Muyanga et al., 2011; Tegebu et al., 2012) examined the gender difference using pooled regression with a binary variable for gender, measuring only the intercept effect and not the slope coefficients. Others (Dillon and Quiñones, 2011) analyzed women's and men's asset dynamics separately but did not disentangle and classify factors causing the difference into observed and unobserved attributes. This paper contributes to the literature by identifying specific covariates affecting livestock ownership within female-and male-headed households, separately. Further, it disentangles specific factors causing differences in livestock ownership and categorizing them into observed and unobserved factors. This is an important input to make interventions more gender sensitive.

Results show that female-headed households own 0.41 TLU lower livestock compared to male-headed households, on average. This is equivalent to 26 percent of female-headed households' level of TLU in the initial survey year (1998). According to the decomposition analysis, 29 percent of the gender difference in livestock ownership is explained by differences in the observed characteristics between the two groups. On the other hand, differences in coefficients account for 51 percent of the difference. While difference in the observed characteristics indicates that FHH are poorer in some characteristics, difference in coefficients show that difference in livestock ownership exists even if female-and male-headed households had the same characteristics. The observed factors contributing to the gender difference in the accumulation behavior are differences in land area, the size of male labor force and the number of children between age of 6 and 14. Further disaggregation of livestock into large animals and small ruminants shows that the difference is more pronounced in large animals. Results inform livestock interventions about the underlying mechanisms affecting livestock accumulation behavior of female-versus male-headed households.

2. Gender Difference in Asset Dynamics-Theoretical Model

2.1. Theoretical model

A growing body of literature documents that gender inequality exists in asset ownership (Meinzen-Dick et al., 2011; FAO, 2011a; FAO, 2011b; Dillon and Quiñones, 2011; Quisumbing, 2011). This has a welfare implication since asset accumulation of rural households is indicative of long-term prospect of moving out of poverty (Carter and Barrett, 2006). Several factors interplay in the process with which a household moves in the asset space. Experiences of positive or negative shocks; access to credit and labor markets; information and inputs from extension agents; endowment of labor and other complementary assets are some to mention (Schmidt and Sevak, 2006; Carter and Barrett, 2006; Quisumbing, 2011; FAO, 2011b). Differences in these factors potentially contribute to gender differences in the asset dynamics. In addition, cultural norms might limit women's access to major assets (Njuki and Sangina, 2013) and utilization of assets. In

Ethiopia, for example, there is a cultural norm against women to use oxen for plowing (Bezabih et al., 2012).

Livestock is an essential asset that has unique features compared to other assets such as land and trees (Binswanger and Rosenzweig, 1986; Arayal and Holden, 2012). This is mainly because animals are mobile, very fragile and require daily feeding and frequent maintenance (Binswanger and Rosenzweig, 1986). In addition, livestock is a lumpy asset (physically indivisible) and less suitable for collateral and rental purposes due to its fragility and mobility (ibid). These features potentially affect the livestock accumulation behavior of households, especially female-headed households. Particularly, the labor requirement for feeding and maintenance may limit female-headed households from accumulating livestock since female-headed households are typically labor constrained.

Land is the other complementary asset- important for livestock production- that female-headed households are less endowed with. Since wives move to their husband's locality upon marriage, female-headed households created due to divorce or death of the household are land-poor (Dokken, 2015). They face land scarcity because access and utilization of the households' land involves their in-laws. Studies have shown that female-headed households who are oxen and labor- poor rent out much of their land to male-headed households (Holden et al., 2009; Holden et al., 2011). If female-headed households rent out their land to their in-laws, it will have a negative implication for the productivity of their plots (Holden and Bezabih, 2008). This may be because female landlords are less able to use threat of eviction as a means to enhance productivity if plots are rented out to tenants with kinship ties (Kassie and Holden, 2007; Holden and Bezabih, 2008).

Empowering female-headed households in terms of land ownership is therefore paramount. Holden et al. (2009) found a significant increase in land productivity in Tigray in the period 1998-2006 due to the land certification program that strengthened the land rights of female-headed households. Holden et al. (2011) and Holden and Ghebru (2013) showed that land certification in particular enhanced the land productivity and welfare of female-headed households.

Female-headed households are therefore constrained in their livestock accumulation due to three reasons. One, they lack the necessary complementary asset, land and labor. Two, lower productivity on their plots imply low availability of animal feed which limits their ability to support more livestock. Three, female-headed households are less mobile and less able to use donkeys in transport activities and hence accumulate fewer donkeys.

Theoretically, asset changes of households can be represented in a multi-period dynamic equation where livestock evolves as a stock. The equations of motion governing the dynamic system for livestock accumulation are presented in equations (1) – (3).

$$A_t = (1+r)\ A_{t-1} + S_t^l \qquad (1)$$

$$A_t = (1+r)\ A_{t-1} + Y_t - C_t - S_t^o \qquad (2)$$

$$A_t = (1+r)\ A_{t-1} + P_t[q\ (L_t^A, G_t, \eta)] + w_t^o L_t^o - C_t - S_t^o \qquad (3)$$

where A_t and A_{t-1} denote livestock asset at time t and t-1; r is the rate at which livestock appreciates. Livestock might also depreciate as a result of livestock disease or death, in which case r<0. S_t^l refers to savings invested in livestock [equation 1] which is equal to household income (Y_t) minus consumption (C_t) and savings invested for purposes other than livestock (S_t^o) [equation 2]. As represented in equation (3), Y_t can be decomposed into farm and non-farm income where P_t refers to price of an agricultural production; q is an agricultural production function which is a function of agricultural labor (L_t^A), own land (G_t) and agricultural risk (η); L_t^o represents labor allocated to non-farm activities and w_t^o is the wage from non-farm activities.

Equation (3) indicates that, livestock accumulation depends on the livestock in the previous year, agricultural capacity (including land ownership), labor endowment and current consumption. Gender differences in these factors potentially contribute to inequalities in livestock ownership between female-headed and male-headed households. Based on the theoretical links, this paper hypothesizes that disparities in the ownership of complementary assets such as land and labor are the main factors causing gender-differentiated livestock dynamics.

2.2. Related studies

Gender specific asset dynamics has been a recent area of focus in the literature. Quisumbing (2011) uses an asset-based approach to poverty dynamics and examine asset accumulation of men and women in Bangladeshi households. The author studies assets owned by wives, husbands and jointly owned assets. She finds that there exists gender inequality in accumulation of assets (both land and non-land) and that women are trapped in asset poverty. In Nigeria, Dillon and Quiñones (2011) study the growth in portfolio of women's and men's assets. They find that the stock and value of men's livestock assets increased over time more than women's livestock assets. They attribute this to the fact that men own large animals while women own smaller animals.

There is growing empirical evidence indicating that the gender of the household head determines the livestock accumulation behavior of rural households. A study by Muyanga et al. (2011) analyzes asset dynamics (physical assets and livestock) in Kenya using five rounds of panel data. The authors find that male-headed households are better at accumulating assets than female-headed households. Tegebu et al. (2012) look at the determinants of the type and number of livestock accumulated in Northern Ethiopia. They find that gender of the household head is one of the factors that determine the type of livestock accumulated and that female-headship is negatively associated with the number of animals.

Our paper is similar with Quisumbing (2011) and Dillon and Quiñones (2011) in that we analyze gender specific asset dynamics. It is different from the aforementioned studies since we classify gender using female and male-headed households and only focus on livestock assets. As in Muyanga et al. (2011) and Tegebu et al. (2012), we investigate whether female headship matter for livestock dynamics. These studies however use pooled regressions with a dummy variable for gender assuming that gender has an effect on the intercept and not on the estimated slope coefficients. In this paper, we estimate separate regressions for female and male-headed households, thereby allowing different slope coefficients. This allows us to examine factors determining livestock dynamics within the two groups as well as the variables explaining differences. Similar with Dillon and Quiñones (2011), this paper identifies factors contributing to gender difference in asset accumulation. Particularly, we study the mechanisms causing gender inequality in asset ownership, an issue which is researched to a limited extent. We further decompose the factors causing the difference into explained and unexplained components, different from Dillon and Quiñones (2011). Hence, this paper shares common feature with Dokken (2015), who studied gender bias in land ownership and classified causes of gender differences into endowment and coefficient effects. [1] We, however, use panel data in order to capture the dynamics of asset, livestock ownership in our case.

3. Data

We use five waves of survey data from the highlands of Tigray region in Ethiopia. Data collection started in 1998 and continued up to 2010 with two to four years gap in between (2001, 2003 and 2006). The survey was initially carried out for a stratified random sample of 400 households in 16 villages. Sample households are representative of population density, market access, agro-climatic conditions and access to irrigation projects in the highlands of the region (Hagos and Holden, 2002). [2] The same households were followed in the subsequent years. The survey covered information on household characteristics, asset ownership (land, livestock and physical assets), agricultural production, non-farm income sources and consumption expenditure. After cleaning and identifying same households

[1] Dokken (2015) finds that female-headed households own smaller land area than male-headed households. The author states that difference is attributed to disparities in the observed characteristics of female-and male-headed households as well as gender bias in the allocation of land.

[2] The survey did not include the lowland pastoral areas of the region (Hagos and Holden, 2002).

across survey years, we remain with 1505 household-year observations (301 households for each year).

Agriculture in the highlands of Tigray region is mainly characterized by a mixed crop-livestock farming system (Hagos and Holden, 2002). In such a setting, livestock serves as an input to crop production and as a form of savings (Campenhout and Dercon, 2012). In Tigray region, livestock is vital for agricultural practices and two thirds of the households in the region own at least one ox (Hagos and Holden, 2002). As in other parts of Ethiopia, a pair of oxen is used for cultivating land. This makes oxen an important and at the same time lumpy but divisible asset for the households. The main constraint of livestock production in Tigray is the lack of feed and water. As a result, farmers spend a long time in a day to take their livestock to water sources (Hagos and Holden, 2002).

Our data shows that the percentage of female-headed households has increased since the initial survey year. [3] Table 1 contains the proportion of female-headed households across the survey years. Overall, approximately 27 percent and 73 percent of the households are female-headed and male-headed, respectively. Across the survey years, there have been switches in gender of the household head. The last three columns of Table 1 summarize the proportion of households that have experienced switches in the head of the household. In total, 9 percent had changes in gender of the head with a larger

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[3] Female-headed households can be classified as *de facto* (husband is away from home) and *de jure* (divorced, widowed, single or separated) female-head households (Kassie et al., 2014). Though this definition has important implications in asset accumulation, our data does not allow us to distinguish between these groups.

percentage changing from male-headed to female-headed households. This is probably due to death, divorce or migration of the household head and the Ethio- Eritrean war. [4]

In table 2, we present the descriptive statistics of household characteristics and asset endowments for female-and male-headed households during the initial (1998) and final (2010) survey years. It can be observed that male-headed households are better endowed in many dimensions than female-headed households in both years. On average, female-headed households have smaller number of adult male members, children and total household members. In terms of asset endowment, female-headed households have lower farm size, livestock holding (measured in tropical livestock units-TLU) and oxen. In 2010, male-headed households seem to be older and better educated than female-headed households. One can observe that the gender difference in livestock endowment is higher in 2010 compared to 1998, with female-headed households having lower livestock holding.

Figure 1 and figure 2 depict the livestock holding for female-and male-headed households. The figures clearly show that the distribution of TLU is shifted right wards for male-headed households at all points compared to the female-headed households in 1998 and 2010. In figure 3, we illustrate the disaggregated average livestock holding for each survey years. The figure reveals that gender differences in terms of total livestock ownership-with greater value for male-headed households- existed in all years.

In order to visualize the dynamics of livestock assets, we plot a bivariate plot of stocks of livestock at beginning (1998) and ending (2010) survey years. Here, we use the

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[4] The Ethio-Eritrean war occurred in the period between May 1998 and June 2000 (Wikipedia)

subsample of households without a switch in the gender of household head across years. [5] Figure 4 illustrates this with a separate representation of the livestock dynamics for male- and female-headed households. It can clearly be observed that male-headed households have larger stocks of animals than female-headed households, especially in the year 2010. Greater proportion of male-headed households (65%) showed improvements in livestock ownership between the two years than female-headed households (59%). This pattern can be observed in figure 4. In general, the unconditional descriptive statistics and figures suggest that there is a significant difference in livestock accumulation between male-and female-headed households. Subsequent analysis performs econometric analysis to examine differences.

4. Method

We use the Blinder-Oaxaca decomposition method proposed by Blinder (1973) and Oaxaca (1973) to examine the mean livestock holding differences between male-and female-headed households. The method allows disentangling gender differences attributed to differences in household characteristics on the one hand and differences in coefficients on the other (Jann, 2008). Modelling livestock dynamics for male-and female-headed households separately takes the following form:

$$Y_{it}^{M} = \beta x_{it}^{M} + \varepsilon_{it}^{M} \qquad (4)$$

$$Y_{it}^{F} = \beta x_{it}^{F} + \varepsilon_{it}^{F} \qquad (5)$$

[5] The sample size in this case is 995 observations (199 households in each year). One observation from each year is removed in Figures 3 and 4 as it was biasing the graphical illustrations. We remain with 990 observations.

Y_{it} represents livestock ownership (TLU) for household *i* and survey year *t*. Superscripts *M* and *F* refer to male-and female-headed households, respectively. x_{it} denote a vector of explanatory variables (age and education of head; adult labor and land endowment; number of children between the age of 6 and 14; dummy for off-farm employment; dummy for switch in gender of household head [6] and year dummy variables. ε_i is an error term with expected value of zero.

We employ fixed effects method to the decomposition analysis by applying within transformation of the variables. This is carried out by subtracting the time average from each variable. Equations (6) and (7) represent transformed versions of equations (4) and (5).

$$\tilde{Y}_i^M = \beta\tilde{x}_i^M + \varepsilon_{it}^M \qquad (6)$$

$$\tilde{Y}_i^F = \beta\tilde{x}_i^F + \varepsilon_{it}^F \qquad (7)$$

where $\sim$ on the variables denotes that the variables are within transformed. Since the regression also controls for time fixed effects, the modeling approach is two-way fixed effects. Equation (8) below represents the mean outcome difference in livestock holding between female-and male-headed households which is equivalent to the difference in the linear prediction at the gender-specific means of the regressors. E $(\cdot)$ denotes the expected value of the respective variables.

$$E(\tilde{Y}_i^M) - E(\tilde{Y}_i^F) = \{E(\tilde{x}_i^M) - E(\tilde{x}_i^F)\}'\beta^F + E(\tilde{x}_i^F)'(\beta^M - \beta^F) + \{E(\tilde{x}_i^M) - E(\tilde{x}_i^F)\}'(\beta^M - \beta^F) \quad (8)$$

[6] Switch in the gender of the household head represents change from male to female and female to male in female-headed and male-headed household regressions, respectively.

Alternatively, equation (8) can be written as:

$$E(\tilde{Y}_i^M) - E(\tilde{Y}_i^F) = \Delta\tilde{x}\beta^F + \Delta\beta\tilde{x}^F + \Delta x\Delta\beta \tag{9}$$

In equation (9), subscript i is suppressed for convenience. The first term in the right hand side is termed as the endowment effect. It measures the average differences in the livestock ownership between female-and male-headed households caused by differences in observed characteristics ($\Delta\tilde{x}$). This is also considered as the explained part of the difference. The second term, which is termed as the coefficient effect, is equivalent to the gender difference in livestock ownership due to coefficient difference ($\Delta\beta$). This accounts for the unexplained part of the difference and it is usually considered as the discrimination effect (Blinder, 1973; Jann, 2008). It is considered as a discrimination effect because differences exist even if the female-headed households had the same characteristics (endowment) as the male-headed households (Blinder, 1973; Oaxaca, 1973). However, it is possible that the coefficient effect also includes differences in unobserved variables (Jann, 2008). The model in this paper controls for relevant confounding factors. Further, it uses fixed effects model to take care of time-invariant unobserved heterogeneity. Therefore, we believe that the effect from unobserved factors is minimal although there is a possibility that there exist systematic differences between female-and male-headed households. The third term in equation (9) represents the interaction between the endowment and the coefficient effect.

A test for attrition bias showed that the inverse mills ratio generated from an attrition probit model is not statistically significant in the fixed effects estimations of male- and female-headed households (see tables A1 and A2 in the appendix). In order to examine if variables in the models for female- and male-headed households are statistically different, we carried out a chi squared test. Results showed that some of the variables are statistically different which validates the use of Oaxaca decomposition approach. We report robust standard errors, clustered by household identity, in the decomposition analysis.

One of the limitations of the decomposition approach is its application in dynamic set up. It looks at an average effect when measuring difference in asset ownership between female- and male-headed households. This makes it difficult to disentangle policy effects of government interventions such as the Productive Safety Net Program and land certification program that has been found to have had substantial impacts in the region (Holden et al., 2009; Holden et al., 2011). Since this policy effect is outside the scope of the paper, it may be studied in future researches.

5. Results

Table 3 summarizes the fixed effects estimates of TLU models for male-and female-headed households. We ran two regressions, Model A and Model B, for both groups. As previously noted, there have been switches in the gender of the household head. Model B in male-headed households' regression adds an indicator variable equal to one if the headship switched from female to male. Analogously, the switch variable in Model B for female-headed households refers to a shift from male to female headship. The coefficient estimates and level of significance in Model A and Model B are consistent for both groups. [7]

[7] In order to test the non-linearity of the model, we log transformed Tropical Livestock Units and found that results are similar with the reported regression output. In addition, we attempted to include squared terms for the continuous explanatory variables and found that they are statistically insignificant except the squared term for the age of the household head, which is included in all the regressions. Non-linearity was also tested by (a) making

Results show that factors determining livestock dynamics differ between male-and female-headed households. Parameter estimates have disparities in terms of magnitude and level of significance. As the male household head becomes very old, livestock ownership becomes lower, reflected in the squared term for age of the household head. This is probably because the prospect of accumulating livestock, as in other investments, becomes lower as one reaches a farther point in his life cycle. Age of the household head does not however affect the livestock holding of female-headed households. Educated household heads among male-headed household heads own larger stocks of animals while education does not seem to matter in female-headed households. In both male and female-headed households, larger land area and greater number of female and male adult members have positive influence on livestock ownership. The higher the number of children between age 6 and 14 in female-headed households, the larger the stock of animals owned, ceteris paribus.

In the female-headed households' regression, findings show that households that switched from male to female-headed households have more livestock compared to those that were consistently headed by females across the survey years (see Model B). A possible explanation for this could be that female-headed households that have recently been headed by males are better endowed with livestock than those headed by females across all years. In the male-headed households' regression, the switch variable is statistically insignificant. In terms of the year-fixed effects, male-headed household owned higher stock

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TLU per farm size as the dependent variable instead of TLU, (b) estimating TLU as a function of labor endowments per farm size. The results were inferior to our estimated model in terms of overall fit of the model (very low R-squared). Hence, we report outputs without transformation.

of animals in 2001 and lower stock of animals in 2006 compared to the year 1998. In 2003, both male-and female-headed households had a lower livestock endowment compared to the base year (1998). This is probably attributed to the fact that 2003 was a severe drought year.

Following upon the fixed effects result, Table 4 presents the mean predicted difference in TLU for male- and female-headed households using Blinder-Oaxaca decomposition technique. It reports the average gender difference and decomposes the causes of the difference into endowments, coefficients and interaction. Decomposition result in Table 4 reveals that differences in the observed characteristics constitute 29 percent of the difference (endowment effect) and difference in returns to characteristics make up 51 percent of the difference (coefficient effect).

Findings reveal that male-headed households own significantly higher TLU than female-headed households. This is similar with findings in Muyanga et al. (2011) and Tegebu et al. (2012) for rural households in Kenya and Ethiopia, respectively. The gender difference in livestock ownership is equivalent to 0.41 TLU and the average predicted values for male and female-headed households are 0.14 and -0.27, respectively. Apparently, the average livestock owned by female-headed household has deteriorated compared to the time average while it has improved for male-headed households.

The question now becomes, what are the factors causing the gender difference in forming livestock assets? In Table 5, we report the details of the decomposition analysis which summarizes the specific effects of the predictors under the endowment and coefficient components. [8] Results show that differences in the endowment of adult male labor contribute to the lower livestock ownership in female-headed households. This is probably related to the fact that male labor endowment is vital for agricultural activities that require physical strength. Ploughing, that typically involves a pair of oxen in the study area and elsewhere in the country, is solely carried out by the male labor force. In addition to the need for physical strength in ploughing activity, there is a cultural norm against women ploughing using oxen (Bezabih et al., 2012). Management of other types of livestock also requires labor endowment in the household. Hence, the shortage of male labor force in female-headed households could hinder these households from acquiring more livestock over time.

Children contribute to the labor requirement in livestock farming by herding the animals (Tegebu et al., 2012). Findings indicate that difference in the endowment of children between the age of 6 and 14 is another cause for the difference in livestock ownership between the two groups. This is probably because female-headed households are smaller and hence less able to provide the necessary labor for management of animals to access public grazing land in which case children may be used to accompany the animals.[9]

Inequality in owned land area also contributes to the gender difference in building livestock asset (see Table 5). In the study area, land ownership is biased towards male-

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[8] We use Model B when reporting the detail of the decomposition analysis.

[9] Number of children might be endogenous in the livestock accumulation decision. Excluding the variable does not however alter the main result and we opt to keep it in the models.

headed households (Dokken, 2015). [10] Further, female-headed households are in a weak position in terms of land management and tenure security (Holden et al., 2011). One reason could be that husbands are the ones who are in charge of managing the land. Women traditionally change their dwelling place to their husband's home village upon marriage which lessens the chance of owning land in their own home village. This eventually renders the wife either to be landless or remain with small portion of the land upon divorce or death of the household head (Holden et al., 2011; Dokken, 2015).

Land area can affect livestock ownership through its effect on availing animal feed from the land and the wealth effect. Ownership of larger land area reflects the wealth of the household and hence the households' ability to invest in productive assets-wealth effect. A small portion of land area can only generate smaller amount of fodder, which is a major constraint in the study area. The availability of crop residue for female-headed households might however depend on their land rental participation. According to Holden et al. (2008), female-headed households are more likely to rent-out their land. Hence, tenants may potentially get much of the fodder depending on the agreement. [11] As a result, we expect that the wealth effect matters more in affecting the difference in livestock ownership. Findings show that more land-poor female-headed households are less able to build large stock of animals.

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[10] The author employed the 2006 data from the panel survey data that this paper uses.

[11] Since this paper considers total land area owned (owner operated and rented-out land) instead of operational land holding, difference due to farm size takes into account of the total endowment.

The coefficient effect (third column in Table 5), which has an overall significance at 10 percent level, reveals that female-headed households would accumulate less livestock even if the returns to their characteristics were the same as male-headed households. When examining specific coefficients, one can notice that the year dummy for 2001 is statistically significant in the model. This implies that this period was the time that contributed to the significantly lower stock of animals in female-headed households. One possible explanation could be that this period was an aftermath of the Ethio-Eritrean war. A common way to treat the army was to provide livestock for slaughtering and the source for livestock was probably the area close to the war zone, Tigray region. This may have affected the livestock accumulation behavior in the study area. Possibly, female-headed households may have been more likely to sell livestock to the military due to three reasons. One, they are more vulnerable than male-headed households. Two, male labor is scarce in these households due to the war, thereby discouraging livestock accumulation and encouraging livestock sale. Three, the market value of livestock during that period may have raised tempting female-headed households to sell livestock due to their relative vulnerability. In this model, the only statistically significant variable is the year 2001. Hence, the coefficient effect may not necessarily reflect the existence of discrimination in livestock accumulation but rather the relative vulnerability of female-headed households.

Tables 6 shows fixed effects result for TLU equivalent of big and small animals. [12] In these estimations, we report Model B version of the regressions, i.e., with a variable controlling for a switch in the gender of the household head. Major findings in the

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[12] Big animals compose of ox, cow, heifer, bull, calve, horse, mule, donkey and camel. Small animals consist of sheep, goat and chicken.

regression for big animals are similar with the model for all animals, except for a slight difference in magnitude. Estimation results for small animals are however different from the regressions for all animals and big animals. This implies that factors determining the livestock dynamics of big animals are different from that of small animals.

In Table 7, we summarize mean gender differences in the ownership of big and small animals. It shows that, for both big and small animals, female-headed households own significantly lower stock of animals. Differences in the ownership of small animals are lower compared to large animals. This implies that large animals such as oxen have less productive value for female-headed households who are constrained with male labor force and land area. The cultural norm also makes it harder for women to utilize oxen for ploughing. Tables 8 and 9 show the factors explaining the gender difference in the accumulation of big and small animals, respectively. Endowment of male labor and farm size commonly contribute to the endowment effect in the dynamics of big and small animals. Differences in the number of children, however, mattered only for big animals. A plausible explanation is that labor requirement from children for looking after small animals is minimal and does not influence differences in the dynamics of small animals. In general, there seems to be a gender inequality in livestock ownership.

6. Conclusions

Using panel data from Northern Ethiopia, we examined whether a gender difference in livestock dynamics exists. By applying the Blinder-Oaxaca decomposition technique, this study investigated the potential causes of the difference between female and male-headed households. Descriptive analysis showed that female-headed households are less well off than male-headed households in terms of labor, land and non-land asset endowments. The empirical analysis revealed that female-headed households own significantly lower livestock asset than male-headed households. Difference in the observed characteristics as well as in the returns to characteristics contributed to the gender disparity in livestock ownership. We find that lower endowment of male labor, children (age 6-14) and land area are the factors causing lower level of livestock accumulation in female-headed households. The decomposition analysis also showed that female-headed households would still own fewer animals even if they had the same coefficients as male-headed households. This difference, which is attributed to unexplained factors, is mainly affected by the period at the aftermath of the Ethio-Eretrean war (2001). Possible reason may be that there was a need to sell livestock to feed the army during that period which is more likely to affect female-headed households due to their relative vulnerability. Findings also showed that gender difference is more pronounced in the stock of big animals than small animals.

Policy implications arising from our results are as follows. First, our result showed that smaller area of land owned by female-headed households is one of the reasons contributing to the gender differentiated livestock dynamics. Therefore, ensuring that land allocation is not biased against wives upon divorce or the death of the household head not only improves the tenure security of female-headed households but also encourages them to build their livestock assets. In relation to this, land certificates for female-headed household have important role to play in increasing the chance of keeping the land upon divorce or death of the husband (Ghebru and Holden, 2013). Second, promotion of a well-functioning labor market would ease the labor constraint in female-headed households and allow them to hire male labor. This way, they will be able to fill in the labor gap in the household for oxen-based farming and livestock herding. As a result, female-headed households would be encouraged to build their livestock asset. Third, policy interventions that encourage livestock accumulation should consider the fact that female-headed households are less endowed with important complementary assets, land and labor.

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Table 1. Percentages of female and male-headed households in the survey years

Year	Female	Male	Any switch between sex [a]	Female to male [a]	Male to female [a]
1998	23.3 (70)	76.7 (231)			
2001	23.9 (72)	76.1 (229)	15.3 (46)	7.3 (22)	8.0 (24)
2003	27.2 (82)	72.8 (219)	6.6 (20)	1.7 (5)	5.0 (15)
2006	29.6 (89)	70.4 (212)	8.3 (25)	3.0 (9)	5.3 (16)
2010	28.6 (86)	71.4 (215)	15.0 (45)	8.0 (24)	7.0 (21)
All years	26.5 (399)	73.5 (1106)	9.0 (136)	4.0 (60)	5.1 (76)

Note:1. Number of households in parentheses

2. In columns 4 to 5, values represent changes from the previous survey year

Source: Own data

Table 2. Descriptive statistics of major household characteristics for male and female-headed households (1998 and 2010)

	All years			1998			2010		
	Female-headed	Male-headed	T-test	Female-headed	Male-headed	T-test	Female-headed	Male-headed	T-test
Age of household head	51.0	54.7	-4.28	47.8	49.9	-0.95	54.5	58.0	-2.01
Education of household head(1=literate, 0=illiterate)	0.08	0.33	-10.1	0.03	0.03	0.12	0.08	0.38	-5.31
Number of adult females	1.19	1.42	-4.74	1.10	1.22	-1.33	1.29	1.47	-1.45
Number of adult males	0.72	1.63	-15.0	0.54	1.48	-7.45	0.73	1.68	-6.40
Number of children	1.26	2.41	-12.8	0.97	2.45	-7.02	1.31	2.17	-4.07
Household size	3.56	5.92	-19.1	2.80	5.37	-9.38	3.59	5.73	-7.62
Land area(tsimdi)	3.35	4.91	-7.28	3.03	4.72	-2.48	3.64	4.54	-2.20
Off-farm income dummy	0.55	0.47	2.46	0.46	0.40	0.81	0.48	0.44	0.62
TLU (all livestock)	1.49	3.58	-11.7	1.60	2.65	-2.98	1.47	3.50	-6.41
TLU (without oxen)	1.04	2.43	-9.15	1.00	1.54	-1.87	0.99	2.13	-4.79
TLU (big animals)	1.38	3.36	-11.5	1.51	2.50	-3.01	1.35	3.19	-6.28
TLU (small ruminants)	0.11	0.22	-4.70	0.09	0.14	-1.16	0.12	0.32	-3.54
Number of oxen owned	0.41	1.05	-12.9	0.54	1.01	-4.02	0.44	1.25	-7.30
Number of observation	399	1106		70	231		86	215	

Note: Big animals include ox, cow, heifer, bull, calve, horse, mule, donkey and camel. Small ruminants include sheep, goat and chicken.
Source: Own data

Table 3. Fixed effects regression of TLU-Male and female-headed households

	Male-headed households		Female-headed households	
	Model A	Model B	Model A	Model B
Age of household head [1]	1.58	1.58	-0.42	-0.64
	(0.49)***	(0.49)***	(0.57)	(0.57)
Age of household head squared [1]	-0.12	-0.12	0.05	0.08
	(0.04)***	(0.04)***	(0.05)	(0.05)
Education of household head	0.87	0.87	-0.19	-0.07
	(0.22)***	(0.22)***	(0.38)	(0.38)
Number of adult female labor	0.22	0.22	0.49	0.50
	(0.11)**	(0.11)**	(0.16)***	(0.16)***
Number of adult male labor	0.25	0.25	0.43	0.46
	(0.10)***	(0.10)**	(0.15)***	(0.15)***
Land area (Tsimdi) [2]	0.06	0.06	0.13	0.13
	(0.03)**	(0.03)**	(0.04)***	(0.04)***
Dummy for off farm employment	-0.01	-0.01	0.20	0.17
	(0.17)	(0.17)	(0.21)	(0.21)
Number of children (>=6 and <=14 years)	0.08	0.08	0.31	0.33
	(0.09)	(0.09)	(0.12)***	(0.12)***
Year 2001	1.57	1.56	0.12	-0.08
	(0.16)***	(0.16)***	(0.21)	(0.22)
Year 2003	-0.45	-0.46	-0.31	-0.42
	(0.16)***	(0.16)***	(0.19)	(0.19)**
Year 2006	-0.52	-0.53	-0.30	-0.40
	(0.16)***	(0.16)***	(0.18)	(0.19)**
Year 2010	-0.18	-0.20	-0.16	-0.28
	(0.16)	(0.17)	(0.19)	(0.20)
Switch between sex [3]		0.18		0.61
		(0.31)		(0.24)**
Observations	1106	1106	399	399
R-squared	0.16	0.16	0.15	0.16

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

[1] Age of the household head is divided by 10 years, i.e., one unit is 10 years.

[2] 1 Tsimdi=0.25 hectare

[3] Switch between sexes represent change in sex of household head from male to female in the case of female-headed households' regressions and from female to male in the case of male-headed households' regressions.

Table 4. Decomposition of mean difference in TLU

		Model A	Model B
Differential	Prediction- Male-headed households	0.14	0.14
		(0.04)***	(0.04)***
	Prediction- Female-headed households	-0.26	-0.27
		(0.07)***	(0.06)***
	Difference	0.40	0.41
		(0.08)***	(0.08)***
Decomposition	*Difference due to:*		
	Endowments	0.18	0.12
		(0.06)***	(0.05)**
	Coefficients	0.18	0.21
		(0.08)**	(0.09)**
	Interaction	0.04	0.08
		(0.06)	(0.08)
	Observations	1505	1505
	No. of households	301	301

Robust standard errors clustered by household ID in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5. Detailed decomposition of causes of difference in TLU

	Differences due to:		
	Endowments	Coefficients	Interaction
Age of household head	-0.04	-0.10	0.14
	(0.05)	(0.08)	(0.11)
Age of household head squared	0.05	0.10	-0.13
	(0.06)	(0.08)	(0.11)
Education of household head	-0.00	-0.04	0.06
	(0.03)	(0.03)	(0.04)
Number of adult female labor	0.00	0.00	-0.00
	(0.01)	(0.01)	(0.01)
Number of adult male labor	0.10	0.03	-0.05
	(0.04)***	(0.03)	(0.04)
Land area (Tsimdi)[1]	0.03	0.01	-0.02
	(0.02)**	(0.01)	(0.02)
Dummy for off farm employment	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)
Number of children (>=6 and <=14 years)	0.04	0.02	-0.03
	(0.02)**	(0.01)	(0.02)
Switch between sex[2]	-0.08	-0.08	0.06
	(0.04)**	(0.07)	(0.05)
Year 2001	-0.00	0.30	0.04
	(0.01)	(0.05)***	(0.02)**
Year 2003	0.00	-0.01	0.00
	(0.00)	(0.04)	(0.00)
Year 2006	0.01	-0.03	0.00
	(0.01)*	(0.04)	(0.01)
Year 2010	0.01	0.02	-0.00
	(0.01)	(0.04)	(0.00)
Total	0.12	0.21	0.08
	(0.05)**	(0.09)**	(0.08)
Number of observation	1505	1505	1505
Number of households	301	301	301

Robust standard errors clustered by household ID in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Results are based on Model B in the previous tables.
[1] 1 Tsimdi=0.25 hectare
[2] Switch between sexes represent change in sex of household head from male to female in the case of female-headed households' regressions and from female to male in the case of male-headed households' regressions.

Table 6. Fixed effects regression of TLU equivalent of big and small animals-Male and female-headed households

	Big animals		Small animals	
	MHH	FHH	MHH	FHH
Age of household head [1]	1.33	-0.61	0.25	-0.03
	(0.47)***	(0.54)	(0.08)***	(0.08)
Age of household head squared [1]	-0.10	0.08	-0.02	0.00
	(0.04)**	(0.05)	(0.01)***	(0.01)
Education of household head	0.84	-0.07	0.03	0.00
	(0.21)***	(0.36)	(0.04)	(0.05)
Number of adult female labor	0.22	0.46	0.00	0.03
	(0.11)**	(0.15)***	(0.02)	(0.02)
Number of adult male labor	0.25	0.44	-0.00	0.03
	(0.09)***	(0.15)***	(0.02)	(0.02)
Land area (Tsimdi) [2]	0.06	0.12	-0.00	0.01
	(0.02)***	(0.04)***	(0.00)	(0.01)*
Dummy for off farm employment	-0.05	0.18	0.03	-0.01
	(0.16)	(0.20)	(0.03)	(0.03)
Number of children (>=6 and <=14 years)	0.07	0.30	0.01	0.02
	(0.08)	(0.11)***	(0.01)	(0.02)
Switch between sex [3]	0.17	0.63	0.02	-0.02
	(0.30)	(0.23)***	(0.05)	(0.03)
Year 2001	1.67	-0.01	-0.11	-0.07
	(0.16)***	(0.21)	(0.03)***	(0.03)**
Year 2003	-0.54	-0.39	0.07	-0.03
	(0.15)***	(0.19)**	(0.03)***	(0.03)
Year 2006	-0.54	-0.48	0.02	0.08
	(0.15)***	(0.18)***	(0.03)	(0.03)***
Year 2010	-0.29	-0.30	0.09	0.02
	(0.16)*	(0.19)	(0.03)***	(0.03)
Observations	1106	399	1106	399
R-squared	0.18	0.16	0.05	0.07

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

[1] Age of the household head is divided by 10 years, i.e., one unit is 10 years.

[2] 1 Tsimdi=0.25 hectare

[3] Switch between sexes represent change in sex of household head from male to female in the case of female-headed households' regressions and from female to male in the case of male-headed households' regressions.

Table 7. Decomposition of mean difference in TLU equivalent of big and small animals

		Big animals	Small animals
Differential	Prediction- Male-headed households	0.13	0.01
		(0.04)***	(0.00)***
	Prediction- Female-headed households	-0.26	-0.01
		(0.06)***	(0.01)*
	Difference	0.39	0.02
		(0.08)***	(0.01)***
Decomposition	*Difference due to:*		
	Endowments	0.11	0.01
		(0.05)**	(0.01)*
	Coefficients	0.18	0.03
		(0.09)**	(0.01)**
	Interaction	0.09	-0.01
		(0.07)	(0.01)
	Observations	1505	1505
	No. of households	301	301

Robust standard errors clustered by household ID in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 8. Detailed decomposition of causes of difference in TLU equivalent of big animals

	Differences due to:		
	Endowments	Coefficients	Interaction
Age of household head	-0.04	-0.09	0.12
	(0.05)	(0.07)	(0.10)
Age of household head squared	0.05	0.08	-0.11
	(0.06)	(0.07)	(0.10)
Education of household head	-0.00	-0.04	0.06
	(0.03)	(0.03)	(0.04)
Number of adult female labor	0.00	0.00	-0.00
	(0.01)	(0.01)	(0.01)
Number of adult male labor	0.09	0.03	-0.04
	(0.04)**	(0.03)	(0.04)
Land area (Tsimdi)[1]	0.03	0.01	-0.01
	(0.02)*	(0.01)	(0.02)
Dummy for off farm employment	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)
Number of children (>=6 and <=14 years)	0.04	0.02	-0.03
	(0.02)**	(0.01)	(0.02)
Switch between sex[2]	-0.09	-0.09	0.06
	(0.04)**	(0.07)	(0.05)
Year 2001	-0.00	0.30	0.04
	(0.01)	(0.05)***	(0.02)**
Year 2003	0.00	-0.03	0.00
	(0.00)	(0.04)	(0.00)
Year 2006	0.01	-0.01	0.00
	(0.01)**	(0.04)	(0.01)
Year 2010	0.01	0.00	-0.00
	(0.01)	(0.04)	(0.00)
Total	0.11	0.18	0.09
	(0.05)**	(0.09)**	(0.07)
Number of observation	1505	1505	1505
Number of households	301	301	301

Robust standard errors clustered by household ID in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
[1] 1 Tsimdi=0.25 hectare
[2] Switch between sexes represent change in sex of household head from male to female in the case of female-headed households' regressions and from female to male in the case of male-headed households' regressions.

Table 9. Detailed decomposition of causes of difference in TLU equivalent of small animals

	Differences due to:		
	Endowments	Coefficients	Interaction
Age of household head	-0.00	-0.01	0.02
	(0.00)	(0.01)	(0.01)
Age of household head squared	0.00	0.01	-0.02
	(0.00)	(0.01)	(0.01)
Education of household head	0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)
Number of adult female labor	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)
Number of adult male labor	0.01	0.00	-0.01
	(0.00)*	(0.00)	(0.00)
Land area (Tsimdi)[1]	0.00	0.00	-0.00
	(0.00)*	(0.00)	(0.00)
Dummy for off farm employment	-0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)
Number of children (>=6 and <=14 years)	0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)
Switch between sex[2]	0.00	0.01	-0.00
	(0.00)	(0.01)	(0.01)
Year 2001	-0.00	-0.01	-0.00
	(0.00)*	(0.01)	(0.00)
Year 2003	0.00	0.02	-0.00
	(0.00)	(0.01)***	(0.00)
Year 2006	-0.00	-0.01	0.00
	(0.00)	(0.01)	(0.00)
Year 2010	-0.00	0.02	-0.00
	(0.00)	(0.01)*	(0.00)
Total	0.01	0.03	-0.01
	(0.01)*	(0.01)**	(0.01)
Number of observation	1505	1505	1505
Number of households	301	301	301

Robust standard errors clustered by household ID in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

[1]1 Tsimdi=0.25 hectare

[2]Switch between sexes represent change in sex of household head from male to female in the case of female-headed households' regressions and from female to male in the case of male-headed households' regressions.

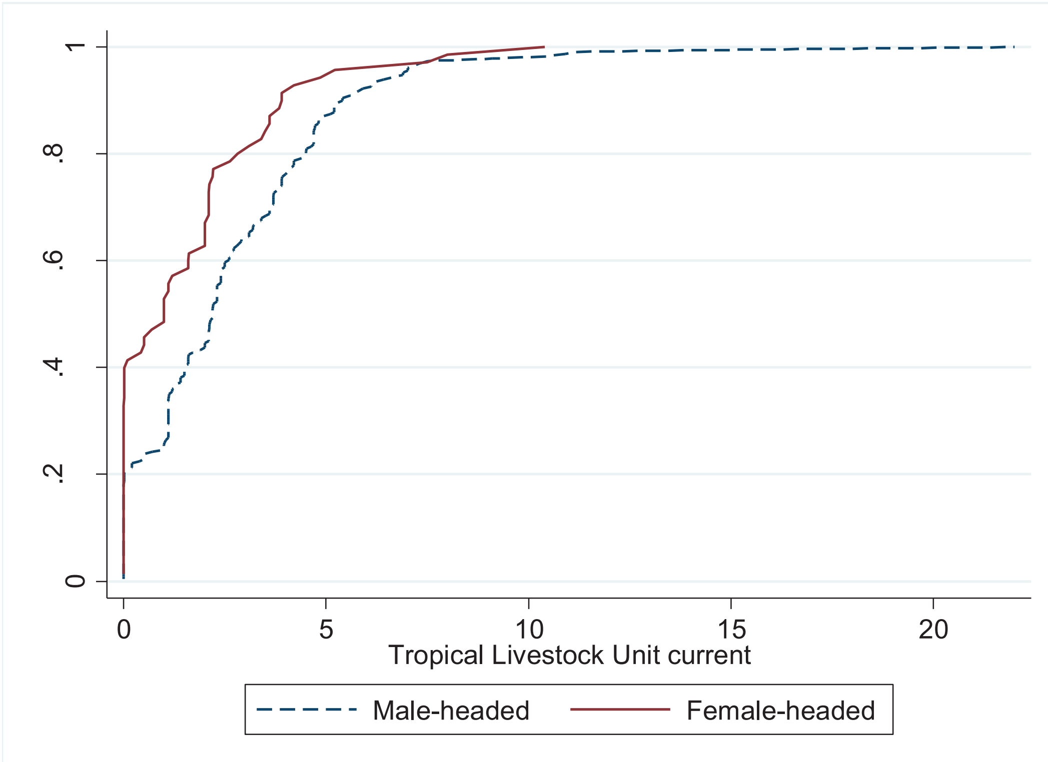

Figure 1. Cumulative density function of TLU for male and female-headed households-1998

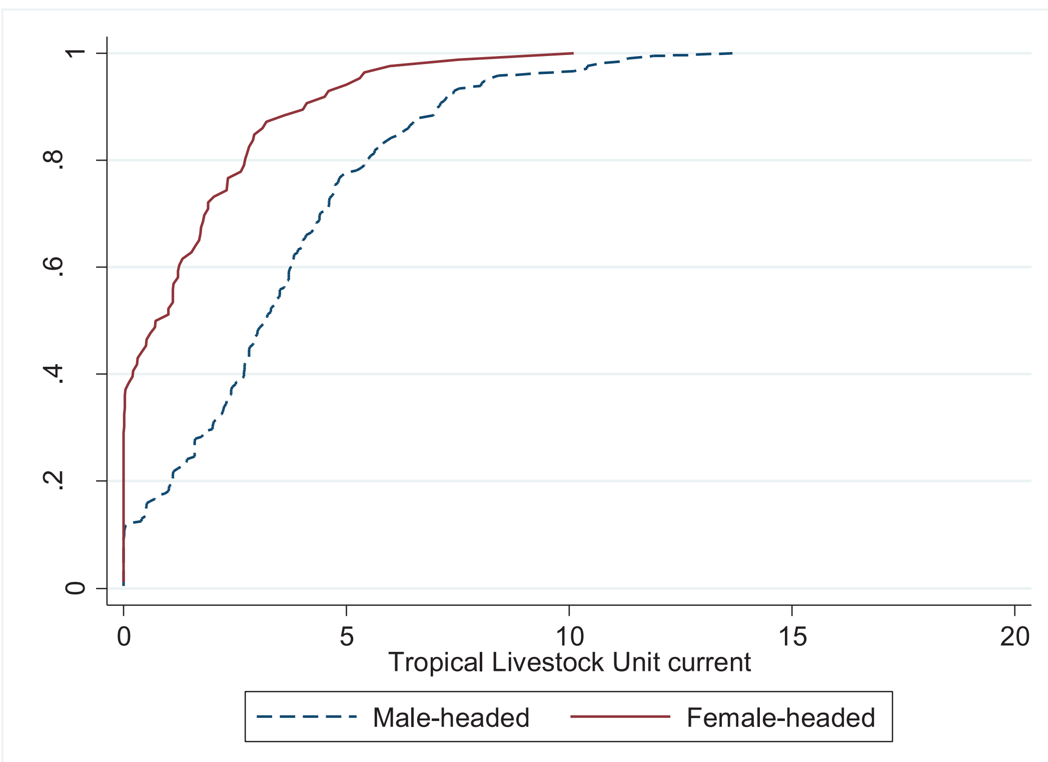

Figure 2. Cumulative density function of TLU for male and female-headed households- 2010

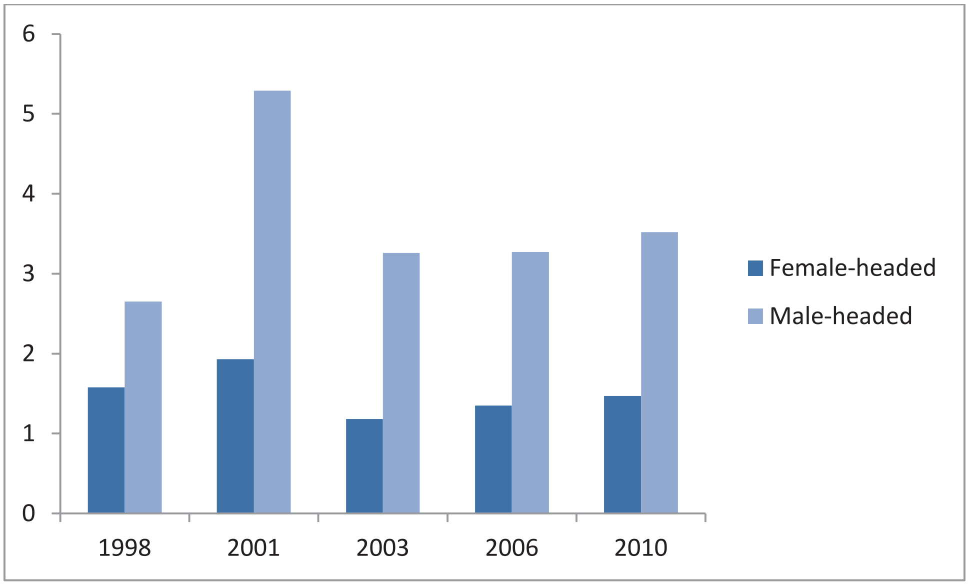

Figure 3. Tropical Livestock Units for female and male-headed households across survey years

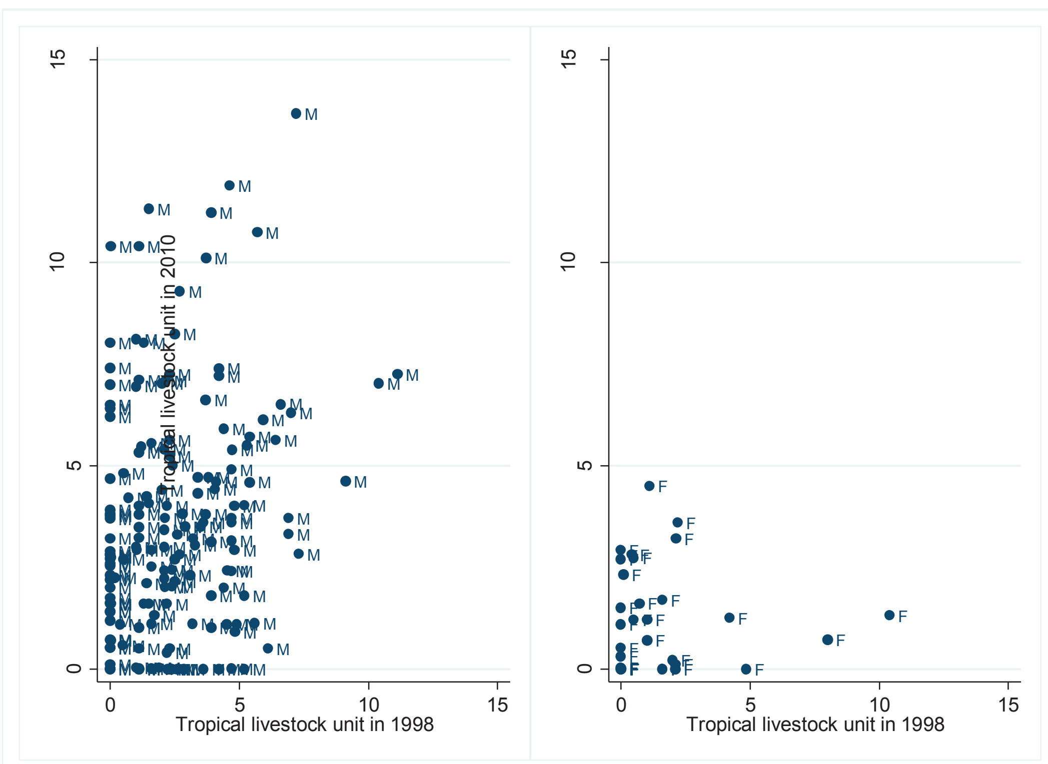

Figure 4. Beginning and ending stocks of tropical livestock units for female and male-headed households separate

Appendix

Table A1. Attrition Probit model

	Probit (1=stayers)
Age of household head [1]	0.01
	(0.00)***
Education of household head	0.15
	(0.08)*
Number of adult female labor	0.09
	(0.04)**
Number of adult male labor	0.09
	(0.03)***
Land area (Tsimdi) [2]	-0.02
	(0.01)***
Dummy for off farm employment	0.07
	(0.06)
Number of children (>=6 and <=14 years)	0.06
	(0.03)**
Year 2001	-0.11
	(0.11)
Year 2003	0.06
	(0.11)
Year 2006	0.02
	(0.11)
Year 2010	-0.64
	(0.09)***
Constant	-0.06
	(0.14)
Number of obs.	1,995
Chi2	140.96
P-value	0.00

* significant at 10%; ** significant at 5%; *** significant at 1%
Standard errors are bootstrapped with 400 replications
[1] Age of the household head is divided by 10 years, i.e., one unit is 10 years.

Table A2- Fixed effects regression of TLU-Male and female-headed households- with attrition correction variable

	MHH	FHH
Age of household head[1]	1.32	-0.72
	(0.56)**	(0.74)
Age of household head squared	-0.11	0.08
	(0.05)**	(0.07)
Education of household head	0.69	-0.10
	(0.24)***	(0.47)
Number of adult female labor	0.20	0.50
	(0.11)*	(0.20)**
Number of adult male labor	0.25	0.43
	(0.11)**	(0.16)***
Land area (Tsimdi)[1]	0.07	0.13
	(0.03)**	(0.04)***
Dummy for off farm employment	-0.02	0.16
	(0.16)	(0.19)
Number of children (>=6 and <=14 years)	0.06	0.35
	(0.09)	(0.11)***
Switch between sex	0.33	0.46
	(0.30)	(0.31)
Year 2001	1.90	-0.17
	(0.30)***	(0.36)
Year 2003	-0.21	-0.42
	(0.21)	(0.29)
Year 2006	-0.28	-0.41
	(0.22)	(0.28)
Year 2010	0.27	-0.31
	(0.38)	(0.46)
Inverse Mills Ratio	-0.75	0.08
	(0.55)	(0.58)
Number of obs.	1,078	392
R-squared	0.16	0.16

* significant at 10%; ** significant at 5%; *** significant at 1%
Standard errors are bootstrapped with 400 replications
[1] Age of the household head is divided by 10 years, i.e., one unit is 10 years.

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This dissertation uses survey data from Northern Ethiopia and Western Uganda to study the role of household strategies and public interventions in enabling households to attain secure rural livelihoods. The thesis composes of four articles. Paper 1 assesses household devised strategies of using forests and diversified income sources to cope with shocks. It uses data from a forested area in Western Uganda. Findings showed that forests serve as safety nets in the face of shocks and that households diversify their income sources in response to shocks. Losses due to non-labor shocks precipitate forest extraction and higher rates of income diversification while shocks affecting labor in the households does not. Papers 2 and 3 investigate the effect of a public intervention, Ethiopia's Productive Safety Net Program (PSNP), on household welfare. The papers use panel data from Northern Ethiopia. Paper 2 studies whether the PSNP promoted investment in livestock and children's education. We find that the PSNP have a positive effect on livestock accumulation and children's education, after controlling for selection bias. Participating in the program protect households from sacrificing their children's education in response to shocks. In paper 3, we study the nutrition impact of the PSNP for children under five years. Findings indicate that the program provide short term nutritional benefit for children, especially in those households that are able to leverage underemployed female labor. Paper 4 examines differences in livestock dynamics between female- and male-headed households and factors contributing to it. Results showed that female-headed households own significantly lower livestock than male-headed households. Lower endowment of land area, male labor and children (age 6-14) in female-headed households are the observed factors causing the difference.

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