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Impacts of the Productive Safety Net Program in Ethiopia on Livestock and Tree Holdings of Rural Households

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Abstract

We evaluated the impacts of the Ethiopian Productive Safety Net Program (PSNP) on rural households' holdings of livestock and forest assets including trees. Using panel data, we applied both regression analysis and propensity score matching. We found no indication that participation in PSNP induces households to disinvest in livestock or trees. In fact, households that participated in the program increased the number of trees planted, but there was no increase in their livestock holdings. We found no evidence that the PSNP protects livestock in times of shock. Shocks appear to lead households to disinvest in livestock, but not in trees. Our results suggest that there is increased forestry activity as a result of PSNP, and that improved credit access encourages households to increase their livestock holdings.

Key Words: trees, livestock, safety nets, Ethiopia

JEL Classification: Q12, Q28

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Introduction

There is an international perception that food aid to food-insecure households in poor developing countries is associated with a dependency syndrome. One hears arguments that food aid may change the behavior of its recipients by making them dependent on it and thus less active in their economic and social activities (Little 2008). Unfortunately, few rigorous empirical studies look at the effects of food aid or safety net programs on the behavior of households, particularly if they influence how much households invest and what they invest in.

We studied the Productive Safety Net Program (PSNP) in Ethiopia to see how it has affected households' investment and disinvestment in productive assets. While there have been some attempts to evaluate the PSNP, to our knowledge the only systematic attempt at evaluating the PSNP was made by Gilligan et al. (2008). However, they only had access to recall data on the variables studied, making any firm conclusions problematic. In our paper, however, we used panel data from household surveys in 2002, 2005, and 2007 in the Amhara region of Ethiopia; these data were collected both before the PSNP started and about two years after it started. This paper also contributes to the existing literature by exploring some of the underlying mechanisms of the relationship between safety net programs and investment in assets.

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The PSNP is currently the largest operating social protection program in sub-Saharan Africa outside of South Africa. It differs from previous food-for-work programs, in that it focuses continuously on selected households over several years and in that the explicit objective is that it will eventually be phased out. For this reason, its impacts and effectiveness are important, both in their own right and because they have implications for food-for-work programs elsewhere.

The PSNP is a public program through which food-insecure people are employed in public work for five days a month during the agricultural slack season. This is intended to enable households to smooth consumption so that they will not need to sell productive assets in order to overcome food shortages. The public work is also intended to create valuable public goods; moreover, by reducing seasonal liquidity constraints, it is intended to stimulate investments as well.

However, there is a risk that the program discourages private investments, which are central to future production opportunities. If more labor is allocated to public programs, then less labor is available for on-farm production and investments. There is also concern that if assets are themselves used as buffers or as a way to spread risk, introducing a public safety net may reduce the demand for asset holdings and lead to reduced on-farm investment.

Hence, in addition to studying the effect of the PSNP on asset holdings, we investigated whether assets themselves are used as informal safety nets. We studied both *ex ante* behavior, by examining whether risk aversion determines investments in assets, and *ex post* behavior, by examining whether assets are sold in times of temporary shocks. We also explored whether the potential role of productive assets as a safety net was affected by the introduction of a public safety net.

This paper focuses specifically on livestock and tree holdings. These assets are especially interesting for several reasons. Livestock is usually considered to be the most important productive asset in rural Ethiopia in general, and in our study areas in particular. If households can increase the number of their livestock, they have a good chance of becoming more food secure. Tree holdings, especially holdings of fast-growing eucalyptus, play a similar role as livestock and are also worth examining from an environmental perspective. Ethiopia's forest cover is estimated to be below 4 percent of the country's total area (about 1 million km^2) and deforestation is estimated at 200,000 hectares per year (Mekonnen and Bluffstone 2008).

Livestock and trees can potentially be informal safety nets. Livestock holdings may be used to buffer temporary income shocks.[1] Drought-resistant trees may also be planted to sell and thus offset income shocks and reduce the vulnerability of income to weather conditions.[2]

This paper is structured as follows. The background section discusses previous experiences with food-for-work programs, in Ethiopia and elsewhere, and describes the PSNP. Section 2 provides a theoretical discussion of some of the possible problems involved. Section 3 presents the data and econometric specifications, section 4 presents the results, and section 5 concludes the paper.

1. Background

In Ethiopia, food insecurity has long been a widespread problem.[3] Over 80 percent of Ethiopia's 80 million people live in rural areas and are heavily dependent on rain-fed agriculture; this makes them extremely vulnerable to changes in weather conditions. Over the last four decades, there have been a number of severe famines due to droughts in Ethiopia. Even in years with normal rainfall, food shortages and hunger are recurrent problems for millions of people. More recently, this problem has been exacerbated by increases in food prices.

The problem of food insecurity in Ethiopia has, to a large extent, been addressed by annual emergency food aid from abroad. During the past two decades, Ethiopia has been the largest recipient of food aid in Africa and one of the largest recipients in the world (Little 2008). For the individual beneficiary, food aid has been characterized by uncertainty, poor timing, and insufficient assistance. In 2005, to combat the persistent problem of food insecurity and to move away from the previous system of annual emergency appeals, the Ethiopian government and a consortium of donors (including the World Bank, U.S. Agency for International Development, Canadian International Development Agency, and several European donors) launched a new social protection program called the Productive Safety Net Program (PSNP). With an annual budget of nearly US$ 500 million, the PSNP is a huge program, reaching more than 7 million Ethiopians (Gilligan et al. 2008).

[1] For a discussion of the potential role of livestock as a buffer, see, e.g., Rosenzweig and Wolpin (1993).

[2] For the role of forest products as natural insurance, see, e.g., McSweeney (2004).

[3] The description of PSNP in this section is largely based on MoARD (2004, 2006).

The PSNP has two components: public works and direct support. Public works are used to mitigate the impacts of climatic and food insecurity risks on chronically food-insecure farmers by providing employment to "able-bodied" laborers. It is the core component of the safety net program and creates a labor market for unskilled labor, primarily by involving them in labor-intensive, community-based activities. Direct support is a minor component and delivers assistance to members of the community who cannot participate in public works but need help.

Rural labor markets in Ethiopia are thin or imperfect and jobs are not readily available when needed. The wage rate for public works can therefore be set at slightly below the market wage in order to attract only the chronically food-insecure, able-bodied household members. Wages are paid in cash or in kind, depending on specific circumstances. Most of the public works are undertaken during the dry season, which is also a slack season, because farmers are expected to return to their usual labor-intensive private agricultural activities during the main rainy season.

The plan is for the safety net program to cover the 5 million chronically food-insecure people in the country for five consecutive years. However, it could be scaled up to 15 million people, depending on needs and resource availability. Many safety net beneficiaries can also benefit from other food security program interventions. The anticipation is that, since households will no longer need to sell off assets as a result of income shocks, their productive assets will increase over time. With the help of the safety net and other programs, these food-insecure households are expected to graduate from their chronic situation in five years.

The PSNP is one of several components of the Ethiopian government's Food Security Program. The other components are subsidies for voluntary resettlement and a package of programs jointly called Other Food Security Programs (OFSP). OFSP includes a wide range of activities that differ by regions, but the main element is a package of loans for agricultural and non-agricultural activities. The federal plan is that 30 percent of the PSNP beneficiaries should also be covered by OFSP. During the 2006–2007 season, 70 percent of OFSP funds were slated for household packages (Slater et al. 2006).

Previous studies from Ethiopia have indicated that, although food-for-work programs have been crucial for saving poor rural households in times of food shortages, they may have negative impacts on agricultural intensification (Barrett et al. 2004), short-term soil conservation measures (Gebremedhin and Swinton 2003), informal risk sharing (Dercon and Krishnan 2004), and growth of livestock holdings (Gilligan and Hoddinott 2007). The latter study concluded that the slower growth rate in livestock holdings among participants may be due to reduced demand

for precautionary savings. This assumes that livestock are used as an income buffer and are sold to cope with temporary shortfalls in income. However, empirical studies of the role of livestock as an income buffer have been mixed (see Fafchamps et al. 1998; McPeak 2004; Rosenzweig and Wolpin 1993; Udry 1995).

Gilligan et al. (2008) found that the PSNP and other food security programs increased food security, but at the same time reduced growth rates in livestock holdings. However, they considered only the average net effect from the beginning of the period considered in their survey to the end. While this is valuable information, it does not say anything about how successful the safety net is in protecting assets in times of temporary income shocks, even though this is one of the main goals of the program.

The basic principles of the PSNP include partnership, continuity, predictability, productivity enhancement, avoidance of the dependency syndrome, integration with *wereda* (district)[4] development plans, and flexibility. Partnership in this case means that the communities own the program and the government plays the leading role, supplemented by donors and non-governmental organizations. Continuity refers to the need to make the safety net program available throughout the year, financed via development funds rather than emergency funds. Resource flows must be predictable year after year and the necessary resources should be ready ahead of time so that vulnerable households and concerned government officials can plan appropriately. Safety nets are intended to enhance productivity (in addition to meeting the immediate consumption needs of vulnerable households), prevent asset depletion of households, and create physical or human capital. To discourage development of a dependency syndrome, able-bodied beneficiaries are required to provide labor in exchange for program benefits; in this way, the program will complement—not crowd out—household efforts to manage potential shocks and higher cost needs.

Safety net activities should also be integrated with wereda development plans to ensure that quality assets are built within the (necessary) budget allocated. These activities include public works, on-farm improvements, educational incentives, and environmental protection measures, such as tree planting on public land and soil/water conservation measures. Safety net

[4] A *wereda* (or woreda) is an administrative district of local government in Ethiopia. Weredas, which are made up of *kebeles*, sub-districts or neighborhood associations, are typically collected together (usually contiguous weredas) into zones.

resources should be flexible enough to offer a wide range of activities that fit the food security plan of the wereda and also ensure timely and efficient use of these resources.

The selection of beneficiaries for both the public works and direct support components of the safety net program uses a mix of administrative criteria and community input. For the public works, beneficiary households are identified through a series of criteria. The basic criteria for inclusion in the program, as stated in the manual, are summarized in table 1. The manual contains additional factors that should be assessed (see table 2).

Table 1. Basic Targeting Criteria for Inclusion in PSNP

• **Households should be members of the community.**
• Chronically food-insecure households which have faced continuous food shortages (usually a 3-month food gap or more) in the last three years and which have received food assistance prior to the commencement of the PSNP program are eligible.
• Households which suddenly become more food insecure as a result of a severe loss of assets and which are unable to support themselves (in the past 1–2 years) are also eligible.
• Any household without family support and other means of social protection and support is eligible.

Source: PIM 2006

Table 2. Additional Factors to be Considered for Targeting by the PSNP

• **Status of household assets: land holding, quality of land, food stock, etc.**
• Income from non-agricultural activities and alternative employment
• Support/remittances from relatives or community

Source: PIM 2006

Early assessments indicate that PSNP does reach the intended households. In a household survey reported in Sharp et al. (2006), beneficiaries and non-beneficiaries were asked why they thought they were included or excluded from the PSNP. The beneficiaries most frequently reported that relative poverty was the main reason they had been included in the program. Similar results were found among non-beneficiaries, who most frequently reported that they were less poor than the beneficiaries as the main reason for their exclusion. Other variables repeatedly mentioned as important were food access, farming assets (landholdings and livestock), and off-farm income.

Beneficiaries who are eligible for direct support receive it without any conditions. Communities select these beneficiaries in collaboration with the lowest government administrative units, the *kebeles*. It is expected that combining the community and the local administration makes targeting more cost-effective and minimizes errors. Three issues that determine eligibility for public works and direct support are a household's chronic history of food need, level of the food gap or unmet need, and household labor available for work.

2. Theory

There has long been concern that food-for-work programs may reduce investment in productive assets. One obvious reason is that the labor used in the food-for-work program will tend to crowd out labor use in other activities, such as on-farm investment. Another possible reason is that food for work may reduce the need for precautionary savings.

Deaton (1990, 1991), Rosenzweig and Binswanger (1993), and other authors have developed a theoretical framework for the role of asset holdings under income uncertainty. They showed that, in the absence of functioning credit markets, households that are sufficiently risk averse will save for the future in order to smooth consumption, even if they have high discount rates. The exact composition of the asset portfolio will depend on the relative yield and riskiness of different assets and the risk aversion of the individual household. For a household with high discount rates, however, reduced uncertainty in future income (through, for example, the existence of a predictable food-for-work program) will lead to increased consumption now at the expense of investment in assets.

In developing countries, savings by agricultural households frequently takes the form of productive assets that are also used on the farm, such as livestock. This means that for the individual farmer (who usually has a high discount rate, but is also liquidity constrained) livestock has a dual role—as a buffer for consumption smoothing and as an income generator. From the policy maker's perspective, however, the fact that livestock is a productive asset makes livestock holdings an important target of government policy to improve agricultural output. The fact that these holdings are depleted in times of negative income shocks is cause for serious concern.

Similarly, Delacote (2007) showed that when tree production is seen as having relatively low profitability and low risk compared to agricultural production, risk-averse households will plant trees to smooth consumption. However, if risk in agriculture is reduced, forest cover will be reduced because the need for consumption smoothing provided by the trees is less. This means

that—to the extent that forest cover also creates positive externalities from reduced soil erosion or improved water flows, for example—reduced risk for the individual farmer will lead to a reduction in the positive externality generated by the forest cover.

Generally speaking, this implies that policies that aim to improve income security for agricultural households may have unintended side effects on their investment behavior. On one hand, policy makers are interested in livestock and forest investment because they have positive impacts on long-term productivity. On the other hand, households without access to credit or insurance markets, and with high discount rates, invest in these assets partly as precautionary measures rather than for the sake of increased productivity. Consequently, they may very well disinvest in these assets if income security improves. Whether this happens in practice and, if so, what assets are affected the most depends on the perceived riskiness and yield of the assets. It also depends on the risk aversion of the households involved and their discount rates.

3. Data and Econometric Specification

In this section, we discuss the farm household data used for the analysis, plus some of the main issues involved with estimating the effects of a program when selection into the program is not random, but is based on characteristics that may in turn affect the outcome of the program treatment. We also present the two methods, regression analysis and propensity score matching, that we used to deal with these issues.

3.1 Data

We used panel data collected in 2002, 2005, and 2007 through collaborative research projects of Addis Ababa University, the University of Gothenburg, and the World Bank. The data come from 14 sites in the East Gojam and South Wollo zones of the Amhara region of Ethiopia. However, we only used the data from South Wollo because the sites in East Gojam were not covered by the PSNP and many of the agricultural characteristics of the two zones are different, making East Gojam unsuitable as a comparison region. The sites were selected to ensure variation in vegetation cover and agro-ecology, while the households from each site were selected at random.

The panel data were supplemented with data from a separate PSNP household survey conducted by the University of Gothenburg, Umeå University, and the Ethiopian Development

Research Institute from April to June 2008.[5] In the PSNP survey the households from the previous sample were asked about whether they had participated in the PSNP or other food-for-work programs during the years 2005, 2006 and 2007; they were also asked a few questions about their perceptions of the program.

Table 3. Description of Variables

Variable	Description
Dependent variables*	
Livestock	Number of livestock owned in TLU
Trees	Number of trees owned
Independent variables for household background characteristics*	
Max educ hhld	Maximum education of household member
Educ hhld head	Education of household head
Age head	Age of household head
Male adults	Number of male adults in household
Female adults	Number of female adults in household
Risk aversion	Constant partial risk-aversion coefficient; average from 2005 and 2007 surveys
Discount rate	Discount rate (stated directly)
Family size	Number of household members
Independent variables for economic indicators*	
Land size	Land size, in hectares
Corr roof dummy	Household home has iron corrugated roof; proxy for income/economic status (1 = yes; 0 otherwise).
Gave loan dummy	Household gave loan to another household; proxy for income/economic status (1 = yes; 0 otherwise).
Credit access dummy	Household has access to credit when needed (1 = yes; 0 otherwise).
Remittances dummy	Household received remittance(s) (1 = yes; 0 otherwise).
Farm income	Farm income, measured as income from farming, including value of crops per year

[5] To obtain information about food security and related programs from different sources, interviews were also conducted with officers responsible for food security issues from the wereda and kebele councils. In addition, some households took part in separate focus-group discussions during the survey period.

Variable	Description
Non-farm income	Non-farm income, measured as income from non-farm activities per year (e.g., remittances and other businesses)
Independent variables for shock dummies*	
Weather	Household experienced any weather-related shock: drought, flood, erosion, frost (1 = yes; 0 otherwise).
Pests, disease, and theft	Household experienced any shock due to crop loss: pest, disease, and theft (1 = yes; 0 otherwise).
Illness or death	Household experienced any shock due to death or illness of a person (1 = yes; 0 otherwise).
Livestock loss	Household experienced any shock due to loss of livestock (1 = yes; 0 otherwise).
Any shock	Household experienced any of the above-mentioned shocks; this is the shock variable actually used in the analysis (1 = yes; 0 otherwise).
Independent variables for kebele dummies*	
Kete	Household lives in Kete kebele (1 = yes; 0 otherwise).
Godguadit	Household lives in Godguadit kebele 1 = yes; 0 otherwise)
Amba Mariam	Household lives in Amba Mariam kebele (1 = yes; 0 otherwise)
Yamed	Household lives in Yamed kebele (1 = yes; 0 otherwise)
Addis Mender	Household lives in Addis Mender kebele (1 = yes; 0 otherwise)
Chorisa	Household lives in Chorisa kebele (1 = yes; 0 otherwise)
Independent variables for* program participation dummies*	
Participation	Household participated public work in the PSNP during 2005 (1 = yes; 0 otherwise)
FFW (Food for work)	Household participated in any other food-for-work program (1 = yes; 0 otherwise)

* The data is from the larger household survey.

** The data is from the PSNP survey.

Note: These variable descriptions apply to the variables used in both the regression and the PSM analyses, although the year of measurement is different.

The dataset contains information on the number of trees and livestock holdings per household, shocks, and household characteristics, as well as data on households' subjective discount rates and measures of risk aversion. Measures of risk aversion were calculated in a risk-

preference experiment, while subjective discount rates were based on both open-ended questions to households about their subjective discount rate and a time-preference experiment.[6] The variables used in this study are described in table 3.

A few comments about the available data are in order. Descriptive statistics are presented in tables 4, 5, and 6. The tropical livestock unit (TLU), where 1 TLU is equivalent to 250 kilograms of livestock, was used as a relatively close proxy measure of the livestock capital available to the household. We measured tree holdings by the number of trees that households grew. Since we did not have measures of the age or volume of the trees, we did not consider this as a proxy for the volume or value of trees. However, it can be seen as a measure of the land area devoted to trees as opposed to other crops. We measured risk aversion using the constant partial risk aversion (CPRA) coefficient calculated from risk-preference experiments conducted in 2005 and 2007, but not in 2002. The payoffs in the risk-preference experiment were similar to those used in Wik et al. (2004), and we followed similar procedures in the computation of CPRA coefficients. The 2005 and 2007 data included time-preference experiments from which discount rates could be computed. However, there were a number of missing values in the data, partly due to inconsistent responses. We therefore used responses to open-ended questions about households' discount rates, which were also available from the 2002 data.

Table 4. Descriptive Statistics of Variables Used in Regression Analysis (Full Sample)

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Participation	561	.2798574	.4493296	0	1
Change in livestock holdings	561	-.0499287	2.119229	-16.29	25.51
Change in tree holdings	561	69.3066	495.9215	-3216	5012
Shock dummy	561	.5383244	.498974	0	1
Interaction participation/shock dummy	561	.1301248	.3367409	0	1
Interaction participation/risk aversion	545	.0851541	.4214732	0	3.873
Change in discount rate	549	.970159	1.251828	-2.813411	4.787492
Change in maximum education of household member	561	.1016043	2.806628	-12	9

[6] The computation of risk-aversion measures was based on Binswanger (1980, 1981), as well as Yesuf (2004) and Wik et al. (2004). The computation of subjective discount rates from the experiment follows Pender (1996) and Yesuf (2004).

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Change in family size	561	-1.044563	1.688134	-10	3
Change in land size	560	-.1775571	1.119806	-14.33879	2.85077
Change in access to credit dummy	561	.0891266	.6058401	-1	1
Change in remittance dummy	561	.0481283	.4812568	-1	1
Change in other food-for-work dummy (FFW)	557	-.1077199	.3485241	-1	1
Discount rate	555	1.233101	.8815156	0	5.298317
Max education of household member	561	5.862745	3.376503	0	14
Education of head of household	561	1.319073	2.723537	0	12
Age of head of household	549	51.63752	15.36068	15	99
Number of male adults in household	561	1.670232	1.040255	0	5
Number of female adults in household	561	1.545455	.8118441	0	5
Risk aversion	545	.4468954	1.000804	0	8.25
Family size	561	6.379679	2.298341	1	18
Land size	560	.9828253	1.131096	0	16.90452
Corrugated roof dummy	561	.4884135	.5003118	0	1
”Gave loan” dummy	561	.0891266	.2851806	0	1
Access to credit dummy	561	.6595365	.474288	0	1
Remittance dummy	561	.1390374	.3462944	0	1
Other food-for-work dummy	561	.1301248	.3367409	0	1
Livestock holdings	561	3.243102	2.278333	0	22.71
Tree holdings	561	145.3708	309.4909	0	3334
Farm income	561	2165.675	1638.77	0	14813.44
Non-farm income	561	289.509	807.4756	0	7000
Kete kebele dummy	561	.258467	.4381827	0	1
Godguadit kebele dummy	561	.1497326	.3571276	0	1
Amba Mariam kebele dummy	561	.1515152	.3588703	0	1
Addis Mender kebele dummy	561	.1194296	.3245827	0	1
Chorisa kebele dummy	561	.1479501	.3553674	0	1
Yamed kebele dummy*	561	.1693405	.3753871	0	1

* The Yamed Kebele dummy was dropped in the regression.

Note: Changes are measured between 2007 and 2005. Levels are measured in 2005.

Table 5. Descriptive Statistics of Variables Used in the PSM (Full Sample)

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Participation	561	.3814617	.486179	0	1
Change in livestock, 2005–2007	561	.5544207	2.183688	-5.76	26.05
Change in tree holdings, 2005–2007	561	54.72727	501.5233	-4010	4954
Livestock holdings	561	2.638752	2.162286	0	13.93
Tree holdings	561	159.9501	328.2372	0	4020
Education of head of household	561	1.11943	2.560343	0	12
Max. education of household member	561	3.99287	3.38325	0	12
Age of head of household	543	49.85635	15.13475	18	96
Number of male adults in household	561	1.540107	.9722467	0	5
Number of female adults in household	561	1.434938	.7390573	0	5
Family size	556	5.226619	2.02215	1	14
Land size	560	.8065441	.6716322	0	8.796792
Iron corrugated roof dummy	561	.3458111	.4760564	0	1
”Gave loan” dummy	561	.0392157	.194281	0	1
Remittance dummy	561	.2067736	.4053532	0	1
Kete kebele dummy	561	.258467	.4381827	0	1
Godguadit kebele dummy	561	.1497326	.3571276	0	1
Amba Mariam kebele dummy	561	.1515152	.3588703	0	1
Addis Mender kebele dummy	561	.1194296	.3245827	0	1
Chorisa kebele dummy	561	.1479501	.3553674	0	1
Yamed kebele dummy*	561	.1693405	.3753871	0	1
Farm income	561	1130.026	925.1711	0	5964.994
Non-farm income	561	269.1899	614.6914	0	6207.092

* The Yamed kebele dummy was dropped in the PSM.

Note: Levels are measured in 2002. The risk aversion, access to credit, discount rate and other food-for-work variables that were used in the regression equation are not used here due to lack of data.

Table 6. Descriptive Statistics for Non-participants and Participants, Respectively

Variable	Non-participants			Participants		
	Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.
Change in livestock holdings	404	-0.16	1.85	157	0.24	2.68
Change in tree holdings	404	52.68	526.09	157	112.09	406.59
Shock dummy	404	0.57	0.50	157	0.46	0.50
Interaction participation/shock dummy	404	0	0	157	0.46	0.50
Interaction participation/risk aversion	392	0	0	153	0.30	0.75
Change in discount rate	396	0.99	1.29	153	0.92	1.15
Change in max education of household member	404	-0.06	2.85	157	0.52	2.67
Change in family size	404	-1.13	1.69	157	-0.83	1.66
Change in land size	403	-0.18	1.16	157	-0.17	1.00
Change in access to credit dummy	404	0.02	0.58	157	0.25	0.64
Change in remittance dummy	404	0.05	0.49	157	0.03	0.47
Change in other food-for-work dummy	400	-0.13	0.38	157	-0.06	0.24
Discount rate	401	1.26	0.89	154	1.15	0.85
Maximum education of household member	404	5.99	3.52	157	5.53	2.97
Education of head of household	404	1.29	2.78	157	1.40	2.59
Age of head of household	400	52.65	16.15	149	48.93	12.65
Number of male adults in household	404	1.75	1.09	157	1.48	0.89
Number of female adults in household	404	1.52	0.82	157	1.61	0,80
Risk aversion	392	0.50	1.08	153	0.30	0.75
Family size	404	6.48	2.40	157	6.11	1.99
Land size	403	0.96	1.18	157	1.04	0.99
Corrugated roof dummy	404	0.54	0.50	157	0.34	0.48
”Gave loan” dummy	404	0.10	0.30	157	0.06	0.23
Access to credit dummy	404	0.70	0.46	157	0.55	0.50
Remittance dummy	404	0.14	0.35	157	0.14	0.35
Other food-for-work dummy	404	0.16	0.36	157	0.06	0.24
Livestock holdings	404	3.44	2.42	157	2.73	1.78
Tree holdings	404	155.46	340.18	157	119.40	209.64

Variable	Non-participants			Participants		
	Obs.	Mean	Std. dev.	Obs.	Mean	Std. dev.
Farm income	404	2276.51	1763.11	157	1880.46	1223.26
Non-farm income	404	325.95	887.15	157	195.74	543.25
Kete kebele dummy	404	0.31	0.46	157	0.12	0.33
Godguadit kebele dummy	404	0.17	0.37	157	0.10	0.30
Amba Mariam kebele dummy	404	0.09	0.29	157	0.30	0.46
Addis Mender kebele dummy	404	0.15	0.36	157	0.03	0.18
Chorisa kebele dummy	404	0.17	0.38	157	0.08	0.28
Yamed kebele dummy	404	0.10	0.30	157	0.36	0.48

The rest of the variables used in the analysis can be divided into five categories: program participation, household background variables, economic indicators, shocks, and kebeles. Two different programs were considered, PSNP and OFSP. Household background variables include family composition (age of head, number of male and female adults), and education (maximum years of education of a household member and education of household head). Economic indicators include income from farm and non-farm activities, asset holdings (trees, livestock, and land holdings), remittances, and credit access. Due to the difficulty of exactly measuring economic status using indicators, such as income, two other indicators of wealth were included: a dummy variable for whether the household's home had a corrugated iron roof, and a dummy variable for whether the household had given a loan. To measure shocks, we used a dummy variable that indicates whether the household experienced any shock related to weather (drought, flood, erosion, and frost), crop loss (pest, disease, and theft), death or illness of a person, or loss of livestock. The data contains six different kebeles.

The dataset does not include price information. However, Ethiopia recorded high inflation throughout the survey period, especially the latter part. Nominal prices therefore increased for all of the outputs and inputs included in the survey. Wood prices appear to have gone up in recent years relative to prices of other crops, which may have made tree planting more attractive. The problem, however, is that many households cannot afford to tie up land for several years until the trees grow to mature size.

3.2 Econometric Methods

To study how participation in PSNP affects livestock and tree holdings, we needed to address the potential problem of selection bias. Selection bias stems from the fact that we cannot know what the outcome for a "treated" (i.e., participating) household will be if it does not receive the treatment. If treatment is randomly assigned, the outcome of untreated individuals serves as a good estimate of the counterfactual. However, if households that are treated have characteristics that differ from the ones that are not treated, comparison of the outcome between the two groups will yield biased estimates.

Formally, the above reasoning can be summarized as follows. Our main parameter of interest was the average treatment effect on the treated, which is given by:

$$ATT = E(Y_1 - Y_0 \mid D = 1) = E(Y_1 \mid D = 1) - E(Y_0 \mid D = 1) \ ,$$

where Y_1 is the treated outcome, Y_0 is the untreated outcome, D indicates treatment status and is equal to 1 if the individual receives treatment and 0 otherwise. The evaluation problem arises from the fact that the untreated outcome for a treated individual, $E(Y_0 \mid D = 1)$, can never be observed. Using the outcome for untreated individuals as an estimate of the counter fact will generate bias equal to:

$$b = E(Y_0 \mid D = 1) - E(Y_0 \mid D = 0) \ .$$

If the selection is based on variables that are observable to the analyst, the problem of selection bias can be solved by controlling for these variables in a regression analysis or the propensity score matching method. However, if the selection is based on variables that are unknown to the analyst, other methods need to be applied. In the PSNP program, treatment is largely based on asset and income variables that are observable both to the policy makers and to the analyst; we therefore applied regression analysis and propensity score matching in this paper. As a point of departure, we used regression analysis. This method allowed us to easily address our primary study questions.

To check the robustness of the effect of the PSNP on asset holdings, we also used propensity score matching (Rosenbaum and Rubin 1983; Heckman et al. 1997, 1998). The advantage of using propensity score matching, compared to regression analysis, is that it is a non-parametric approach in which the functional relationship between the dependent and independent variables is not specified, and in which no distributional assumptions are made for the outcome variable. Propensity score matching on observables also ensures that treated and

untreated households are comparable on observable variables, something that is not guaranteed in the regression analysis. In both methods, we used the changes in asset holdings, rather than levels, as dependent variables. This removed the problem of selection on unobservables that affects the levels of asset holdings. There is, of course, still a risk that selection is based on unobservable variables that affect not only levels but also changes in asset holdings. This is an unavoidable limitation of any type of study that is not based on experimental data.

As we assumed that selection is based on variables that are observable to the analyst, it is important to control for variables that govern eligibility to the program. In the PSNP implementation manual and previous studies, the following variables are suggested: status of assets, income from non-agricultural activities and alternative employment, and support from relatives or community. It is also important to control for other variables that affect changes in asset holdings.

3.3 Regression Analysis

In the regression equation, changes in livestock and tree holdings were estimated as functions of variable levels at the beginning of the program and as changes in explanatory variables since the beginning of the program.

The general regression model to be estimated can be described as:

$$\Delta y_t = f(\Delta X_t, X_{t-1}, y_{t-1}) \ ,$$

where y is tree/livestock holdings and X is the set of explanatory variables. The variables of special interest in this study are PSNP, risk aversion, income shocks, and the interaction effects of PSNP and risk aversion and income shocks. In the analysis, 2007 is used as period t and 2005 is used as period t-1.

The above specification gives rise to two potential problems. First, there is a risk of simultaneity between changes in asset holdings and both program participation and income variables. Second, there is a risk that y_{t-1} is correlated with the error term.

To avoid the potential risk of simultaneity between asset holdings and PSNP participation, we only used participation in period t-1 as an explanatory variable in the regression equation. Because most of the households participated in all of the years, the effect of this variable should be interpreted as the general effect of program participation and not only the effect of participation in period t-1. We employed the same strategy for the indicators of income and economic status. To avoid the problem of correlation between the level of the lagged

dependent variable and the error term, asset holdings in period *t*-1 was instrumented with the level in period *t*-2 and other explanatory variables in period *t*-2. We tested endogeneity of the lagged dependent variable using the Durbin-Wu-Hausman (DWH) statistic. The test is based on the fact that if the variable is exogenous, OLS (ordinary least squares) should yield consistent estimates, and the only difference between OLS and 2SLS (two stage least squares) estimates should be different standard errors. If the results differ, it means that the presence of endogenous variables makes OLS estimates inconsistent.

In both the livestock and the tree regression, the null hypothesis that the lagged dependent variables are exogenous was rejected. To test if the instruments were correctly excluded from the estimated equation, we used the Sargan (1958) test for over-identification. Under the null hypothesis, the excluded instruments were uncorrelated with the error term. In the livestock regression, correct exclusion of instruments could not be rejected. However, in the tree equation, the test indicated that this approach would be problematic because several of the explanatory variables from period *t*-2 appeared to be correlated with the error term. We therefore used a simpler approach, where only the number of trees in period *t*-2 was used as an instrument for period *t*-1.

3.4 Propensity Score Matching

Propensity score matching (PSM) relies heavily on two assumptions that formally can be written as:

Assumption P1 (conditional independence)

$Y_0 \perp D \mid X$,

where $\perp$ indicates stochastic independence and X is a set of observable characteristics; and

Assumption P2 (common support)

$\Pr(D=1 \mid X) < 1$.

Assumption P1 means that, conditional on a set of observed characteristics, the untreated outcome is independent of treatment status, i.e., $E(Y_0 \mid D=1) = E(Y_0 \mid D=0)$. This implies that the untreated outcome can be used as an unbiased estimation of the counterfactual outcome for treated individuals, which solves the evaluation problem described in the previous section. Rosenbaum and Rubin (1983) were the first to show that matching on the probability of treatment p(x) = Pr(D=1|X), referred to as the propensity score, is valid.

Assumption P2 means that no explanatory variable is allowed to perfectly predict treatment. In order to control for time invariant unobserved heterogeneity, we followed the approach suggested by Heckman et al. (1997, 1998) and used change in Y as the outcome variable.

When estimating the propensity score, it is important that the variables used to predict the probability of treatment are unaffected by treatment, i.e., they should be measured before the program started or be fixed over time. We therefore use 2002 as our baseline year. The outcome is defined as the change in asset holdings between 2005 and 2007. To make the PSM analysis comparable to the regression analysis, a household is considered treated if it participated in public work in 2005.[7]

For the conditional independence assumption to be fulfilled, the variables included in the matching procedure needed to be correlated with both treatment and outcome. There are no general rules for what variables to include in the model. We included all the variables described in table 3, except for the program participation variables.

There are a number of different algorithms that can be used to find one (or more) comparable untreated individual to each treated individual. For this paper, we used single nearest neighbor matching with replacement. Single nearest neighbor matching has the advantage that it is straightforward and, compared to the use of multiple neighbor matching, it has lower bias, although at the expense of higher variance. Common support is imposed by dropping those treatment observations with propensity scores outside of the range of the control observations.

To test how well the PSM performed, we considered two different indicators. First, we tested differences in means for each specific variable used in the probit model. Second, we performed a likelihood-ratio test of the joint insignificance of all the regressors.

4. Results

Table 7 presents results from the livestock models and table 8 presents the results from the tree models. Sargan tests indicated that for all three livestock models the excluded instruments were uncorrelated with the error term, and the DWH tests rejected the hypothesis of exogeneity for all three livestock models. Neither of these tests could be carried out for the tree

[7] This approach has the drawback that some of the households that participated in 2005 dropped out before 2007, and that some of the households that participated in 2007, but not in 2005, are considered untreated.

models, where there was only one instrumental variable. Because the number of trees was a count data variable, the error term will be heteroskedastic—we therefore estimated robust versions of the tree models.

Table 7. Changes in Livestock Holdings Estimated Using Regression Analysis (Livestock Instrumented)

Variable	Model 1			Model 2			Model 3		
	Coeff.	*Std. err.*	*P > t*	*Coeff.*	*Std. err.*	*P > t*	*Coeff.*	*Std. err.*	*P > t*
Livestock	-0.175	0.077	0.024	-0.182	0.077	0.017	-0.186	0.076	0.015
Participation	0.285	0.223	0.201	-0.023	0.296	0.937	0.037	0.304	0.904
Shock	-0.384	0.175	0.028	-0.550	0.205	0.007	-0.557	0.205	0.007
Shock/particip-ation				0.581	0.379	0.126	0.593	0.379	0.117
Risk aversion /participation							-0.163	0.198	0.411
Δ disc. rate	-0.193	0.138	0.163	-0.189	0.137	0.169	-0.191	0.137	0.164
Δ max. educ.	0.030	0.034	0.385	0.024	0.034	0.483	0.025	0.034	0.460
Δ family size	0.071	0.064	0.264	0.080	0.064	0.210	0.079	0.064	0.212
Δ land size	0.305	0.213	0.151	0.299	0.211	0.157	0.302	0.211	0.151
Δ credit	0.497	0.217	0.022	0.524	0.216	0.015	0.517	0.216	0.016
Δ remittance	0.364	0.218	0.096	0.397	0.218	0.068	0.416	0.218	0.057
Δ FFW	-0.235	0.514	0.647	-0.292	0.511	0.567	-0.280	0.510	0.584
Discount rate	-0.163	0.181	0.367	-0.175	0.180	0.332	-0.169	0.180	0.347
Max. educ. of household	-0.017	0.035	0.620	-0.025	0.035	0.486	-0.025	0.035	0.475
Educ. of household head	0.094	0.036	0.009	0.096	0.036	0.008	0.095	0.036	0.008
Age of house-hold head	0.004	0.006	0.553	0.005	0.006	0.470	0.004	0.006	0.490
Male adults	0.017	0.099	0.867	0.016	0.098	0.869	0.013	0.098	0.895
Female adults	-0.125	0.123	0.310	-0.121	0.122	0.321	-0.133	0.123	0.278
Risk aversion	-0.050	0.089	0.579	-0.047	0.089	0.595	-0.003	0.104	0.975
Family size	0.075	0.058	0.194	0.084	0.058	0.147	0.088	0.058	0.130
Land size	0.316	0.217	0.145	0.302	0.216	0.162	0.307	0.216	0.155
Corrugated roof	-0.015	0.195	0.939	-0.015	0.193	0.937	-0.014	0.193	0.940
Gave loan	0.642	0.337	0.057	0.676	0.335	0.044	0.655	0.336	0.051
Credit access	0.718	0.293	0.014	0.743	0.291	0.011	0.739	0.290	0.011
Remittance	-0.249	0.344	0.469	-0.224	0.342	0.512	-0.209	0.342	0.541

Other FFW	-0.500	0.569	0.380	-0.504	0.565	0.372	-0.501	0.564	0.374
Farm income	0.000	0.000	0.075	0.000	0.000	0.074	0.000	0.000	0.073
Non-farm inc.	0.000	0.000	0.310	0.000	0.000	0.308	0.000	0.000	0.275
Tree holdings	0.000	0.000	0.651	0.000	0.000	0.719	0.000	0.000	0.731
Kete	1.109	0.360	0.002	1.039	0.360	0.004	1.062	0.360	0.003
Godguadit	0.937	0.429	0.029	0.917	0.426	0.031	0.921	0.425	0.030
Amba Mariam	0.716	0.326	0.028	0.640	0.327	0.050	0.671	0.328	0.041
Addis Mender	-0.161	0.388	0.677	-0.162	0.385	0.674	-0.140	0.385	0.715
Chorisa	0.348	0.364	0.339	0.309	0.362	0.393	0.320	0.361	0.376
Constant	-0.496	0.605	0.413	-0.406	0.603	0.501	-0.427	0.602	0.478

Table 8. Changes in Tree Holdings Estimated Using Regression Analysis (Lagged Value of Tree Holdings Instrumented with Robust Standard Errors)

Variable	Model 1			Model 2			Model 3		
	Coeff.	*Std. err.*	*P > t*	*Coeff.*	*Std. err.*	*P > t*	*Coeff.*	*Std. err.*	*P > t*
Trees	-0.394	0.438	0.368	-0.386	0.437	0.377	-0.390	0.434	0.369
Participation	76.686	40.653	0.059	119.789	54.650	0.028	114.835	58.097	0.048
Shock	-49.272	37.840	0.193	-24.941	44.421	0.574	-24.682	44.367	0.578
Shock /participation				-87.895	77.813	0.259	-88.746	77.401	0.252
Risk aversion /participation							14.181	31.482	0.652
Δ disc. rate	-16.294	22.400	0.467	-15.642	22.401	0.485	-15.695	22.395	0.483
Δ max. educ.	-8.953	7.511	0.233	-8.980	7.524	0.233	-9.035	7.525	0.230
Δ family size	-3.957	14.578	0.786	-4.564	14.596	0.755	-4.492	14.600	0.758
Δ land size	24.191	36.592	0.509	24.463	36.494	0.503	24.420	36.490	0.503
Δ credit	66.570	42.459	0.117	63.374	42.634	0.137	63.798	42.624	0.134
Δ remittance	134.975	55.377	0.015	134.418	54.842	0.014	133.377	55.356	0.016
Δ FFW	-124.531	78.149	0.111	-118.522	80.324	0.140	-118.894	80.167	0.138
Discount rate	-28.287	25.686	0.271	-26.874	25.593	0.294	-27.330	25.492	0.284
Max. educ. of household	-7.026	8.911	0.430	-6.818	8.877	0.442	-6.805	8.877	0.443
Educ. of household head	-9.374	8.314	0.260	-9.478	8.341	0.256	-9.337	8.258	0.258

Age head	1.207	1.423	0.396	1.138	1.419	0.423	1.157	1.409	0.411
Male adults	6.111	21.466	0.776	6.349	21.410	0.767	6.570	21.474	0.760
Female adults	-12.551	25.868	0.628	-13.146	25.970	0.613	-12.424	25.938	0.632

Variable	**Model 1**			**Model 2**			**Model 3**		
	Coeff.	***Std. err.***	***P > t***	***Coeff.***	***Std. err.***	***P > t***	***Coeff.***	***Std. err.***	***P > t***
Risk aversion	-27.143	12.776	0.034	-27.322	12.944	0.035	-29.641	13.993	0.034
Family size	18.320	22.159	0.408	18.079	22.168	0.415	17.955	22.181	0.418
Land size	26.106	38.289	0.495	27.467	38.459	0.475	27.514	38.427	0.474
Corrugated roof	55.859	37.234	0.134	55.420	37.303	0.137	55.369	37.269	0.137
Gave loan	212.475	119.235	0.075	211.645	118.992	0.075	212.408	118.639	0.073
Credit access	21.004	59.423	0.724	18.246	59.763	0.760	18.144	59.679	0.761
Remittance	147.030	79.174	0.063	146.996	79.247	0.064	146.565	79.197	0.064
Other FFW	-63.381	83.216	0.446	-62.251	84.446	0.461	-61.741	84.115	0.463
Farm income	13,301	13,016	0,307	13.514	13.084	0.302	13.525	13.077	0.301
Non-farm inc.	-0.002	0.020	0.910	-0.003	0.020	0.896	-0.002	0.020	0.903
Livestock	0.046	0.060	0.448	0.044	0.060	0.466	0.044	0.060	0.468
Kete	95.130	73.414	0.195	96.633	73.605	0.189	95.427	73.878	0.196
Godguadit	89.075	56.509	0.115	89.284	56.565	0.114	87.941	56.997	0.123
Amba Mariam	247.346	87.138	0.005	255.709	89.028	0.004	254.080	89.538	0.005
Addis Mender	11.118	103.955	0.915	11.312	103.904	0.913	9.226	103.659	0.929
Chorisa	136.355	90.326	0.131	137.656	90.745	0.129	136.350	91.233	0.135
Constant	-199.023	160.094	0.214	-211.660	161.234	0.189	-210.376	161.677	0.193

For the changes in livestock holdings, there was no statistically significant impact of PSNP participation, as such, in any of the three estimated models. Income shocks had a negative impact on livestock holdings, supporting the buffer hypothesis; the interaction variable between PSNP participation and income shocks was positive and was almost identical to the income shock variable in magnitude (but was not statistically significant). Access to credit, which is one of the measures included in OFSP, had a positive impact on livestock holdings; so did the education level of the household head, as well as the level of farm income. Households that gave loans or received remittances also had larger increases in livestock holdings. On the other hand, we noted that, contrary to expectations, the household's discount rate did not appear to matter for the change in livestock holdings, and neither did risk aversion.

For changes in the number of trees on the household's land (table 8), many of the estimated coefficients had the same signs as those for the change in livestock holdings. However, tree holdings actually increased more for PSNP participants than for non-participants, and this difference was statistically significant. Income shocks had no significant effect on the change in the number of trees on the farm. The discount rate did not matter for tree holdings either. Risk aversion did have an impact, but we noted that the sign suggested that trees were not seen as a safer alternative than crops; tree holdings increased less for the risk-averse households. PSNP participation did not appear to affect the impact of risk aversion. Similar to the results for livestock holdings, remittances and being a lender had positive impacts on the change in tree holdings.

Table 9 displays the PSM results and table 10 displays t-tests for differences in means for individual regressors in the treated and untreated sample.

Table 9. Average Treatment Effect on the Treated (ATT)

Baseline year	Outcome	Treated house-holds	Number of treated households in support group	Untreated house-holds	Number of untreated house-holds in support group	ATT livestock (std. err.)	ATT trees (std. err.)
2002	Δ 2005–2007	Public work, 2005	148	No public work, 2005	390	0.17 (0.30)	111.04 (74.66)

Table 10. Test of Differences in Means of Single Regressors Used in the Propensity Score Matching

Variable	Mean			t-test	
	Sample	*Treated*	*Control*	*t*	*P > t*
Shock	Unmatched	.46053	.56923	-2.29	0.023
	Matched	.46	.42	0.70	0.487
Livestock	Unmatched	2.0918	2.8821	-3.88	0.000
	Matched	2.0991	1.9546	0.74	0.460
Trees	Unmatched	122.47	176.8	-1.71	0.088
	Matched	119.28	143.41	-0.79	0.432
Educ. of household head	Unmatched	1.2368	1.1282	0.44	0.662
	Matched	1.2	.96	0.82	0.412

Max. educ. of household member	Unmatched	3.9079	4.0769	-0.52	0.603
	Matched	3.8867	3.98	-0.24	0.808
Age of household head	Unmatched	47.118	50.879	-2.61	0.009
	Matched	47.253	48.467	-0.76	0.448

Variable	**Mean**			**t-test**	
	Sample	***Treated***	***Control***	***t***	***P > t***
Male adults in household	Unmatched	1.4211	1.6333	-2.32	0.021
	Matched	1.4133	1.34	0.75	0.456
Female adults in household	Unmatched	1.3684	1.4846	-1.66	0.098
	Matched	1.3667	1.4933	-1.62	0.106
Family size	Unmatched	5.0592	5.3538	-1.53	0.127
	Matched	5.0667	4.9467	0.53	0.594
Land size	Unmatched	.95216	.7603	2.98	0.003
	Matched	.89155	.86213	0.42	0.675
Corrugated roof	Unmatched	.20395	.39744	-4.33	0.000
	Matched	.20667	.19333	0.29	0.774
Gave loan	Unmatched	.02632	.04359	-0.94	0.350
	Matched	.02667	.02	0.38	0.703
Remittance	Unmatched	.19079	.20769	-0.44	0.661
	Matched	.19333	.21333	-0.43	0.668
Kete	Unmatched	.11842	.31538	-4.78	0.000
	Matched	.12	.11333	0.18	0.858
Godguadit	Unmatched	.09868	.16923	-2.07	0.039
	Matched	.1	.1	-0.00	1.000
Amba Mariam	Unmatched	.30263	.09231	6.35	0.000
	Matched	.30667	.28	0.51	0.613
Addis Mender	Unmatched	.03289	.15641	-4.00	0.000
	Matched	.03378	.01351	1.15	0.253
Chorisa	Unmatched	.07895	.16667	-2.64	0.009
	Matched	.08	.08667	-0.21	0.835
Farm income	Unmatched	1025.1	1197	-1.93	0.054
	Matched	1022.6	1049.1	-0.28	0.779
Non-farm income	Unmatched	191.68	289.55	-1.70	0.090
	Matched	190.23	181.63	0.16	0.872
Pseudo R^2	0.243	LR chi2	156.09	p>chi2	0.000

unmatched		unmatched		unmatched	
Pseudo R^2 matched	0.028	LR chi2 matched	11.57	p>chi2 matched	0.930

Joint insignificance for the regressors was rejected in the unmatched sample, but not in the matched sample. Looking at differences in means of individual regressors between the treated and untreated groups, we found no significant differences in means in the matched sample.

As can be seen in table 9, there appear to be no significant difference in changes in livestock or tree holdings between participants and non-participants. It is important to note here that the results are sensitive to the choices of input variables and matching method. Some choices of method or variables produce statistically significant results, but a sensitivity analysis indicated that most of the methods produced results that were not statistically significant. Similar problems were found in Gilligan and Hoddinott (2007).

5. Conclusions

In this paper, we used both regression analysis and propensity score matching to evaluate the impacts of the Ethiopian Productive Safety Net Program on rural households' holdings of livestock and forest assets/trees. We used panel data collected in three surveys from 2002 to 2007. There are remaining potential problems, such as possible selection issues. Still, unlike many similar studies, this study is an improvement for several reasons, including the fact that we had data on actual behavior both before and after the program started. The data used for the two approaches differed slightly, but the results are nonetheless similar in nature.

We found no indication that participation in PSNP leads households to disinvest in livestock or trees; in fact, the number of trees increased for households that participated in the program. It could be the case that participation in PSNP (where tree planting and subsequent forest management work on public lands are usual activities) leads to households becoming more skilled in forestry, and that they switch to increased forest planting as a result. In the presence of some possible competition for labor between PSNP and private activities, tree planting may also have been chosen because it tends to be less labor intensive.

An alternative, perhaps more plausible, interpretation is that while recent increases in wood prices may have made tree planting more profitable than crops, farmers may nonetheless

be hesitant to plant trees because they take several years to grow and the land is unavailable for crop farming in the meantime. If this is the case, having a secure source of income from the PSNP while trees mature may well encourage farmers to switch from annual crops to trees. This would also explain the observed negative relationship between risk aversion and the number of trees; any long-term planting decisions would also be affected by uncertainty about future land tenure, making risk-averse farmers more hesitant to make planting decisions when the benefits are several years in coming.

We found no evidence that the PSNP protects livestock in times of shock. Shocks appear to lead households to disinvest in livestock, but not in trees. Conceivable explanations are that livestock is a more liquid asset and that livestock may die due to shocks, such as bad weather conditions. Another explanation can be that while households may harvest trees in times of shock, they may replant in sufficient numbers so that the total number of trees does not change much; replanting trees appears to be easier than reinvesting in livestock. Given the uncertain weather conditions, the fact that most of the households in our study areas mostly grow eucalyptus trees (which are fast growing and drought resistant) may also have contributed to this result.

PSNP has only been in place since 2005, and it may be too early to say what the longer-term impacts are. However, the official goal is to phase it out in a few years' time. Looking at our findings, it appears that there is no trend toward increased livestock holdings as a result of the program, despite the fact that this is one of its goals. On the other hand, the program does appear to encourage additional tree planting, which may have become more profitable in recent years. Thus, the program does seem to have raised the long-term income earning potential of the households in the survey, although perhaps not in the intended manner. Whether households will in fact be able to graduate from the program at its scheduled end date in 2010 remains to be seen, but it does appear that their incomes may be higher than before.

Our results suggest that increased forestry activity is taking place as a result of PSNP, and that improved credit access (which is part of OFSP, but not PSNP) leads to increases in livestock holdings. The first of these impacts is somewhat unexpected; the second impact is expected, but it is surprising that this factor appears to be more important than the existence of the PSNP. To the extent that PSNP and OFSP have lasting effects on household welfare, their effects appear to be more complex and indirect than expected.

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