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Social Protection and Household Composition: A Panel Data Analysis of Tigrai, Northern Ethiopia

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Abstract: Although development intervention programs can have far-reaching impacts beyond their stated objective, there have been few careful studies of unintended outcomes of such programs. This study assesses the role of Ethiopia's Productive Safety Net Program (PSNP) on household size and dependency ratio using the Difference-in-Difference (DiD) method based on panel data from four rounds over 12 years collected in Tigrai, northern Ethiopia. Results show that member households in the public works component of the PSNP have maintained a larger household size than their counterparts outside the PSNP. Member households also had a larger dependency ratio than their counterparts outside the PSNP five years after the program started (2005-2010). With the graduation of members and the downscaling of the program in the period 2010-2015, the effects on household size and dependency ratio were reduced and vanished.

Keywords: Household size, dependency, safety nets, difference in differences

JEL codes: D02, D15, D18.

1. Introduction

Ethiopia has suffered recurring droughts and various other shocks that led to a persistent food insecurity problem. As a result, the country has been one of the top aid-receiving countries in the world (Abdulai et al., 2005; Little, 2008). Aid provided relief to affected sections of society for an extended period. Later, efforts were made to link aid with the rehabilitation of natural resources using the Food-for-work (FFW) program (MoARD, 2015)[1]. Through FFW programs, affected people were assisted in rehabilitating mostly forests and degraded lands. However, most FFW programs before the Productive Safety Net Program (PSNP) lacked predictability because they usually came as reactions to drought and other shocks. Therefore, the Government of Ethiopia started the PSNP to permanently enable food-insecure rural households to achieve food security and escape poverty by building assets (MoARD, 2010). The main innovation of this program is that it provides households with continuous access to FFW/cash for work (CFW) and free food access (FFA) to labor-deprived sections of the society for the duration of the phase of the program, with possible extension (Gilligan et al., 2009).

There are studies of the impact of the PSNP on several stated outcomes of the program, such as food security and poverty (Berhane et al., 2014; Gilligan et al., 2009; Nega et al., 2010) and children's education and nutrition (Debela et al., 2015; Gebremariam et al., 2024). Other studies assessed the impact on household asset accumulation (Andersson et al., 2011; Debela & Holden, 2014; Gilligan et al., 2009), technology adoption, investments in land, smallholder agriculture and its productivity (Adimassu & Kessler, 2015; Alem et al., 2010; Bahru & Zeller, 2022; Hoddinott et al., 2012). There are also studies on the impact of the PSNP on environmental outcomes, such as tree cover (Hirvonen et al., 2022) and climate change mitigation (Woolf et al., 2018). Some studies assess the links of the PSNP with food prices

[1]MoARD = Ministry of Agriculture and Rural Development (of Ethiopia)

(Sabates-Wheeler & Devereux, 2013) and graduation from the program (Arega, 2012; Sabates-Wheeler & Devereux, 2013; Sabates-Wheeler et al., 2021). However, to the best of our knowledge, no study has been conducted on the impact of this program on household size and dependency ratio, except for Hoddinott and Mekasha (2020), which examined the effect of PSNP on household size.

Hoddinott and Mekasha (2020) used a survey of sampled households in four rounds between 2006 and 2012 covering four regions in Ethiopia (Tigrai, Amhara, Oromia, and Southern Nations, Nationalities and Peoples (SNNP)). They employed the Difference-in-Differences (DiD) method to identify impact. Our study is similar in using survey data and utilizing the DiD method but differs in three features. First, we examine the effect of the PSNP not only on household size but also on the dependency ratio. We define dependency ratio as the ratio of the number of dependents to the number of adult members of the household. Secondly, Hoddinott and Mekasha (2020) did not have before-treatment data for families that had participated since the start of the program and had to drop them from their analysis. We have data before the beginning of the program and hence are better able to compare results before and after treatment for all households in the treatment versus the non-treatment groups in our sample. Finally, our study is focused on one region (Tigrai) with a larger sample from this region, covering a more extended period. Hoddinott and Mekasha (2020) started in 2006 and finished in 2012, while our study involved one survey round before the program's start (2003), and the last survey was in 2015.

Public intervention programs may directly and indirectly affect the behavior and capabilities of households (Sadoulet et al., 2001). Some of the impacts can be unintended, given the program design. When conceived, public intervention programs aim to alter households' capacity to escape poverty (Bradshaw, 2007; Solomon et al., 2012). Nevertheless, such programs may also end up with related but unanticipated outcomes.

The public works (PW) component of the PSNP provides households with income and simultaneously requires them to work on community asset-building programs. On the one hand, the eligibility to be a member of the PSNP and the decision as a member on the amount of time to spend on PW depends on the size of the household (the consumption need of the household plus the ability to work). On the other hand, the PSNP provides member households access to food/cash payments, which depends on the household size. The program clearly states that all members of an eligible household are registered as PSNP clients (MoARD 2010). Providing food/cash may increase the ability of the household to feed and maintain a larger household size. Thus, households can condition their household size based, among other things, on what they get or expect from the PSNP and the level of disutility (drudgery) due to work in the program.

This study assesses whether the PSNP potentially enables households to build a larger household size and dependency ratio that may contribute to enhanced dependency on PSNP and undermine its purpose of reducing vulnerability and dependency. Specifically, this study raises the following two questions.

- Does PSNP membership and participation lead to larger household size among member households?
- Does PSNP membership and participation lead to a higher dependency ratio in the households?

This study is important on three grounds. First, it investigates a potential unintended impact that may undermine the longer-term benefits of the program, and as such, it provides insights for the future design of similar programs. Second, it assesses how the PSNP has affected household size and dependency ratio. These issues have not been examined well enough so far despite their pivotal role in determining the overall impact of this and other similar programs.

Third, this study employs a rigorous impact assessment method, which controls for the endogeneity of selection into the program and uses household panel data of five rounds running from 2001 to 2015 containing member and non-member households. The study allows the identification of this type of program's longer-term impact.

2. Theoretical framework

A common approach in analyzing rural household decision-making is to use agricultural household models. In such models, households are a combination of utility-maximizing consumers and profit-maximizing producers of farm goods and typically face imperfect markets (de Janvry & Sadoulet, 2006). Theoretically, household size may contribute to household utility, and the household workforce contributes to its production and, thereby, its utility. However, a larger household may also entail a higher maintenance cost. Maintaining a household involves higher consumption needs in terms of food and the monetary costs of taking care of the needs of dependent members in the form of food, clothing, etc., as well as labour costs. The workforce of a household with a higher dependency ratio has to work harder to meet the consumption needs of the whole household, *ceteris paribus*.

A larger household positively contributes to utility as socio-cultural values have shaped people's perceptions, favoring having more members and staying together. Staying together in this context can be taken as a source of utility, and the utility gained from this can be termed 'happiness from staying together.' With larger household sizes, there can also be the benefit of economies of scale in consumption due to sharing household public goods (Deaton & Paxson, 1998). Maintaining a large household is an additional economic benefit if it possesses the resources to make its members productive. Children and relatives can help in household agricultural activities and boost income, or some are sent for education (investment in education) and serve as future sources of additional income in the form of remittance or can

serve as future insurance. The insurance can support the parents when they become old (a sort of pension). Especially for households participating in the PW component of the PSNP, larger household sizes mean they can work more hours in the program and get more payment as the program stipulates full family targeting of eligible households (MoARD 2010).

Therefore, household size, on the one hand, increases the household's utility and, on the other hand, increases the household's resource burden. Thus, a typical household faces a trade-off between the benefits of having a larger household size and the additional costs that come with it. Therefore, technically, the choice of household size affects both the objective function (household utility) and the constraints of the household (full income constraint). We may expect diminishing marginal utility from larger household sizes. Access to PSNP may lift this marginal utility curve because access to FFW/CFW can increase the marginal returns of additional members and reduce the marginal costs of keeping existing members. These benefits can happen for two main reasons. Firstly, as the PSNP aims at full family targeting, an additional household member may mean additional working days and more income, provided there are able-bodied members in the household. Secondly, income from PSNP may serve as a safety net for the household's basic consumption needs, enabling the household to maintain more members at a lower cost. This may happen as able-bodied household members can now work in the PSNP and get additional income without the need to go further away in search of work for income. Thus, the optimization problem of the household can then be conceived using standard agricultural household models such as Singh et al. (1986) and de Janvry and Sadoulet (2006)

The household is assumed to have a minimum subsistence level of consumption, which it always needs to satisfy. This minimum subsistence level of consumption is a function of household size itself. Access to PSNP contributes to fulfilling the subsistence level of consumption, especially in the face of shocks to agricultural production. Since household size

does not enter directly into the household's utility function, studies focus on the two behavioral factors that affect it: fertility and migration (Becker, 1960; Hagen-Zanker & Himmelstine, 2013; Stecklov et al., 2007). The PSNP may increase the ability of member households to maintain a larger household size by reducing the incentives for outmigration and/or due to higher fertility. The PSNP could reduce the outmigration of household members as they might need to work on the PSNP itself or help with other household chores. Thus, outmigration may reduce the household size, and since adult members are most likely to out migrate, it may also reduce the dependency ratio. Besides, PSNP membership might also lead to higher fertility as the program allows pregnant and lactating mothers to be off duty with their benefits from the PSNP intact (MoARD, 2010). If this happens, an increase in children may lead to an increased dependency ratio in the household. Based on the discussion, we intend to test the following two hypotheses:

- ***Hypothesis 1.*** *Ceteris paribus, the optimal household size of PSNP member households is higher than that of non-member households.* The testable implication of this hypothesis is that member households have incentives to increase their household size. It also leads to:
- ***Hypothesis 2.*** *PSNP membership and participation facilitate a higher optimal dependency ratio than for non-member households.*

3. Objectives and administrative organization of Ethiopia's PSNP

The PSNP program in Ethiopia is a core component of the country's food security program (Lavers, 2013). According to (MoARD 2010, p.5), the program aims "to assure food consumption and prevent asset depletion for food insecure households in chronically food insecure *woredas* (districts) while stimulating markets, improving access to services and natural resources, and rehabilitating and enhancing the natural environment." The transfer of cash

and/or food to households aims to enable consumption smoothing and avoid asset depletion by creating the means to rehabilitate community assets and improve access to social services. This program was officially launched in 2005, although the consultation with development partners started in 2003 (MoARD, 2015). The program is implemented in phases, and evaluating each phase helps design the next phase (Hoddinott et al., 2024)[2]. Within the period of our survey data, there are two phases of the program: phase 1 (2005-2010) and phase 2 (2010-2014). In phase 1, the program operated using the standard approach to support member households. In phase 2, the program started to graduate households and downsize the support.

During phase 1, the program mobilized targeted households. It provided them with finance to be engaged in public works such as soil and water conservation on hill slopes and social services infrastructure. Cash/food was paid for up to five days of work a month per household member for six months in a year until the recipient households graduated from the program. The program stipulated full family targeting. Thus, a household could work five days per month for each household member and receive the benefits accordingly. The maximum number of days a single household member could work monthly was 20 (Hoddinott et al., 2024). Graduation happened during phase 2 when households had accumulated assets and income levels to meet 12 months of food needs and withstand modest shocks (MoARD, 2015). Some households participated in the direct support component of this program. These households received unconditional cash or food transfers because their members were unable to work (MoARD, 2015).

The program used administrative and community targeting approaches to identify eligible households. The administrative element of the targeting process included the provision of PSNP client allocation (the number of clients targeted in a given region, *woreda, kebelle (tabia)*, etc), input into the key criteria used within a locality, and oversight of the accuracy and transparency

[2] The PSNP has undergone lots of changes through its phases. For a detailed review of the program see Hoddinott, J., Berhane, G., Gilligan, D. O., Hirvonen, K., Kumar, N., Lind, J., Sabates-Wheeler, R., & Taffesse, A. S. (2024). Securing food, building livelihoods? .

of the targeting system (MoARD, 2010). The key community element of the targeting approach is identifying target households by the Community Food Security Task Force and verifying the client list through a public meeting in which the entire PSNP client list is read out and discussed (MoARD, 2010). Eligibility criteria for including households in the program were that households should be members of the community, should be chronically food insecure and have faced continuous food shortages (3 months food gap or more per year) in the last three years, households who suddenly became food insecure due to severe loss of assets and households without adequate family support and other means of social protection and support. Additional criteria used to refine the PSNP client list further included the status of the household assets (livestock ownership, land, and land quality), income from agriculture and non-agricultural activity, and specific vulnerabilities, such as female-headed households, elderly-headed households caring for orphans and households with members suffering from chronic illnesses (MoARD, 2010)

4. Materials and methods

4.1 Study area and data

We collected data from 12 *woredas* in the Tigrai region of northern Ethiopia. The data is panel data of six rounds starting from 1998 and extending to 2015. This study employs the last four rounds, from the third round (i.e., 2003) to the last round in 2015. Although the sample size of this survey had increased over time, reaching a maximum of 695 households in the last survey, we followed only those households surveyed during 2003, which is the baseline for our study. The survey rounds we use are suitable for evaluating the PSNP, as the survey rounds in 2003 and 2006 provide baseline data before the impact of PSNP starts to take place. The survey round in 2006 collected data for the 2005 agricultural production (*meher* season) and therefore captured the households' situation at the start of PSNP. Even though the PSNP became

operational in 2005, benefits received from PSNP were reported to have started later. While the 2006 survey collected data on household size and dependency ratios in April/May 2006, this was too early to expect any impacts of PSNP on these variables. We therefore include 2006 in the pre-program period. We classify the survey rounds into three episodes: namely, the before-program period (2003-2006), the full-scale program period (phase 1: 2006-2010), and the scaling-down period (phase 2: 2010-2015). Table 1 presents the number of households across the survey years and the level of attrition.

Table 1 Sample size and sample attrition across the survey years

Year	Available HHs	Attrition
2001	374	-
2003	354	20
2006	333	41
2010	330	44
2015	306	68

Source: Authors' computation based on NMBU and MU Household Panel data survey.

We used stratified random sampling to ensure large variation in population density, market access, agro-climatic conditions, and access to irrigation in the region (Hagos & Holden, 2002). Each survey round was carried out in June-September, avoiding bias due to seasonality. A questionnaire with predominantly the same structure and questions was used to avoid bias due to the lack of comparability of survey instruments. The data included household characteristics, asset ownership, land ownership, and public programs such as credit and the PSNP. A community-level questionnaire captured village-level information such as demographics, agricultural production structure, infrastructure, institutions, and land-related issues.

4.2 Empirical Strategy

The treatment for this study is membership in the public works component of the PSNP. We can think of the introduction of the PSNP in 2005 as a natural experiment and try to analyze its impact on various indicators. Our data allows us to consider such an approach since we have

data on the same households (since 2003) in both the treated and control groups before and after the start of the PSNP. Therefore, the impact of membership in public works on household size and dependency ratio can be captured using a standard DiD model, which can be specified as follows.

$$Y_{it} = \beta_0 + \beta_1 PW_{it} + \delta_t yr_t + \alpha_t yr_t PW_{it} + \varphi_i X_{it} + \gamma IMR + \epsilon_i + u_{it} \quad (1)$$

In this model,

- the outcome variable Y_{it} represents household size and dependency ratio in the household. Household size refers to the total number of household members, while the dependency ratio is defined based on the age of household members. We include household members aged under 15 years and above 65 years in the dependents category, while members between 15 and 65 years of age are included in the productive age category. Then, the dependency ratio equals the ratio of dependents to the productive age category.
- PW_{it} represents treated (member) households.
- β_1 represents the coefficient that captures the estimated mean difference in household size between the treatment group (public work member households) and control group (non-member households) before the start of the PSNP (i.e., it is the baseline difference between the two groups).
- δ_t represents the coefficients for the years in the panel rounds.
- α_t represents the year-specific DiD treatment effect estimates indicating whether the change in household sizes and dependency ratios differed between members and non-members in 2010 and 2015. We also include the estimate for 2006 to test for the common trend assumption.
- φ_i represents the coefficients on the control variables.

- ϵ_i represents household fixed effects and controls for observable and unobservable time-invariant household, farm, and location characteristics. This is followed by the random time-variant error term, u_{it}.

In explaining the household size and dependency ratio, we expect that time-varying household features, such as productive assets (livestock and land), can be crucial in addition to membership in PSNP and participation in public works. We expect the age of the household head and the spouse to correlate positively with household size and dependency ratio up to when their children start to leave the family or they contribute more as producers in the household. We therefore expect a non-linear relationship between the age of the head and spouse and household size and dependency ratio based on Chayanov's household life cycle theory (Chayanov 1925). According to this theory, household size is small for young couples soon after marriage, then grows as they get more children. Then, the workforce of the household increases as the children grow up and then again decreases as the children may leave for reasons like marriage and migration. Our interest lies in the later stage of the household development cycle. The proxy variable we include is whether the spouse is older than 42 years. We expect household size to decrease for such households because childbirth may be unlikely after this age and because grown-up children may leave when the spouse is older. The basis for our expectation that grown-up children may start to leave such a household is that women in the study area marry and give birth at an early age (commonly in the late teens). Hence, it is likely that at least firstborn children could marry and leave the household. Hardships and shocks may also trigger early marriages of daughters. PSNP membership and participation may protect against such hardships and shocks. There may also be positive effects on children's health and survival.

Regarding the gender of the household head, predicting its effect is not straightforward. However, we may expect that male-headed households have larger household sizes as they may be able to provide for a larger household than female-headed households. Female-headed households may also be widows or divorced and may, therefore, also have smaller household sizes. Concerning the endowment variables (farm size and livestock endowment), we expect they will positively affect household size and dependency as they enable maintaining a larger household and potentially more dependents.

We introduce λ to test and control for attrition bias since we are using unbalanced panel data. We follow the approach of Miller and Wright (1995) and include the inverse Mills ratio (IMR) from a probit regression of attrition. We regress the attrition dummy on the control variables of our outcome equation (X_{it}) and the attrition model can be specified as follows.

$$Attri = \gamma_0 + \gamma_i X_{it} + v_{it} \qquad (2)$$

Where $Attri$ is a dummy variable equal to one for households absent in any survey rounds (from 2003 to 2015). We used the survey in 2001 as a basis. Table A2 in Appendix A provides the results of this regression. We had 374 households in 2001, while in the following rounds, we had fewer households due to attrition (see Table A1 in Appendix A for the details).

We rely on the Difference-in-Difference (DiD) method to identify the impacts, which controls for time-invariant unobservable effects and inspects the trends of the dependent variables before, during and after the treatment. Our hypotheses imply that we expect a break and a change in the trend for the treatment group compared to the control group after treatment. A significant positive change in this trend for member households compared to non-member households is assumed to be an effect caused by the treatment (Wing et al., 2018). However, in our setting, the treatment is expected to protect against shocks. The unprotected non-member households may be more negatively affected by such shocks and are, therefore, exposed to

adverse changes in the trends. Figure 1 seems to indicate precisely that. Member households have been better able to protect their families, and we do not see a shift in the trend for them from 2006 to 2010, but we do so for the unprotected control households. However, associated with the scaling back of the PSNP and partial graduation of households, we see a declining trend for treated households, indicating that the effects of the treatment on household sizes and dependency ratios are not fully sustained.

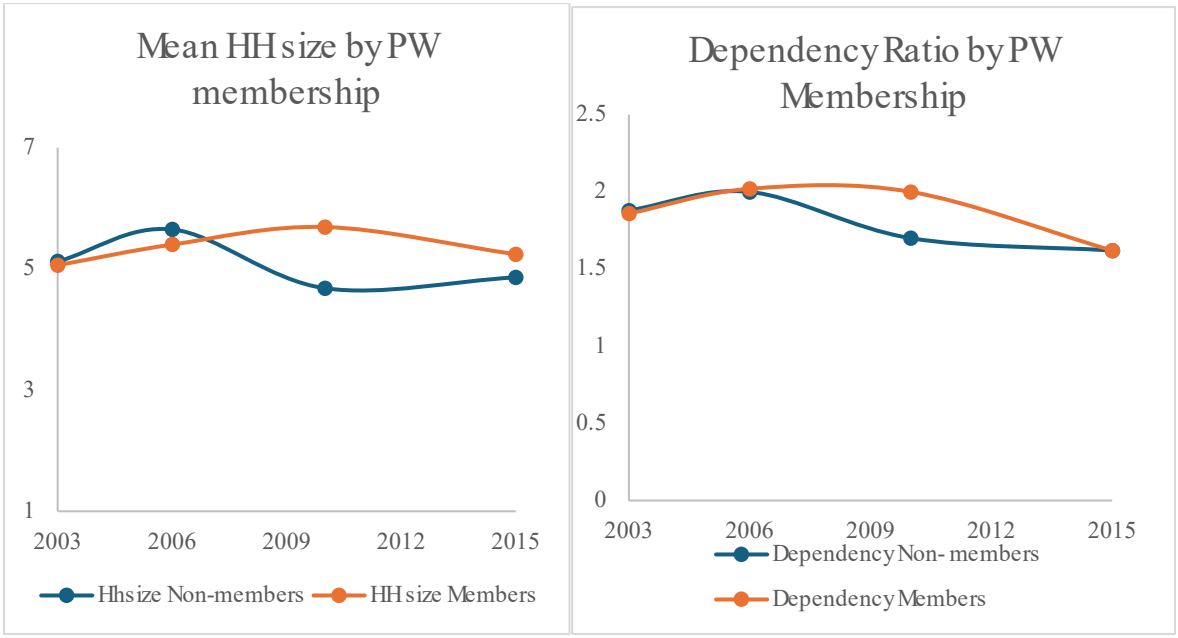

Figure 1 Household size and dependency ratio between members and non-member households of the PSNP

5. Results and Discussion

5.1 PSNP membership and extent of graduation

The PSNP consists of public works and direct support components. Most are public works program members (see Table 2). Up to 90% of PSNP's Tigrai members are in the public works program (Debela & Holden, 2014).

Table 2 Membership in the public works component of the PSNP

Membership Status	2006		2010		2015	
	Number	Percentage	Number	Percentage	Number	Percentage
Member	161	48.2	157	47.6	144	47.1
Non-member	173	51.8	173	52.4	162	52.9
Total	334	100	330	100	306	100

Source: NMBU and MU Household Panel survey data.

It is important to recognize that 19 member households had graduated from the program between 2010 and 2015. This may contribute to a reduced treatment effect in 2015 unless the treatment effect is long-lasting. To explicitly test and control for graduation, we introduced a dummy variable, which equals one if the household has graduated and zero otherwise. We run the DiD regression models with and without this graduation dummy to assess whether the change from 2010 to 2015 is different for graduated versus ungraduated households (see Table 5). We recognize that graduation can be a result of treatment and differential performance for these households.

5.2 PSNP participation, household size, and dependency ratio

Table 3 shows the development of the outcome variables over the four survey rounds for the PSNP member and non-member households. Note that we included graduated PSNP member households in the treatment (member) group in 2015, as the impact from earlier treatment may have prevailed after the treatment ended. Household size and dependency ratio figures were not statistically different before the PSNP started. However, by 2010, five years after the program started, PSNP member households had significantly larger household sizes and dependency ratios. By 2015, the differences in the outcome variables had reduced and become statistically insignificant. This reduction may be due to the graduation and scaling down of PSNP support (19 households graduated in 2015 in our sample). Graduation started to get focus from donors and government authorities, and it began to take place on a relatively larger scale in Tigrai from

2012 (Sabates-Wheeler et al., 2021). The changes in the outcome variables seem to indicate that the effects were only temporary, and this may say something about the sustainability of the treatment effects. The program may, for a period, have reduced the extent of outmigration of young household members as it was easier to retain them in the household through PSNP participation. We explore evidence of such mechanisms by inspecting household composition in more detail over survey rounds (see Table 4).

Table 3 Household size, dependency ratio, and public works membership

Year	Household size				Dependency ratio			
	Treated	Control	Diff.	t-value	Treated	Control	Diff.	t-value
2003	5.06	5.17	-0.11	-0.47	1.86	1.88	-0.02	-0.17
2006	5.40	5.65	-0.25	-1.03	2.02	2.00	0.02	0.17
2010	5.69	4.68	1.01***	4.19	2.00	1.70	0.30***	3.61
2015	5.26	4.84	0.42	1.62	1.62	1.62	0.003	0.04

Source: Authors' computation based on NMBU & MU household panel data. Significance levels: *** 1%, ** 5%.

We argued that the difference between member and non-member households observed due to PSNP participation may result from a stronger ability to retain household members (reduced pressure towards outmigration of young adults or giving birth to more household members when the conditions of the household are more favorable. Households facing economic hardships may send away young adults who may choose to leave their households and try their luck elsewhere. Early marriage for daughters could be another mechanism to reduce the family size and dependency ratio. We compared the two groups of households in terms of the average number of children below the age of 15 years and male and female young adult members. Table 4 shows that PSNP households have more children throughout the survey years and have maintained significantly more young female members (adolescent girls) in 2015 only.

Table 4 Comparison of PSNP member and non-member households by number of young adults in the household before, during, and after the PSNP

Variable	Treated	Control	Difference	t-value
Before the PSNP (2003)				
Children < 15 years	2.46	1.86	0.60***	3.35
Males (16-18 years)	0.19	0.24	-0.05	-0.80
Females (16-18 years)	0.19	0.13	0.06	1.39
Males (19-22 years)	0.18	0.15	0.03	0.66
Females (19-22 years)	0.13	0.12	0.01	0.24
Before the PSNP (2006)				
Children < 15 years	2.47	2.10	0.37*	1.89
Males (16-18 years)	0.26	0.20	0.06	1.32
Females (16-18 years)	0.20	0.16	0.04	0.82
Males (19-22 years)	0.25	0.20	0.05	1.01
Females (19-22 years)	0.10	0.14	-0.04	-0.87
During the PSNP (2010)				
Children < 15 years	2.20	1.50	0.70***	3.752
Males (16-18 years)	0.22	0.18	0.04	0.914
Females (16-18 years)	0.29	0.22	0.07	1.352
Males (19-22 years)	0.16	0.15	0.01	0.309
Females (19-22 years)	0.25	0.22	0.03	0.794
After the PSNP (2015)				
Children < 15 years	1.70	1.20	0.50***	2.904
Males (16-18 years)	0.28	0.22	0.06	1.19
Females (16-18 years)	0.29	0.18	0.11**	2.11
Males (19-22 years)	0.34	0.26	0.08	1.29
Females (19-22 years)	0.35	0.33	0.02	0.164

Source: Authors' own computation based on NMBU & MU household panel data.

Significance levels: *** 1%, ** 5%, * 10%.

5.3 Household features and endowments of member and non-member households

Table 5 presents other control variables of potential relevance with average data for treated and control households. Before the start of the PSNP, member households had younger household heads and slightly less land than non-member households. We see more significant differences after the first five years of the PSNP. The share of female-headed households has increased more for non-member households, but they also have increased their livestock holdings. By

2015, we see mostly insignificant differences between treated and control households, except for livestock, where non-member households have been able to expand their holding more.

Table 5 Mean difference in key control variables between members and non-members of the public works program

Variable	Treated	Control	Difference	t-value
Before the PSNP (2003-2006)				
HH head female	0.21	0.24	-0.03	-0.99
HH head's age	55.8	57.8	-2.0**	-2.25
Spouse's age	43.4	44.5	-1.10	-1.23
Spouse age is greater than 42 dummy (1=yes)	0.53	0.55	-0.02	-0.38
Total area of land the HH owns in *tsimdi*	4.38	4.85	-0.47*	-1.88
Total livestock units the HH owns	2.48	2.68	-0.20	-1.15
During the PSNP (2010)				
HH head female	0.24	0.34	0.1**	1.98
HH head's age	58.9	62.3	-3.4**	-2.57
Spouse's age	46.5	49.6	-3.1**	-2.38
Spouse age is greater than 42 dummy (1=yes)	0.63	0.71	-0.08	-1.34
Total area of land the HH owns in *tsimdi*	4.0	4.6	-0.6	-1.57
Total livestock units the HH owns	2.3	2.8	-0.5**	-2.31
After the PSNP (2015)				
HH head female	0.24	0.24	0.00	0.03
HH head's age	61.2	62.1	-0.9	-0.67
Spouse's age	49.0	51.4	-2.4*	-1.71
Spouse age is greater than 42 dummy (1=yes)	0.76	0.76	0.00	0.03
Total area of land the HH owns in *tsimdi*	4.4	4.9	-0.5	1.19
Total livestock units the HH owns	2.5	3.1	-0.6**	-2.11

Source: Authors' own computation based on NMBU & MU household panel data. Significance levels: *** 1%, ** 5%, * 10%.

5.4 Econometric results

We conducted a DiD estimation of household size and dependency ratio based on our treatment variable (participation in the public works of the PSNP), including control variables with household fixed effects (see Table 6). The household fixed effects control for time-invariant household, farm, and location-specific observable and unobservable factors. We estimated the models with and without the dummy variable for graduated households to see whether gradation

correlated significantly with the model results. The interaction between the 2006 year dummy and PSNP (*PW*) tests whether member and non-member households have a significantly different trend before treatment. Table 6 shows no such significant difference.

However, the coefficients of the interaction terms between *PW* membership and the 2010 and 2015 year dummies (treatment effects) are positive and statistically significant (at 1% and 5% levels in 2010 and 2015, respectively) in the household size regressions. In the dependency ratio regressions, the treatment effect is statistically significant (at 1% level) and has a positive sign in 2010 but is insignificant in 2015. Including the control for graduated members barely made any difference in the results. Therefore, the results indicate that the program affected household sizes and dependency ratios five years into the program. However, from 2010 to 2015, the treatment effects were reduced in the case of household size and almost vanished for the dependency ratio. This may indicate that household size for treated households increased not because of having more children (fertility). Instead, the increase appears to result from treated households being more able to retain household members (avoid migration). We saw that PSNP member households (Table 4) retained more adolescent girls in 2015 than non-member households, and this may explain the larger household size, which does not contribute to increasing the dependency ratio. This result is consistent with the findings of Hoddinott and Mekasha (2020) also, who found that PSNP member households have larger household size mainly due to delayed marriage of adolescent girls in the household

Table 6 Panel DiD household fixed effects regression for impact of membership in public works on household size and household dependency ratio

Variables	Without graduation dummy		With graduation dummy	
	Household size	Dependency ratio	Household size	Dependency ratio
HH is a member in PW	-0.252	-0.225*	-0.260	-0.239*
	(0.327)	(0.122)	(0.329)	(0.124)
Year 2006 dummy	0.730**	0.175	0.727**	0.169
	(0.292)	(0.106)	(0.293)	(0.107)
Year 2010 dummy	-0.025	0.023	-0.029	0.017
	(0.296)	(0.118)	(0.298)	(0.118)
Year 2015 dummy	-0.020	-0.056	-0.027	-0.068
	(0.374)	(0.127)	(0.379)	(0.127)
Interaction 2006*PW	-0.479	-0.004	-0.473	0.006
	(0.369)	(0.133)	(0.370)	(0.134)
Interaction 2010*PW	1.005***	0.321***	1.014***	0.335***
	(0.349)	(0.121)	(0.351)	(0.123)
Interaction 2015*PW	0.874**	0.079	0.877**	0.085
	(0.397)	(0.123)	(0.397)	(0.122)
Household head female	-1.223***	-0.370***	-1.223***	-0.370***
	(0.217)	(0.064)	(0.217)	(0.064)
Household head age	0.040	-0.025	0.039	-0.025
	(0.085)	(0.033)	(0.085)	(0.033)
Household head age squared	-0.001	0.000	-0.001	0.000
	(0.001)	(0.000)	(0.001)	(0.000)
Graduated from PSNP dummy (1=yes)			0.106	0.175
			(0.603)	(0.157)
Spouse age	0.214**	0.026	0.214**	0.026
	(0.093)	(0.032)	(0.093)	(0.032)
Spouse age squared	-0.002***	-0.001*	-0.002***	-0.001*
	(0.001)	(0.000)	(0.001)	(0.000)
Land the HH owns in *tsimdi*	0.087***	0.031**	0.087***	0.032**
	(0.032)	(0.012)	(0.032)	(0.012)
Total livestock units the HH owns	0.132***	0.047***	0.132***	0.047***
	(0.039)	(0.014)	(0.039)	(0.014)
IMR from attrition probit	1.915**	0.891***	1.914**	0.890***
	(0.743)	(0.321)	(0.743)	(0.320)
Constant	-21.159**	-7.242**	-21.126**	-7.188**
	(8.305)	(3.522)	(8.313)	(3.518)
Observations	1097	1097	1097	1097
Number of households	326	326	326	326
Within R-squared	0.12	0.14	0.12	0.14
F(16, 325); F(17,325)	7.62	9.48	7.27	8.98

Significance levels: *** 1%, ** 5%, * 10%. Figures in parentheses are cluster robust standard errors

Looking at the correlation of the additional control variables with household size and dependency ratio, we find that the household head being female is negatively correlated (at a 1% significance level) with household size and dependency ratio. Keeping in mind that this variable only captures the change in household head status among households, it is not surprising that a change from male-headed to female-headed households causes a reduction in household size as such a change typically is associated with divorce or widowhood, which either is associated with splitting of households or loss of a household member. The spouse's age is non-linearly correlated (at the 5% and 1% significance levels and with positive and negative signs for the linear and quadratic age terms) with household size. This indicates a concave relationship between household size and the age of the spouse, which is in line with Chayanov's development cycle theory as households in the sample change and are on different stages of this cycle over the panel years. Finally, we see that changes in households' productive assets (land and livestock) are positively correlated (and significant at 1% and 5% levels) with household size and dependency ratio. This result is also plausible because such productive assets enable households to feed a family and keep more children.

Conclusion

This study assessed the role of membership in the public works component of the PSNP on household size and dependency ratio of member households using panel data from four rounds (2003-2015) in the Tigrai region of northern Ethiopia. We assessed the impact using the DiD approach. Our results show that PSNP membership and participation are associated with increased household size during phase 1 (2005-2010) of the program (2007-2009), while the effect was reduced during phase 2 (2010-2015) of the program when graduation and down-scaling of the program had started. Our results also show that PSNP membership and participation resulted in significantly higher dependency ratios for member households after phase 1 of the program. However, this effect disappeared five years later.

Our results show that PSNP helped member households maintain or retain more young adult members for a longer time than non-member households. This may mean that the positive long-term impacts of the PSNP on food security and asset accumulation that previous studies have shown might have been diluted by increased household size, which seems to be mainly a result of forestalling migration of young adult members. We may argue that the PSNP has contributed to reduced forced youth outmigration from member households as they became more food secure during the program. However, our findings indicate that the effects on household size and dependency ratio were only temporary. The downside is that we see no significant permanent asset building among member households that would have enabled them to maintain larger families after the program's end. For our key variables of interest, the main effect of the program seems to have been a protection against short-term shocks, which has temporarily reduced youth outmigration. These findings do not mean that the program has not provided many other benefits, such as improved child nutrition and more investment in local public goods, such as soil and water conservation, tree-plating, and infrastructure.

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Appendix

A. Handling of Attrition

As stated in the methodology section we followed the 372 households starting from 2001 for looking at trends and handling of attrition. Table 1A summarizes attrition of sample households by year.

Table A1 Attrition of sample households

Year	Available HHs	Attrition
2001	374	
2003	354	20
2006	334	40
2010	330	44
2015	306	68

Source: Authors' own computation based on NMBU & MU household panel data

Then we first estimated a probit model of attrition, taking the control variables we use in our main model. There is a correlation between attrition and several control variables (see Table A2). Thus, we included the inverse Mill's ratio from the attrition probit in our main models to control for bias due to sample attrition.

Table A2 Year by year probit regression of attrition

Variables	***2003***	***2006***	***2010***	***2015***
HH head female	-0.025	0.431*	0.031	0.322
	(0.370)	(0.243)	(0.255)	(0.296)
HH head age	-0.018	-0.001	0.007	-0.010
	(0.019)	(0.007)	(0.009)	(0.011)
Age of spouse	-0.006	0.041***	0.029**	0.017
	(0.029)	(0.014)	(0.012)	(0.015)
Age of spouse>42 dummy (1=yes)	-0.179	-0.492	-0.691*	-0.382
	(0.557)	(0.362)	(0.392)	(0.461)
Total area of land the HH owns in tsimdi	-0.045	0.039	-0.002	-0.036
	(0.056)	(0.028)	(0.045)	(0.048)
Total livestock units the HH owns	-0.021	0.029	-0.201**	0.107**
	(0.056)	(0.033)	(0.079)	(0.053)
Constant	-0.396	-3.142***	-2.433***	-1.899**
	(0.841)	(0.607)	(0.703)	(0.823)
Observations	335	324	309	299

Significance levels: *** 1%, ** 5%, * 10%.