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Food and Agriculture
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Reducing vulnerability to weather shocks through social protection

**Evidence from the implementation of
Productive Safety Net Programme (PSNP)
in Ethiopia**

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Abstract

This article uncovers the mechanisms shaping the impact of the public work component of Ethiopia's Productive Safety Net Programme (PSNP) on beneficiaries and communities' food security and vulnerability to various shocks. Using three waves of a national representative household survey, this study provides quantitative evidence on the pathways through which the social protection intervention affects direct beneficiaries and their community peers. The empirical findings show that the PSNP beneficiaries are less likely to be food insecure and experience harvest losses in the aftermath of droughts. Moreover, the beneficial effects of the programme spill over to the community peers. This is likely to reflect the nature of the public works implemented through the programme, such as the integrated community-based watershed development, including soil and water conservation measures and rangeland management (in pastoral areas). Also, no significant impacts have been found when households self-report stresses not related to adverse weather events. The results of this study provide evidence to inform the debate on the effectiveness of the PSNP. From a policy perspective, they suggest to explicitly integrate environmental and climate considerations to design social protection programmes targeting poor agricultural households that are highly vulnerable and exposed to weather shocks.

Keywords: social protection, climate, vulnerability, food security, droughts, agriculture.

JEL codes: H55, O55, Q18, Q54.

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The working paper is part of the research agenda on the role of social protection and adoption of climate-smart approaches and climate risk management and has been supported by the Strategic Programme to reduce rural poverty. It aims to contribute to the objectives of promoting inclusive economic growth and combating climate change which are stated in the FAO Strategic Framework 2022–2031 under the interconnected economic, social and environmental dimensions of agrifood systems denominated “Better Environment” and “Better Life”.

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1 Introduction

Climate change is associated with greater incidence and severity of environmental disasters and extreme weather events (IPCC, 2013). One of the most affected regions in the world is sub-Saharan Africa that during the last decades, has experienced frequent disasters including floods and droughts. Within the region, small-scale producers relying on rainfed agriculture are the most exposed to climate-related hazards and, at the same time, are the least able to cope with the adverse effects of extreme weather events (Zougmore *et al.*, 2016). Reducing smallholders' climate-related vulnerability, therefore, is a key priority to ensure their food security and livelihoods (Bradshaw, Dolan and Smit, 2004; Wang *et al.*, 2009).

Most of the existing literature has demonstrated that the capacity to make the required adjustments crucially depends on the existence of policies to support the access to information, credit, insurance, markets, technology and extension services (Bastagli *et al.*, 2019; Boone *et al.*, 2013; Covarrubias, Davis and Winters, 2012; Davis *et al.*, 2012; Hoddinott *et al.*, 2012; Prifti *et al.*, 2020; Tirivayi, Knowles and Davis, 2016; Todd, Winters and Hertz, 2010). However, during the last decade, more attention has been devoted to leveraging social protection measures to improve the adaptive capacity of vulnerable households (Zougmore *et al.*, 2016). As a consequence, terms such as "Adaptive Social Protection (ASP)" (Arnall *et al.*, 2010; Davies *et al.*, 2009, 2013; Leichenko and Silva, 2014) and "shock-responsive social protection" have been forged to refer to the adaptive role of social protection (FAO, 2021; TRANSFORM, 2020; UNICEF, 2019). The first one indicates that social protection may "help to build the resilience of poor and vulnerable households by investing in their capacity to prepare for, cope with and adapt to shocks" (Bowen *et al.*, 2020); the second one refers on "shocks that affect a large proportion of the population simultaneously (covariate shocks). In this way, social protection can complement and support other emergency interventions" (European Commission, 2019).

Ethiopia's Productive Safety Net Programme (PSNP) is a notable example of how social safety nets can be designed to meet the social protection needs of the most vulnerable while simultaneously reducing the risks related to climate-related disasters (World Bank, 2013). Previous studies assessed the impacts of the PSNP programme on agriculture productivity, use of inputs, agricultural investments and management strategies (Berhane *et al.*, 2015; Hoddinott *et al.*, 2012), gender-related vulnerabilities (Jones, Woldehanna and Tafere, 2010) and resilience to climate shocks (Knippenberg and Hoddinott, 2017). Other studies focused on the implementation features such as institution and people's preferences (Simons, 2016; Vinci and Roelen, 2020), graduation from the programme (Sabates-Wheeler *et al.*, 2021) and relative efficiency of different transfer types (Sabates-Wheeler and Devereux, 2010). However, important knowledge gaps remain on the mechanisms that guide the impact of PSNP on households' adaptive capacity to climate shocks. For example, it is unclear whether PSNS only impacts the programme participants or the effect of the programme is also transmitted to non-beneficiaries (e.g. in the same communities or territories) through a set of possible indirect channels. It is also unclear whether PSNP reduces households' vulnerability only to climate shocks or also to other types of shocks.

In this work, we take advantage of three waves of a nationally representative household survey to expand our understanding of the mechanisms underlying the PSNP impacts. This is important to improve the evidence around the effectiveness of PSNP in reducing household's vulnerability to shocks and, from a policy perspective, it helps to inform policy discussions on

how to effectively leverage PSNP – and more generally, social protection interventions – to increase households' adaptive capacity to climate change.

This analysis investigates the causal impact of beneficiaries' participation in the public work component of the PSNP on the probability of self-reporting food insecurity, crop losses and/or complete crop failure because of drought or other types of shocks. The rationale for such a comparative perspective is motivated by the nature of the public works implemented through the PSNP that are expected to yield most of the benefits when agricultural activities and food security are threatened by adverse weather events, and droughts in particular. Potential endogeneity issues due to different sources of unobserved endogeneity are controlled for with an instrumental variable approach (IV) in the framework of a linear model with fixed effects.

Our findings highlight that PSNP beneficiaries are less food insecure and less likely to experience complete crop losses in the aftermath of droughts. Conversely, no differences have been detected between PSNP beneficiaries and households not involved in the programme when they are exposed to other shocks, such as fire, pests, insects, wild animals, thefts, shortage of farm inputs, and prices. Moreover, the results show that the adaptive gains are partially transmitted to households not participating in the PSNP but living in the same village (indirectly treated). In fact, the community infrastructures related to the PSNP are defined by considering the community priorities. Sub-projects like farmers' training centres, irrigation schemes, schools and clinics are expected to support the whole community regardless of the individual PSNP membership. However, the results also point out that the adaptive capacity of PSNP direct beneficiaries increases relatively more than the rest of the community. This suggests that the PSNP contribution to household adaptive capacity goes beyond the construction of community agricultural and infrastructure assets and can be due to the monetary transfers as well as to the acquisition of skills and knowledge that are replicated on the beneficiaries' own fields. As an example, the PSNP programme also promotes household level water harvesting technologies which are expected to directly benefit the programme beneficiaries.

The structure of the article unfolds as follows: Section 2 provides the background for this study, by describing the lively debate about the effectiveness of the PSNP and pointing out the novelty of this study; Section 3 introduces the conceptual framework on which the identification strategy, presented in Section 4, has been tailored. Section 5 provides information and descriptive statistics on the dataset and main variables used for the analysis; Section 6 discusses the empirical results and foregoes the discussion on policy implications contained in Section 7. The concluding remarks are provided in Section 8.

2 Background and literature

2.1 The Public Safety Net Programme in Ethiopia

Ethiopia's Productive Safety Net Programme (PSNP) is a large national social safety net (SSN) programme that was launched in 2005 by the Ethiopian government to provide solutions to chronic food insecurity by addressing its causes – such as environmental degradation – and through interventions in education, health and water. In 2009, to counteract the increasing ravages of climate change, the programme boosted the integration of environmental and climate change considerations, prioritizing climate resilience (European Union, 2020). The programme targets vulnerable households in chronically food insecure and high climate-risk exposed districts (*woredas*) such as Afar, Amhara, Dire Dawa, Harari, Oromiya, Southern Nations, Nationalities and Peoples, Somali and Tigray. Its final objective is to improve food security, increase resilience to shocks and strengthen climate change adaptation and mitigation.

The PSNP is designed to support a local enabling environment for community development by transferring payments (in cash or in-kind)¹ to able-bodied members of communities willing to contribute to labour-intensive public works. These works are typically related to community assets' development (such as integrated watersheds development, roads, water infrastructure, schools, and clinics), soil and water conservation measures as well as rangeland management interventions in pastoral areas² (Government of the Federal Democratic Republic of Ethiopia - Ministry of Agriculture, 2010). A minority share of eligible individuals (between 15 percent to 20 percent), who are unable to supply labour due to pregnancy or lactation, disability, infirmity, or a high household dependency ratio, receive unconditional support (without providing any labour for public works) through income transfers within the programme component defined "direct support".

The national institutional structures and the key role of community representatives in the PSNP implementation are the most distinctive characteristics of the intervention. The targeting is based on an interacting administrative and community approach: the amount of aid allotted to each district (*woreda*) is determined by the federal government based on historical records and contingent needs. The list of beneficiaries is compiled at the village (*kebele*) level by an elected council with the aim of prioritizing the community's most vulnerable households and those who experienced losses due to shocks.³ The list of targeted households is subsequently approved at *woreda* level by the District Food Security Task Force (DFSTF).⁴

¹ The access to the markets determines whether the beneficiaries receive cash or an equivalent payment in food, primarily wheat, maize and cooking oil.

² It is worth highlighting that the labour is provided during the dry season to not interfere with agricultural activities.

³ The target households are (a) acutely food-insecure due to a shock resulting in the severe loss of assets; (b) households lacking adequate family support and other means of social protection and support; (c) households having a low level of household assets (land, livestock, land quality) relative to their neighbours; (d) households having a below average income from agricultural and non-agricultural activities; (e) households perceived to be vulnerable within the community, such as female-headed households, elderly households, or households with chronically-ill members (Government of the Federal Democratic Republic of Ethiopia - Ministry of Agriculture, 2010).

⁴ In each village, the Village Food security Task Force determines which households are eligible for the public works programme versus the direct support programme. Depending on the size of the village, one or more Community Food Security Task Forces oversee the community a participatory process.

The programme pays public workers for up to five days of work per month per household member, for six months a year, until the recipient households graduate from the programme by accumulating assets or reaching an income level that enables them to meet 12 months of food needs and to withstand modest shocks. Through the years, the PSNP has been complemented by other programmes that provide inputs, technical assistance and training in livelihood activities (crop and livestock, off-farm and employment) and other services to clients to promote income diversification, prevent assets depletion, and ultimately enable households to graduate out of the programme.

2.2 Previous contributions on the impact of PSNP

The impact of PSNP has been assessed on several livelihood, agriculture and food security outcomes. Previous studies show that PSNP generates large improvements in terms of asset holdings (particularly when complemented by other programmes such as the Other Food Security Programme [OFSP] or the Household Asset Building Programme [HABP]), but modest or no improvements in terms of households' food security (Berhane *et al.*, 2015; Gilligan, Hoddinott and Taffesse, 2009). Similarly, the PSNP has shown no effect on agricultural inputs use or on productivity, and a limited effect on agricultural investments, when implemented alone. However, when complemented by OFSP or HABP, the PSNP has a positive impact on agricultural investments, fertilizers use and, in a few cases, on productivity (Hoddinott *et al.*, 2012). Recently, the limited impact on agricultural productivity has been confirmed, taking advantage of satellite-based agricultural yield indicators, which highlight that the productivity gain associated with the public work component of the PSNP is equivalent to a 2.2 percent increase in the upper bound estimates (Gazeaud and Stephane, 2022).

Jones, Woldehanna and Tafere (2010) show that the PSNP has enhanced women's participation in rural public works programmes, although several design features prevent from pursuing its full transformative potential. Vinci and Roelen (2020) suggest that the heterogeneous results about the effectiveness of the PSNP may depend on the quality of institutions at the community level. Sabates-Wheeler and Devereux (2010) show that cash transfers distributed through the PSNP are susceptible to price inflation that may undermine the transfers' purchasing power and jeopardize the impact on food security. Burns (2014) and Simons (2016) argue that although a pro-poor implementation and several successes (such as saving lives, reducing distress sales and providing community-level services), PSNP has underperformed in building household assets and increasing livestock accumulation. As a result, the programme did not significantly reduce poverty, and proceeded to involuntary or prematurely graduate out most of the households despite the lack of evidence on livelihood strengthening. In particular, Sabates-Wheeler *et al.* (2021) explain that the need to demonstrate the effectiveness of the programme has resulted in quotas of households to be fulfilled by the field staff regardless their actual livelihood conditions.

PSNP explicitly recognizes that smallholders' food security is inherently linked to their capacity to cope with and adapt to climate shocks. Therefore, it targets the reduction of the beneficiaries' climate vulnerability among its main objectives. Despite those clear targets, the quantitative and qualitative impact assessments conducted so far, with only one relevant exception, have neglected climate vulnerability aspects and have provided mixed findings of the programme's effectiveness. To the best of our knowledge, only Knippenberg and Hoddinott (2017) have explicitly considered the impact of the PSNP on the beneficiaries' vulnerability to climate shocks. The study finds that the impact of droughts on the food insecurity experienced by PSNP recipients (number of months experiencing food insecurity) is 57 percent lower relative

to the non-beneficiaries. Moreover, the PSNP beneficiaries completely absorb the adverse impact of the shock relatively more quickly (within two years). The authors, therefore, suggest that PSNP is an effective means to mitigate the adverse effects of climatic shocks.

Our work expands this evidence in two ways. First, it provides insights into the underlying mechanisms through which the public work component of the PSNP is expected to affect the beneficiaries' vulnerability to the shocks. Second, it points out the existence of indirect effects on the beneficiaries' community peers. Both the contributions are meant to shed more light on the programme's effectiveness by considering pathways and dimensions that have been so far neglected, at least from a quantitative point of view, by previous studies and evaluations.

3 Conceptual framework

The complex links between social protection interventions, agricultural investments and smallholders' adaptive capacity can be identified through the concept of vulnerability (Adger, 2006; Janssen and Ostrom, 2006; Miller *et al.*, 2010), i.e. the response of social-ecological systems to stresses or perturbations, including climate-related shocks. Social protection programmes may reduce beneficiaries' vulnerability to climate shocks by relaxing both the budget and the risk constraints related to the adoption of adaptive management strategies, by boosting agricultural investments and by supporting the accumulation of assets (Scognamillo and Sitko, 2021; Sitko, Scognamillo and Malevolti, 2021). In particular, the transfer, either in cash or in-kind, may directly reduce resource constraints that act as barriers to agricultural investments and the adoption of new agricultural practices (Hoddinott, 2008; Holden and Binswanger, 1998; Prifti, Daidone and Davis, 2019). Transfers can also affect beneficiaries' preferences (Karlan *et al.*, 2014; Schwab, 2019) and their intertemporal discount rate (Hagos and Holden, 2006), favouring the accumulation of assets that may be used to insure against future food security shocks (Berhane *et al.*, 2015; Gilligan, Hoddinott and Taffesse, 2009). Moreover, when transfers are complemented with the provision of technical knowledge and management skills that can be reproduced in the beneficiaries' own fields, they can change the risk profiles of the clients, altering the opportunity costs of adopting new management strategies (Devereux, 2016; Tirivayi, Knowles and Davis, 2016).

With this conceptual framework in mind, this study aims to uncover the mechanisms through which social protection impacts food security and the climate vulnerability of PSNP recipients and their communities. The channels through which PSNP may affect beneficiaries' livelihood are threefold: i) supporting beneficiaries' consumption and food security through the monetary transfers; ii) enhancing beneficiaries' adaptive capacity by providing them with new knowledge and skills that allow physical assets accumulation and agricultural investments; iii) reducing the vulnerability to shocks of the entire community to which the beneficiaries belong through the construction of community infrastructures (indirect effect on peers, Government of the Federal Democratic Republic of Ethiopia - Ministry of Agriculture, 2014). In particular, given the nature of the public works implemented through the programme – covering a large number of adaptation-to-climate activities, such as the implementation of soil and water conservation measures, the PSNP is expected to affect mainly the households' capacity to cope with and to adapt to climate shocks (Berhane *et al.*, 2015; Devereux, 2016; Hoddinott *et al.*, 2012; Tirivayi, Knowles and Davis, 2016).

These three channels are not mutually exclusive and may potentially interact by either crowding-in or crowding-out the related impacts. Given that, testing the existence of these pathways is particularly important to correctly assess the causal impact of the PSNP under normal conditions and in the aftermath of shocks. As an example, by controlling for the indirect impact on the community peers, the average direct impact of the programme on the beneficiaries may be either magnified (should the programme contribute to developing a more climate-resilient environment which, in turn, would increase the returns from the individual agricultural investments) or, at least partially, absorbed (should the benefits of the programme also steam from the community infrastructures).

4 Data and descriptive statistics

The dataset used for this analysis spans across three waves of a geo-referenced nationally representative household panel survey data from Ethiopia collected by the Living Standard Measurement Integrated Surveys of Agriculture (LSMS-ISA) of the World Bank and the Central Statistics Agency of Ethiopia. Such a database, denominated Ethiopia Rural Socioeconomic Survey (ERSS), encompasses three agricultural seasons (2011–2012, 2013–2014 and 2015–2016), covering all regional states except the capital, Addis Ababa.

The primary sampling units encompass 333 enumeration areas (EAs), including 290 rural areas and 43 small towns. A total of 3 639 households have been interviewed across the EAs at the baseline and then tracked and re-interviewed across two subsequent survey rounds, for a total of 10 917 observations. ERSS is a multi-topic survey that includes household, agriculture (post-planting and post-harvest), livestock and community questionnaires allowing to collect a broader set of information including sociodemographic characteristics, agriculture management strategies implemented as well as assets owned by all the sampled households. The questionnaires also collect information on the shocks suffered by the households, as well as the coping strategies adopted and the social protection assistance received during the reference period. The households' information is complemented with community data, which allows to broaden the focus on villages and collect information on infrastructures and the implementation of the programme across the years.

The ERSS sample is designed to be representative of rural and small-town areas of Ethiopia. At the regional level, it is representative of the four bigger regions of the country (i.e. Amhara, Oromiya, and Tigray), while for the other smaller regions (i.e. Afar, Benshangul Gumuz, Dire, Dawa, Gambella, Harari and Somalie), estimates can be produced for their cumulative combination. Given these characteristics, the ERSS is expected to cover adequately the implementation of the PSNP in the country across the years considered, although – being national representative – the share of the households involved in the public work component is rather small (about 1 percent).

Using the ERSS, four main dependent variables have been computed to identify the households' agriculture and livelihood vulnerabilities to different shocks. The first variable measures the self-reported occurrence of crop losses and is calculated as a dummy that takes value one if the area harvested is smaller than the area planted. The second variable proxies for complete crop failure, computed as a dummy equal to one if the damages to the crop affect more than 75 percent of the total harvest. The third and fourth variables proxy for food insecurity. The third one is a dichotomous variable equal to one if the household reported having experienced a food insecurity episode during the agricultural season preceding the interview (from April to December). The fourth variable is a continuous measure of the length of the food insecurity episode in months.

To disentangle the impact of the programme in the aftermath of extremely dry weather episodes (hereafter droughts) from the impact encountered in the context of other shocks (such as fire, pests, insects, wild animals, thefts, shortage of farm inputs and prices), we diversify our dependent variables based on the self-reported motivation (drought or any other shock not previously mentioned) provided to explain agriculture and food security distresses. Against these dimensions, we evaluate the impact of the public work component of the PSNP, as measured by a dummy variable equal to one if any household member has participated in public works as part of the PSNP programme.

We relax the concerns about self-reported weather shocks by controlling for drought episodes occurring in the period of our analysis. We do so by combining the ERSS data with granular information on precipitation and temperature and computing a Standard Precipitation and Evapotranspiration Index (SPEI). Precipitation and temperature data, respectively, come from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) database of the Climate Hazards Center of UC Santa Barbara, and the European Center for Medium-Range Weather Forecasts (ECMWF).⁵ We have processed information on rainfalls and average temperatures for the year considered to calculate the SPEI with an accumulation period of 9 months (from April–December), encompassing the two rainy seasons in the country (*meher* and *belg*). The SPEI, as defined Vicente-Serrano, Beguería and López-Moreno (2010), is a standardized index that identifies extreme dry and wet periods based on the departures from the long-term historical mean. In this analysis, the info contained in the SPEI has been discretized by creating a dummy variable equal to one when the index is below the threshold of -1.5, and zero otherwise.

Besides controlling for weather extremes, we also consider several demographic and economic factors that may influence our outcomes. Specifically, to account for household demographic characteristics, we include a dummy equal to one if the household head is female, the head age, the household size, the share of household members of working age and their average education, and a dummy equal to one if the household had any health problems in the last 12 months. We also include an agricultural asset wealth index, the cultivated land area, the total livestock as measured by the Tropical Livestock Unit (TLU), and a dummy equal to 1 if irrigation occurs with a water pump, to account for household agricultural activities. We add a dummy equal to one if the household received any credit in the last 12 months, and the distances from the nearest population centre, from primary schools and from the nearest weekly market, to control for market and services' access. Lastly, we account for village- and community-related factors, by including three dummies, respectively equal to one if the community is provided with an extension service, if there exists collective action within the community, and if the PSNP has ever been implemented in the Kebele in the past.

The complete descriptive statistics by a round of data collection and participation in the public work programme of the PSNP have been reported in Annex 1. In line with the programme's target criteria, women-headed households, historically recognized as a vulnerable group (Government of the Federal Democratic Republic of Ethiopia - Ministry of Agriculture, 2014), are overrepresented among the programme beneficiaries. Public work participants are the poorest in terms of physical assets (agricultural assets and livestock) and human capital (proxied by the household size), although the share of household members of working age, used as a proxy of the able-bodied members in the household, is significantly higher as compared to non-participants. There are no substantial differences between households participating and not participating in the PSNP in terms of self-reported food insecurity. However, in terms of agricultural distresses, the percentage of households experiencing harvest losses due to other shocks in 2010 and droughts in 2013 is slightly higher for non-beneficiaries. Moreover, in 2010 and 2013, households not participating in the PSNP were more likely to report complete crop failure due to other shocks.

⁵ Rainfall data for each decade (ten days) interval are extracted from the CHIRPS database over the period 1989–2015. CHIRPS incorporates CHPclim, 0.05° resolution satellite imagery (~ 5 km), and in-situ station data to create gridded rainfall time series for trend analysis and seasonal drought monitoring. Information on temperature has been extracted merging data from two database delivered by the ECMWF. As a result, the dataset contains decadal observations on average, maximum and minimum temperature at a resolution of 0.25° (~ 27 km) over the period 1989–2015.

5 Econometric framework

The aim of this paper is to estimate the causal impact of the participation in the public work component of PSNP on beneficiaries' adaptive capacity and food security in the aftermath of a shock. The main empirical challenge in doing so is controlling for all the possible confounding factors. We take advantage of the panel structure of the data, which allows us to control for unobserved time invariant heterogeneity within the household (household fixed-effects) as well as for covariant unobserved heterogeneity across each of the three years considered (time fixed-effects). As aforementioned, we also rely on a rich set of household time-varying control variables that may influence our outcomes. These controls include variables related to household sociodemographic characteristics, assets holding, local infrastructure and services, access to financial markets and exposure to climate shocks.

However, since the PSNP targets the most vulnerable within the community and the selection of the beneficiaries is done according to a set of minimum requirements upon the community council's decision, we cannot rule out the hypothesis that some non-covariant time varying factors could affect both the selection into the treatment and the outcomes considered (selection bias). Therefore, to identify the unbiased treatment effect of the programme, we need to deal also with the sources of endogeneity as explained in what follows.

5.1 Identification strategy

The most suitable way to control for the unobserved time invariant heterogeneity in a quasi-experimental setting is to employ an instrumental variable approach. A suitable instrument is correlated with the endogenous treatment variables (relevance), but does not directly affect the outcome variable considered, i.e. it is not correlated with the error term of the outcome equation model conditionally on the other covariates (validity). If this condition is met, the instrument satisfies the exclusion restriction.

To find a suitable instrument in our research setting, we rely on the information on the programme implementation mechanisms and the related flaws. Indeed, the fact that this study focuses on the household outcomes in the aftermath of shocks excludes the risk of exposure to weather hazards based on granular information on precipitation and temperature from the possible set of instruments. We have rather used a variable identifying precipitation and temperature anomalies as an additional control to relax the concern about self-reported shocks. Furthermore, we have used this information to check if the self-reported outcomes are coherent with the objective geographic location of the occurrence of weather-related shocks (see Annex 2).

Therefore, in order to deal with potential endogeneity, according to Knippenberg and Hoddinott (2017), our analysis relies on the construction of the instruments through the leave-out mean aggregations at the district (*woreda*) level of community (*kebele*) characteristics. These instruments, also known as Hausman instruments,⁶ are computed as:

$$Z_{jt} = \frac{\sum_{i=1}^K Z_{itjk} - \sum_{i=1}^J Z_{itjk}}{|K| - |J|} \quad (1)$$

⁶ This identification strategy has been proposed by Hausman, Leonard and Douglas (1994) so these kind of exclusion restrictions have been named after the author.

where Z is the Hausman instrument associated with the household i at the time t residing in the *woreda* K and the *kebele* J .

Such an instrumental variable approach, if valid, allows to control for the endogeneity due to the correlation between beneficiaries' unobservables and the PSNP targeting criteria characterizing the community-level (*kebele*) programme implementation. However, to relax the concerns about the exclusion restrictions' validity, the information is aggregated at a higher level compared to the unit of analysis so to not directly affect the outcomes variables conditional on all the other observed characteristics. To approximate a random assignment of the instrument, this study takes advantage of the flaws in the graduation process characterizing the PSNP implementation in the considered period. In fact, as highlighted by several quantitative and qualitative studies (e.g. Burns, 2014; Sabates-Wheeler *et al.*, 2021), most of the households have been involuntary or prematurely "graduated out" of the programme as the result of the quotas imposed on field staff for reasons not linked to the beneficiaries' livelihood and vulnerability conditions. Given that, we assume that the leave-out mean of the shares of households "graduated-out" of the programme at the time of the interview in each district is not correlated with the beneficiaries' unobservables. Nonetheless, the relevance of the instrument is justified by the fact that, as the number of people graduated-out from the PSNP increases, the probability of participating to the programme is expected to decrease as the limited resources at the national level are re-allocated to the districts (*woredas*) more in need.

A similar approach has been employed when testing the indirect treatment effects on the beneficiaries' peers. In this case, we have created a dichotomous variable identifying households living in *kebele* and hosting at least one PSNP beneficiary. This variable has been then instrumented with the district leave-out mean of communities listing the PSNP as an important event that took place in the *kebele* in the previous two years that made people better off. The validity of such an instrument relies on the fact that the successful implementation of the programme within the district (*woreda*) during the years preceding the interview is expected to be related to district characteristics that are plausibly unrelated to the current peers' unobservables. Moreover, the instrument is expected to be correlated with the probability of living in a community hosting one PSNP beneficiary (relevance), although the direction of the empirical link could be either positive (if it reflects the penetration of the programme in the district) or negative (if an increased share of *kebeles* benefitting of the PSNP elsewhere in the *woreda* implies decreased resource availability in the considered *kebele*).

5.2 Estimation procedure

Once the suitable instruments have been identified, the model is estimated in a linear fashion using a two-step IV estimation procedure (Cerulli, 2014; Wooldridge, 2010). The model consists in estimating a binary response model via maximum likelihood for the treatment in the first step and then using the nonlinear fitted probabilities as alternative instruments for the binary endogenous explanatory variables. Such a probit (logit)-two stage least squares (2SLS) approach allows the treatment probability to vary non-linearly with all the other explanatory variables X_{it} included in the outcome equation, and the instruments Z_{jt} . Assuming that the community utility function deriving from the participation of a specific household in the PSNP is a latent variable, equation (2) describes the selection as follows:

$$D_i = \begin{cases} 1 & \text{if } D_i^* \geq 0 \\ 0 & \text{if } D_i^* < 0 \end{cases} \quad (2)$$

where D_i is the observed dichotomous treatment indicator (PSNP participation) and D_i^* is the community latent utility determined by the selection of the treated household.

Given the binary nature of the treatment D_i , the orthogonal projection of the vector \mathbf{D} in the vector space generated by the exogenous variables $(\mathbf{X}_{it}, \mathbf{Z}_{jt})$ is equivalent to the propensity score (equation 3a):

$$E(\mathbf{D}|x, z) = p(\mathbf{D} = 1|x, z) \quad (3a)$$

Therefore, assuming that the error term of the selection equation is standard normally distributed, estimating the probability of receiving the treatment through a probit estimator⁷ allows for efficiency gains relatively to the traditional 2SLS estimator.⁸ Furthermore, Wooldridge (2010) claims that this procedure has a desired robustness property as the equation (3a) does not need to be correctly specified. Also, to account for possible correlation between unobserved heterogeneity and explanatory variables, we use the Mundlak (1978) device such that equation (3a) becomes:

$$E(\mathbf{D}|x, z) = p(\mathbf{D} = 1|x, \bar{x}, z, \bar{z}) \quad (3b)$$

The combination of the Mundlak device and the pooled maximum likelihood estimation allows to obtain estimators robust to general forms of dynamic misspecification. In fact, although in binary models, controlling for the unobserved time invariant heterogeneity through a Mundlak device is not equivalent to time demeaning, the method provides a strong analogy with the fixed effect estimation. In fact, the estimated β comes from the deviations of x_{it} from its individual time mean, as \bar{x} and \bar{z} are included among controls (Semykina and Wooldridge, 2010, 2018).

The resulting estimated probabilities from the probit model, p_D , are subsequently used as instruments for the following structural model estimated through a 2SLS:

$$\begin{cases} Y_{it} = a_t + \tau \bar{\mathbf{X}}_t + \beta_0 + \beta_1 \hat{D}_{it} + \beta_2 \mathbf{X}_{it} + \epsilon_{1it} \\ D_{it} = a_t + \tau \bar{\mathbf{X}}_t + \beta_0 + \beta_1 P_{Dit} + \beta_2 \mathbf{X}_{it} + \epsilon_{2it} \end{cases} \quad (4)$$

where Y_{it} is the outcome variable; D_{it} is the endogenous binary treatment; \hat{D}_{it} is the predicted linear probability from the first stage; P_{Dit} is the excluded instrument from the equation (3b); \mathbf{X}_{ijt} is the vector of exogenous controls; a_t captures the time fixed effects; $\bar{\mathbf{X}}_t$ is the vector of the group-means of the control variables (the Mundlak device) which allow to capture the household time invariant unobserved heterogeneity;⁹ ϵ_{1it} and ϵ_{2it} are the errors terms. The estimated confidence intervals (CI) have been bootstrapped with 200 repetitions and clustered at the household level to improve the precision of asymptotic approximations in small samples. This is particularly important in our research framework because our treatment group (PSNP participants) is quite small as compared to the rest of the population, and as a consequence,

⁷ The logit follows similar argument (Cerulli, 2014).

⁸ (Cerulli, 2014) shows that among all the projections of D on the (x, z) subspace, the orthogonal one produces the “smallest” projection error.

⁹ The Mundlak device, also known as the correlated random effects approach (Chamberlain, 1980, 1982), is similar in spirit to the fixed-effects estimation in the case of linear models (Semykina and Wooldridge, 2018). Indeed, modelling the household time invariant heterogeneity in a linear model or augmenting the main equation by $\bar{\mathbf{X}}_t$ and estimating it by ordinary least squares would produce β that would be identical to fixed-effects estimates (Mundlak, 1978).

the usual asymptotic approximation assumptions may not hold and the linear estimator, though unbiased, may no longer be consistent (Conley and Taber, 2011).

Finally, this structural model has also been used to control for the indirect treatment effect on beneficiaries' peers by including another dichotomous endogenous variable capturing the presence of at least one beneficiary in the community. In line with the baseline model, also in this case, the nonlinear fitted probabilities from a maximum likelihood estimator augmented with a Mundlak device have been used as an exogenous instrument to control for the potential endogeneity of the additional endogenous variable.

6 Empirical results

6.1 Impact of PSNP on beneficiaries' vulnerability to shocks

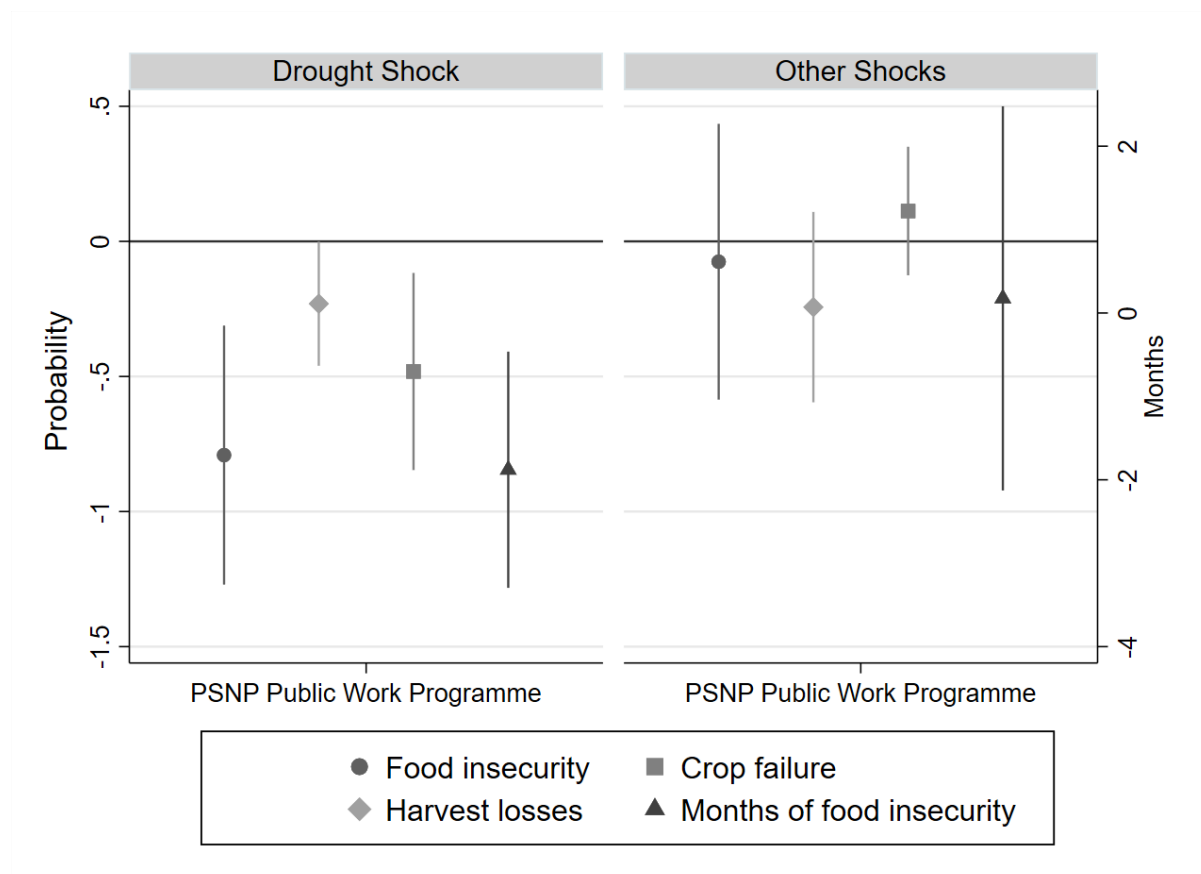
This study identifies the causal effect of the public work component of the PSNP on the beneficiaries' adaptive capacity to different shocks. We expect that households may respond in a different way to various shocks as performed public works will directly or indirectly affect their capacity to deal with specific risks. To consider this potential heterogeneity, we have distinguished households who have self-reported crop losses and food insecurity due to drought from households who self-reported crop losses and food insecurity due to other types of shocks.

The results (Figure 1) show that households participating in the PSNP are 79 percent less likely to experience food insecurity due to droughts and are food insecure for a relatively shorter time period (-1.9 months shorter, on average) as compared to the households not participating to the programme. Moreover, PSNP beneficiaries are 23 percent less likely to experience crop losses and 48 percent less likely to experience complete crop failure due to a drought.¹⁰ This is in line with previous evidence by Knippenberg and Hoddinott (2017), which estimates a reduction of about 57 percent in the beneficiaries' food insecurity in the aftermath of a drought episode.

Furthermore, no significant impacts of PSNS on households who have faced distress associated with other shocks (such as fire, pests, insects, wild animals, thefts, shortage of farm inputs, and prices) have been found. These findings suggest the existence of other channels, besides the income effect, from which PSNP participants benefit from the programme. For example, the skills and knowledge acquired through the programme may favour the replication of the risk management strategies learnt through (such as building soil and water conservation structures) in the beneficiaries' own fields.

¹⁰ Complete results from the models with and without IV are available in Annex 2.

Figure 1. Impact of PWP-PSNP by type of shock



Note: Probability of food insecurity, harvest losses and crop failure (left axis) months of food insecurity (right axis).

Source: Authors' elaboration based on estimated results.

6.2 Controlling for impacts on community peers

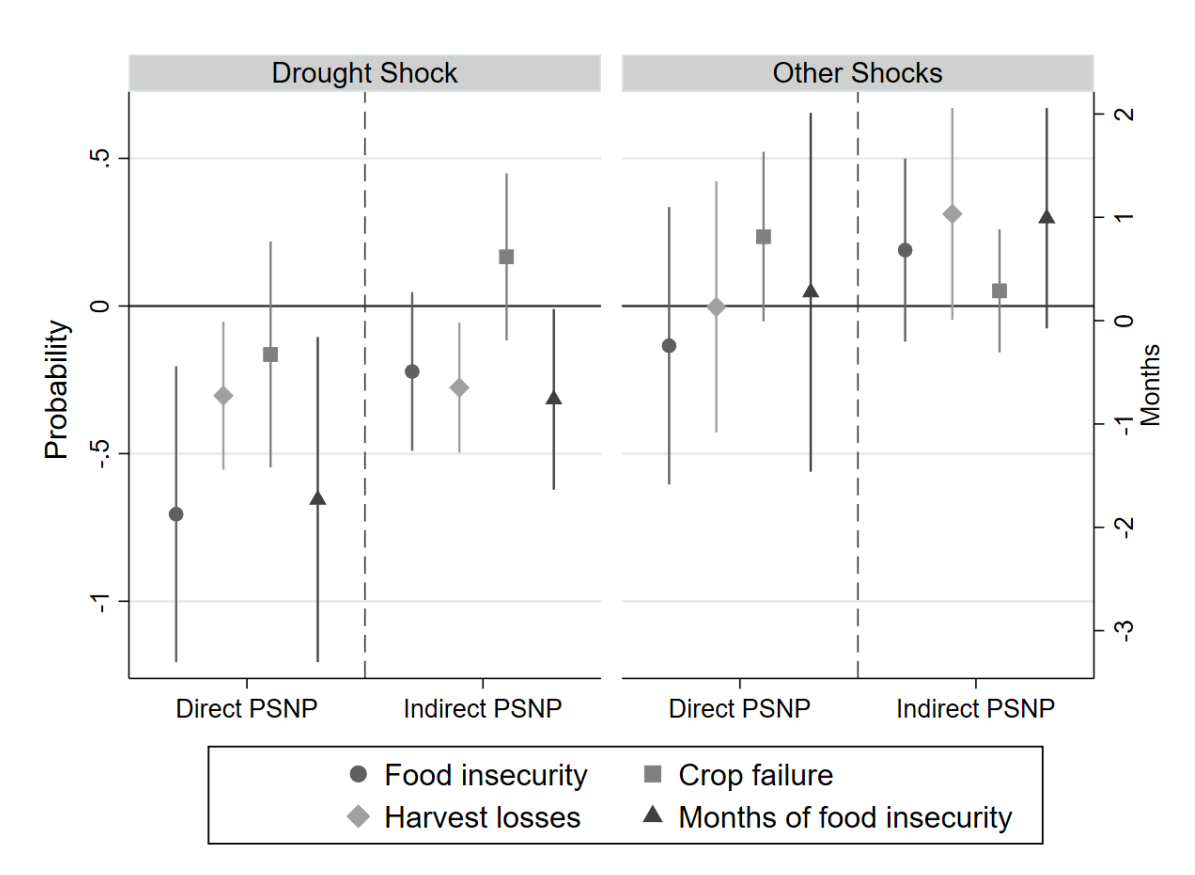
The interpretation of the results from the previous section suggests that the lower vulnerability of the PSNP beneficiaries to drought shocks may indirectly also benefit their community peers. In fact, the public work implemented through the programme consists in building infrastructure, which may lower the vulnerability to extreme dry episodes of the entire community. Testing the existence of an indirect impact on community peers is particularly important as one of the objectives of the programme is to build resilience at the community level. Furthermore, if the spillovers are detected, the possibility that the programme allowed a transfer of skills and knowledge that the beneficiaries applied in their own field would be further supported.

The empirical results confirm that PSNP partially reduces the vulnerability to droughts of the beneficiaries' community peers who are not directly involved in the public work programme (Figure 2).¹¹ Although they are not less likely to experience food insecurity in the aftermath of drought relatively to non-beneficiaries peers, the length of the period of deprivation is significantly lower (-0.76 months) and they are also 28 percent less likely to experience harvest losses in case of extreme dry events. Consistently, the indirect impact of the PSNP on the community peers is negligible when the distresses are not related to droughts.

¹¹ Complete results from the models with and without IV are available in Annex 3.

It is worth noting that the indirect impact on the peers does not crowd out the direct effect on the PSNP beneficiaries in case of drought. In fact, also after controlling for the indirect impact on the community peers, the PSNP participants are less likely to experience food insecurity (-70 percent) or to experience it for a shorter period (-1.7 months shorter, on average) in the aftermath of droughts compared to non-beneficiaries. Beneficiaries are also about 30 percent less likely to experience crop losses, although the probability of experiencing complete crop failures turns out to be not statistically different from zero but preserving the negative sign. Coherently with all the previous results, also, in this case, no direct impact associated with the PSNP participation has been detected when the household reported distresses due to other shocks.

Figure 2. Direct and Indirect impact of PSNP by type of shock



Note: Probability of food insecurity, harvest losses and crop failure (left axis) months of food insecurity (right axis).

Source: Authors' elaboration based on estimated results.

7 Policy implications

The results from this analysis call attention to several relevant policy implications that, although based on the evaluation of the Ethiopian PSNP, may provide indications for the development of adaptive social protection interventions in other countries characterized by extended areas of rural poverty and highly exposed to the risk of weather shocks.

First, social protection programmes can be effectively leveraged to increase the adaptive capacities of the beneficiaries to climate shocks. This is possible by incentivizing the adoption of climate-risk-reducing management practices, by relaxing budget constraints, and by stimulating the transfer of skills and knowledge. In a context of limited resources, combining programmes dedicated to poverty relief and vulnerability-to-climate reduction can be particularly important to optimize resources and maximize results.

Second, increasing the synergies between different programmes as well as implementing institutions could help to magnify the coverage of these programmes without necessarily increasing the resource budget dramatically.

Third, the effectiveness of adaptive social protection programmes may vary under different types of shocks and across multiple outcomes, including poverty reduction, food security and adaptive capacity. In the case of PSNP, the programme has been found to reduce vulnerability specifically to droughts, and not to other types of shocks, most probably because the public works implemented through the programme are very much focused on enhancing adaptation to climate shocks. The specificity of the programme is important to consider when one designs adaptive measures and identifies expected outputs.

Fourth, strengthening the markets for credit and insurance remains crucial to reduce the vulnerability to other not covariant shocks which are not directly linked to the public work implemented. That is true, particularly in rural contexts, where these markets are still missing or incomplete.

Lastly, the fact that the PSNP public work generates positive spillover effects to the beneficiaries' community peers indicates that similar activities should be promoted at the community level. Reducing the vulnerability to climate shocks and increasing the systemic resilience to these extreme events is a common goal of the communities, the governments, and the stakeholders involved throughout the agrifood systems.

8 Conclusions

Ethiopia's Productive Safety Net Programme (PSNP) was launched in 2005, with the objective of improving food security and reducing the vulnerability of the target beneficiaries through public works, cash transfers, and nutritional feeding programmes. This study contributes to the existing literature on the impact of the PSNP by focusing on the public work component of the programme, which, in our view, is more strongly linked to the reduction of the vulnerability to extreme weather events and the strengthening of climate resilience. As the labour-intensive works, promoted through the programme, are based on the construction of integrated community-based watershed development, mainly related to soil and water conservation measures, this analysis has considered the agricultural and food security response of beneficiaries and their communities to the shocks with particular attention to droughts. Differently from previous studies that have evaluated the impact of the programme using primary information collected for this purpose (that is not openly accessible), this work has taken advantage of three waves of a national representative multipurpose survey collected by the World Bank in collaboration with Central Statistics Agency of Ethiopia. Using such a dataset increases the empirical challenges of retrieving the causal effect of the programme, but it has clear advantages: (a) our empirical findings are replicable as the dataset can be freely accessed through the World Bank website; (b) the presence of the agricultural module allows to test the existence of the effect of PSNP on the pathways from the agricultural outcomes to the food security of beneficiaries and community peers.

The PSNP programme has been updated and modified multiple times since its launch. The period covered by this study overlaps with the third phase of the PSNP. The fourth and fifth phases of the PSNP were launched, respectively, in mid-2015¹² and 2021, with important reforms drawn on the lessons learnt from the past.¹³ Estimating the impact of the programme innovations will be a fruitful area of research over the next years when panel data covering will be available.¹⁴

Despite the programme reforms, the findings from this study are still expected to significantly contribute to the lively debate about its effectiveness. Our results point out that the reduction of the beneficiaries' vulnerability to droughts, as well as that of their community peers, is a crucial dimension that policy makers, researchers and donors must carefully consider. Moreover, from a policy point of view, this study suggests that there is scope to link, even more explicitly than what has already been done, the social protection interventions to the climate adaptation objectives in Ethiopia. Beyond the specific case study, our findings may reinforce the quantitative evidence on the benefits related to integrating environment and climate change mitigation and adaptation strategies in the formulation and the implementation of social protection programmes in countries characterized by extended areas of rural poverty and highly exposed to the risk of weather shocks.

¹² However, the first changes in the programme implementation have been realized since 2016.

¹³ The PSNP-IV explicitly considers nutrition security aspects and improvements of environmental and disaster risk management strategies, among the objectives. The latest programme implementation phase, PSNP-V, is characterized by adjustments to the programme targeting (with a focus on the extra poor) a broader geographic coverage as well as a new methodology for client recertification and programme exit.

¹⁴ The 2018/2019 ESS available since January 2021 is a new panel based on a refreshed sample.

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Annex 1

Table A1. Descriptive statistics of the variable by PSNP Participation and survey year

	2011					2013					2015				
	NO PSNP		PSNP		DIFF.	NO PSNP		PSNP		DIFF.	NO PSNP		PSNP		DIFF.
	Mean	Obs.	Mean	Obs.		Mean	Obs.	Mean	Obs.		Mean	Obs.	Mean	Obs.	
Food insecurity drought	0.09	3 523	0.10	51	0.005	0.08	3 603	0.09	33	-0.012	0.14	3 618	0.25	21	-0.119
Months of food insecurity drought	0.26	3 523	0.20	51	0.060	0.23	3 603	0.41	33	-0.178	0.49	3 618	0.64	21	-0.150
Harvest losses drought	0.02	3 523	0.02	51	0.000	0.03	3 603	0.00	33	0.031***	0.12	3 618	0.10	21	0.015
Crop failure drought	0.02	3 523	0.05	51	-0.031	0.06	3 603	0.18	33	-0.123	0.24	3 618	0.39	21	-0.155
Food insecurity other shocks	0.22	3 523	0.24	51	-0.020	0.24	3 603	0.28	33	-0.036	0.15	3 618	0.06	21	0.089
Months of food insecurity other shocks	0.59	3 523	0.90	51	-0.307	0.67	3 603	0.69	33	-0.018	0.41	3 618	0.19	21	0.221
Harvest losses other shocks	0.08	3 523	0.00	51	0.080***	0.19	3 603	0.09	33	0.099	0.18	3 618	0.12	21	0.054
Crop failure other shocks	0.06	3 523	0.00	51	0.059***	0.20	3 603	0.00	33	0.201***	0.10	3 618	0.06	21	0.036
HH Head is female	0.21	3 523	0.41	51	-0.196***	0.22	3 603	0.42	33	-0.200	0.23	3 618	0.72	21	-0.491***
HH Head age	44.74	3 523	37.56	51	7.181***	46.12	3 603	38.08	33	8.041*	47.72	3 618	47.20	21	0.517
HH size	5.22	3 523	3.23	51	1.995***	5.24	3 603	2.79	33	2.447***	5.19	3 615	2.30	21	2.898***
Share of HH members in working age	0.49	3 523	0.62	51	-0.138***	0.48	3 603	0.66	33	-0.178***	0.49	3 615	0.51	21	-0.022
Avg. educ. of members in working age	2.39	3 523	1.50	51	0.885***	2.62	3 603	2.17	33	0.451	2.73	3 618	2.05	21	0.676
Health problem during last 12 months	0.51	3 523	0.34	51	0.172**	0.53	3 603	0.36	33	0.167	0.28	3 618	0.10	21	0.179***
Total livestock in TLU	2.26	3 523	0.89	51	1.366***	2.59	3 603	0.95	33	1.644***	2.34	3 618	0.65	21	1.694***
Ag asset wealth index normalized	0.24	3 523	0.20	51	0.049*	0.23	3 603	0.13	33	0.107***	0.23	3 618	0.18	21	0.048
Total land cultivated area (GPS acres)	3.57	3 523	2.74	51	0.829	3.32	3 603	1.25	33	2.073***	3.17	3 618	0.57	21	2.599***
Irrigation with water pump	0.03	3 523	0.00	51	0.025***	0.02	3 603	0.01	33	0.011	0.01	3 618	0.00	21	0.013***
HH received credit	0.29	3 523	0.12	51	0.163***	0.32	3 603	0.40	33	-0.082	0.25	3 618	0.15	21	0.100
Dist. from nearest populated centre	35.85	3 523	43.26	51	-7.412	36.60	3 603	60.96	33	-24.362	37.16	3 618	27.25	21	9.910**
Dist. from primary school	1.14	3 523	0.06	51	1.088***	1.39	3 603	0.78	33	0.605	0.81	3 618	0.45	21	0.365
Dist. from nearest weekly market	5.63	3 523	10.81	51	-5.172*	5.36	3 603	8.36	33	-3.004	7.53	3 618	4.70	21	2.826
Extension service within the community	0.91	3 523	0.98	51	-0.068***	0.90	3 603	0.98	33	-0.081***	0.91	3 618	0.96	21	-0.051
Collective action within the community	0.46	3 523	0.69	51	-0.223*	0.55	3 603	0.57	33	-0.024	0.00	3 618	0.00	21	0.000***
PSNP implemented in the Kebele	0.36	3 523	0.98	51	-0.616***	0.33	3 580	0.80	33	-0.466***	0.36	3 618	1.00	21	-0.645
SPEI<=-1.5	0.01	3 523	0.00	51	0.007	0.00	3 603	0.00	33	0.002	0.50	3 618	0.65	21	-0.151

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' elaboration based on estimated results.

Annex 2

Table A2. Probit and IV-first stage – direct effects of PSNP

	(1) Probit PSNP	(2) 1 st Stage Regression PSNP
Share of graduated in the <i>Woreda</i> (leave-out mean)	-0.0061**	-
Household level predicted probability to participate to the PSNP	-	0.733***
Household (HH) head is female	0.2866	0.004
HH head age	-0.0159*	-0.000
HH size	-0.2497***	-0.000
Share of HH members in working age	-0.0583	0.005
Avg. educ. of members in working age	0.0290	0.000
Health problem during last 12 months	-0.1004	0.000
Total livestock in TLU	-0.0832	0.000
Agr. asset wealth index, normalized	0.5245	-0.006
Total land cultivated area (GPS acres)	-0.1483**	-0.000
Irrigation with water pump	-0.3165	-0.002
HH received credit	-0.0704	-0.002
Dist. from nearest populated centre (in log)	0.0056	-0.003
Dist. from primary school (in log)	-0.0497	-0.002
Dist. from nearest weekly market (in log)	0.0091	-0.000
Extension service within the community	0.3274	0.004
Collective action within the community	0.3036**	0.005*
PSNP ever implemented in the Kebele	-0.0679	-0.009
year_2011	0.1566	0.000
year_2013	-0.0296	-0.002
SPEI<=-1.5	-0.1846	-0.000
Mundlak HH head is female	-0.1032	-0.005
Mundlak HH head age	-0.0022	-0.000
Mundlak HH size	0.0776	-0.001
Mundlak share of HH members in working age	0.2732	-0.001
Mundlak avg. educ. of members in working age	-0.0682**	-0.001
Mundlak health problem during last 12 months	-0.0710	-0.002
Mundlak total livestock in TLU	0.0605	0.002
Mundlak Ag asset wealth index, normalized	-0.4461	0.005
Mundlak total land cultivated area (GPS acres)	-0.1586	0.002
Mundlak irrigation with water pump	0.6106	0.014
Mundlak HH received credit	0.1859	-0.003
Mundlak dist. from nearest populated centre (in log)	-0.0562	0.004
Mundlak dist. from primary school (in log)	0.0069	-0.001
Mundlak dist. from nearest weekly market (in log)	0.0209	-0.001
Mundlak extension Service within the community	-0.7511***	-0.016***
Mundlak collective action within the community	-0.3443	-0.000
Mundlak PSNP ever implemented in the Kebele	1.3536***	0.020***
Mundlak leave-out mean PSNP	0.0037	-0.000
Mundlak SPEI<=-1.5	0.9222**	-0.010
Constant	-1.2099***	0.017*
Observations	10 823	10 813

Notes: Probit (col.1); IV first stage (col.2). Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' elaboration based on estimated results.

Table A3. IV-second stage – direct effects of PSNP on households' stressors due to droughts

	(1) Food insecurity	(2) Months of food insecurity	(3) Harvest losses	(4) Crop failure
PSNP	-0.791***	-1.879***	-0.231**	-0.482***
HH head is female	-0.012	-0.062	0.021*	-0.019
HH head age	-0.000	0.000	0.001	0.000
HH size	0.012**	0.033*	0.008**	0.003
Share of HH members in working age	0.038*	0.176**	0.011	-0.020
Avg. educ. of members in working age	-0.002	-0.012	0.002	0.001
Health problem during last 12 months	0.025***	0.064**	-0.004	0.000
Total livestock in TLU	-0.013	-0.030	0.003	0.013
Agr. asset wealth index, normalized	-0.034	-0.236*	-0.035	-0.027
Total land cultivated area (GPS acres)	0.000	-0.002	0.017***	0.037***
Irrigation with water pump	0.018	0.035	0.029**	0.011
HH received credit	0.019*	0.022	0.014*	0.010
Dist. from nearest populated centre (in log)	0.019	-0.022	-0.001	0.004
Dist. from primary school (in log)	-0.008	-0.039*	0.002	-0.012**
Dist. from nearest weekly market (in log)	-0.005	-0.006	-0.007***	-0.010***
Extension service within the community	-0.023*	-0.205***	-0.005	-0.021
Collective action within the community	0.029***	0.073**	0.017***	0.002
PSNP ever implemented in the Kebele	-0.043**	-0.117*	-0.056***	-0.041**
year_2011	-0.022**	-0.020	-0.051***	-0.135***
year_2013	-0.048***	-0.104***	-0.047***	-0.089***
SPEI<=-1.5	0.087***	0.470***	0.104***	0.190***
Mundlak HH head is female	0.025	0.118	-0.028**	0.012
Mundlak HH head age	0.001	0.003	-0.001*	-0.000
Mundlak HH size	-0.013**	-0.028	-0.006	0.000
Mundlak share of HH members in working age	-0.053**	-0.260**	0.007	0.037
Mundlak avg. educ. of members in working age	-0.005*	-0.010	-0.004**	-0.007***
Mundlak health problem during last 12 months	-0.030**	-0.048	0.007	0.017
Mundlak total livestock in TLU	0.069***	0.204***	-0.007	0.017
Mundlak agr. asset wealth index, normalized	-0.126**	-0.382**	0.133***	0.052
Mundlak total land cultivated area (GPS acres)	-0.039***	-0.092***	-0.012**	-0.017**
Mundlak irrigation with water pump	0.006	-0.031	-0.053**	0.036
Mundlak HH received credit	0.014	0.069	0.008	0.006
Mundlak dist. from nearest populated centre (in log)	-0.009	0.037	0.002	-0.030**
Mundlak dist. from primary school (in log)	0.005	0.056	0.006	0.014
Mundlak dist. from nearest weekly market (in log)	0.019***	0.028	0.011***	0.019***
Mundlak extension Service within the community	0.058***	0.308***	0.019	-0.025
Mundlak collective action within the community	-0.019	0.025	-0.049***	-0.023
Mundlak PSNP ever implemented in the Kebele	0.220***	0.706***	0.103***	0.198***
Mundlak leave-out mean PSNP	-0.002***	-0.008***	0.000	-0.001***
Mundlak SPEI<=-1.5	-0.099***	-0.254***	-0.011	-0.008
Constant	0.024	-0.027	0.008	0.169***
Observations	10 823	10 823	10 823	10 823

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' elaboration based on estimated results.

Annex 3

Table A4. IV-second stage – direct effects of PSNP on households' stressors due to other shocks

	(1) Food insecurity	(2) Months of food insecurity	(3) Harvest losses	(4) Crop failure
PSNP	-0.075	0.175	-0.243	0.112
HH head is female	0.052**	0.225***	0.007	-0.012
HH head age	0.001	0.004	-0.001	0.001
HH size	0.002	-0.001	0.003	-0.005
Share of HH members in working age	-0.065**	-0.123	-0.023	-0.014
Avg. educ. of members in working age	-0.004	-0.015*	-0.001	-0.002
Health problem during last 12 months	0.012	0.046*	0.006	0.013*
Total livestock in TLU	-0.002	-0.021	0.032***	0.006
Agr. asset wealth index, normalized	-0.014	-0.120	-0.060	-0.004
Total land cultivated area (GPS acres)	0.010	0.014	0.012**	0.013***
Irrigation with water pump	-0.005	0.018	-0.012	0.025
HH received credit	0.048***	0.153***	-0.000	0.010
Dist. from nearest populated centre (in log)	0.017	0.071	-0.003	-0.002
Dist. from primary school (in log)	-0.002	0.014	0.002	0.010*
Dist. from nearest weekly market (in log)	0.007*	0.042***	-0.013***	0.004
Extension service within the community	0.058***	0.188***	0.001	-0.013
Collective action within the community	0.023**	0.056*	-0.021**	0.010
PSNP ever implemented in the Kebele	-0.036*	-0.118*	-0.018	0.017
year_2011	0.009	0.031	-0.136***	-0.078***
year_2013	0.066***	0.202***	-0.002	0.040***
SPEI<=-1.5	-0.048***	-0.120***	-0.054***	-0.056***
Mundlak HH head is female	-0.012	-0.057	-0.002	0.013
Mundlak HH head age	0.000	-0.000	0.000	-0.000
Mundlak HH size	0.007	0.029	0.003	0.003
Mundlak share of HH members in working age	0.086**	0.249**	0.041	0.008
Mundlak avg. educ. of members in working age	-0.011***	-0.031***	-0.001	0.002
Mundlak health problem during last 12 months	0.026	0.054	0.018	0.002
Mundlak total livestock in TLU	-0.090***	-0.258***	-0.022*	-0.004
Mundlak agr. asset wealth index, normalized	-0.072	-0.333*	0.246***	0.229***
Mundlak total land cultivated area (GPS acres)	-0.029***	-0.056	-0.010	-0.001
Mundlak irrigation with water pump	-0.113***	-0.420***	0.005	-0.075**
Mundlak HH received credit	0.062***	0.116**	-0.007	0.025*
Mundlak dist. from nearest populated centre (in log)	-0.031	-0.118	-0.027	0.004
Mundlak dist. from primary school (in log)	0.041***	0.075*	0.005	-0.013
Mundlak dist. from nearest weekly market (in log)	-0.014***	-0.076***	0.020***	-0.013***
Mundlak extension Service within the community	-0.014	-0.094	0.004	0.029*
Mundlak collective action within the community	-0.022	0.022	0.017	-0.005
Mundlak PSNP ever implemented in the Kebele	0.012	0.096	0.057***	-0.075***
Mundlak leave-out mean PSNP	0.000	-0.001	0.000	0.001***
Mundlak SPEI<=-1.5	-0.098***	-0.262**	-0.079***	0.023
Constant	0.208***	0.568***	0.206***	0.042*
Observations	10 823	10 823	10 823	10 823

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' elaboration based on estimated results.

Table A5. Probit and IV first stage – direct and indirect effects of PSNP

	(1)	(2)	(3)
	Probit PSNP	Probit PSNP in the <i>Kebele</i>	1 st Stage PSNP
Share of graduated in the <i>Woreda</i> (leave-out mean)	-0.0061**	-	-
Share of better-off communities in the <i>Woreda</i> because of PSNP (leave out mean)	-	0.2638***	-
Household level predicted probability to participate to the PSNP	-	-	0.769***
<i>Kebele</i> level predicted probability to be selected for PSNP	-	-	0.133***
HH head is female	0.2866	-0.0616	0.006
HH head age	-0.0159*	0.0006	-0.000
HH size	-0.2497***	0.0250*	-0.001
Share of HH members in working age	-0.0583	0.0427	0.003
Avg. educ. of members in working age	0.0290	-0.0048	0.000
Health problem during last 12 months	-0.1004	-0.0203	0.001
Total livestock in TLU	-0.0832	0.0827***	-0.003
Agr. asset wealth index, normalized	0.5245	0.1717	-0.011
Total land cultivated area (GPS acres)	-0.1483**	-0.0264	0.002
Irrigation with water pump	-0.3165	0.0543	-0.002
HH received credit	-0.0704	0.0463	-0.004
Dist. from nearest populated centre (in log)	0.0056	0.1217***	-0.006
Dist. from primary school (in log)	-0.0497	0.0021	-0.002
Dist. from nearest weekly market (in log)	0.0091	-0.0025	0.000
Extension service within the community	0.3274	0.0515	0.001
Collective action within the community	0.3036**	0.1413***	-0.002
year_2011	0.1566	0.4501***	-0.020***
year_2013	-0.0296	0.3109***	-0.017***
SPEI<=-1.5	-0.1846	-0.2018***	0.007*
Mundlak HH head is female	-0.1032	0.0433	-0.006
Mundlak HH head age	-0.0022	-0.0010	0.000
Mundlak HH size	0.0776	-0.0353**	0.001
Mundlak share of HH members in working age	0.2732	-0.1222	0.004
Mundlak avg. educ. of members in working age	-0.0682**	0.0541***	-0.003***
Mundlak health problem during last 12 months	-0.0710	0.2506***	-0.011**
Mundlak total livestock in TLU	0.0605	-0.2186***	0.011***
Mundlak agr. asset wealth index, normalized	-0.4461	-0.1112	-0.000
Mundlak total land cultivated area (GPS acres)	-0.1586	-0.0308	0.002
Mundlak irrigation with water pump	0.6106	1.0246***	-0.015
Mundlak HH received credit	0.1859	-0.0127	-0.003
Mundlak dist. from nearest populated centre (in log)	-0.0562	-0.0051	0.002
Mundlak dist. from primary school (in log)	0.0069	-0.2624***	0.010**
Mundlak dist. from nearest weekly market (in log)	0.0209	-0.1533***	0.006***
Mundlak extension Service within the community	-0.7511***	-0.2001**	-0.008
Mundlak collective action within the community	-0.3443	-0.0050	0.001
Mundlak leave-out mean PSNP	0.0037	-0.0065***	0.000***
Mundlak SPEI<=-1.5	0.9222**	0.9147***	-0.042***
Constant	-1.2099***	0.2058	-0.063***
Observations	10 823	10 914	10 833

Notes: Probit (col.1–2); IV first stage (col.3). Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' elaboration based on estimated results.

Table A6. Second stage – direct and indirect effects of PSNP on households’ stressors due to droughts

	(1) Food insecurity	(2) Months of food insecurity	(3) Harvest losses	(4) Crop failure
PSNP	-0.705***	-1.732**	-0.304**	-0.164
PSNP in the <i>Kebele</i>	-0.222	-0.762*	-0.276**	0.167
HH head is female	-0.016	-0.075	0.019	-0.017
HH head age	-0.000	0.000	0.001	0.000
HH size	0.014***	0.039*	0.009**	0.002
Share of HH members in working age	0.042**	0.192**	0.017	-0.021
Avg. educ. of members in working age	-0.003	-0.012	0.001	0.001
Health problem during last 12 months	0.024***	0.060**	-0.006	0.001
Total livestock in TLU	-0.006	-0.007	0.011	0.008
Agr. asset wealth index, normalized	-0.018	-0.197	-0.021	-0.038
Total land cultivated area (GPS acres)	-0.003	-0.014	0.012***	0.040***
Irrigation with water pump	0.017	0.034	0.028*	0.018
HH received credit	0.022**	0.031	0.016**	0.009
Dist. from nearest populated centre (in log)	0.025	0.000	-0.002	0.017
Dist. from primary school (in log)	-0.007	-0.037*	0.003	-0.011*
Dist. from nearest weekly market (in log)	-0.006	-0.008	-0.007***	-0.010***
Extension service within the community	-0.022*	-0.197***	-0.002	-0.029**
Collective action within the community	0.038***	0.105***	0.029***	-0.010
year_2011	0.012	0.099	-0.006	-0.160***
year_2013	-0.021	-0.015	-0.015	-0.104***
SPEI<=-1.5	0.074***	0.423***	0.086***	0.200***
Mundlak HH Head is female	0.025	0.117	-0.026*	0.004
Mundlak HH Head age	0.001	0.003	-0.001	0.000
Mundlak HH size	-0.013**	-0.030	-0.009**	0.003
Mundlak share of HH members in working age	-0.060**	-0.283**	-0.004	0.040
Mundlak avg. educ. of members in working age	-0.001	0.001	-0.000	-0.009***
Mundlak health problem during last 12 months	-0.009	0.023	0.029**	0.008
Mundlak total livestock in TLU	0.067***	0.200***	-0.022**	0.041***
Mundlak agr. asset wealth index, normalized	-0.228***	-0.716***	0.101**	-0.025
Mundlak total land cultivated area (GPS acres)	-0.054***	-0.143***	-0.016***	-0.028***
Mundlak irrigation with water pump	0.058	0.148	0.014	-0.010
Mundlak HH received credit	0.018	0.088	0.012	0.007
Mundlak dist. from nearest populated centre (in log)	-0.005	0.052	0.014	-0.046***
Mundlak dist. from primary school (in log)	-0.007	0.015	-0.015	0.033*
Mundlak dist. from nearest weekly market (in log)	0.017**	0.022	-0.000	0.034***
Mundlak extension Service within the community	0.073***	0.354***	0.015	0.009
Mundlak collective action within the community	-0.032*	-0.017	-0.055***	-0.025
Mundlak leave-out mean PSNP	0.001***	0.002**	0.001**	0.002***
Mundlak SPEI<=-1.5	0.028	0.183	0.087**	0.002
Constant	0.133	0.350	0.163**	0.049
Observations	10 846	10 846	10 846	10 846

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors’ elaboration based on estimated results.

Table A7. Second stage – direct and indirect effects of PSNP on households' stressors due to other shocks

	(1) Food insecurity	(2) Months of food insecurity	(3) Harvest losses	(4) Crop failure
PSNP	-0.135	0.274	-0.003	0.235
PSNP in the <i>Kebele</i>	0.189	0.991*	0.312*	0.051
HH head is female	0.054**	0.236***	0.006	-0.013
HH head age	0.001	0.004	-0.000	0.001
HH size	0.001	-0.006	0.002	-0.005
Share of HH members in working age	-0.066**	-0.129	-0.028	-0.017
Avg. educ. of members in working age	-0.004	-0.014	-0.000	-0.002
Health problem during last 12 months	0.012	0.049*	0.007	0.014**
Total livestock in TLU	-0.008	-0.051	0.023*	0.005
Agr. asset wealth index, normalized	-0.025	-0.174	-0.077	-0.004
Total land cultivated area (GPS acres)	0.012	0.026	0.018***	0.015***
Irrigation with water pump	-0.004	0.024	-0.010	0.028
HH received credit	0.045***	0.141***	-0.003	0.011
Dist. from nearest populated centre (in log)	0.020	0.090	0.005	-0.005
Dist. from primary school (in log)	-0.002	0.016	0.002	0.010*
Dist. from nearest weekly market (in log)	0.008**	0.044***	-0.011***	0.003
Extension service within the community	0.052***	0.155***	-0.009	-0.014
Collective action within the community	0.013	-0.001	-0.038***	0.006
year_2011	-0.019	-0.116	-0.184***	-0.086***
year_2013	0.046**	0.101	-0.036	0.035**
SPEI<=-1.5	-0.039**	-0.069	-0.034*	-0.052***
Mundlak HH Head is female	-0.014	-0.069	-0.004	0.015
Mundlak HH Head age	0.000	0.000	0.001	-0.000
Mundlak HH size	0.009	0.038*	0.006	0.003
Mundlak share of HH members in working age	0.094**	0.281**	0.051	0.010
Mundlak avg. educ. of members in working age	-0.014***	-0.045***	-0.005	0.001
Mundlak health problem during last 12 months	0.012	-0.020	-0.003	-0.005
Mundlak total livestock in TLU	-0.079***	-0.192***	0.003	-0.007
Mundlak agr. asset wealth index, normalized	-0.058	-0.312	0.232***	0.262***
Mundlak total land cultivated area (GPS acres)	-0.027**	-0.046	-0.013	0.004
Mundlak irrigation with water pump	-0.157***	-0.657***	-0.072	-0.089**
Mundlak HH received credit	0.062***	0.110*	-0.008	0.021
Mundlak dist. from nearest populated centre (in log)	-0.041	-0.171*	-0.046*	0.004
Mundlak dist. from primary school (in log)	0.056***	0.154***	0.033*	-0.011
Mundlak dist. from nearest weekly market (in log)	-0.007	-0.030	0.035***	-0.013**
Mundlak extension Service within the community	-0.005	-0.036	0.026	0.023
Mundlak collective action within the community	-0.016	0.050	0.021	0.000
Mundlak leave-out mean PSNP	0.000	0.001	0.002***	-0.000
Mundlak SPEI<=-1.5	-0.155***	-0.533***	-0.156***	-0.016
Constant	0.099	-0.019	0.015	0.014
Observations	10 846	10 846	10 846	10 846

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' elaboration based on estimated results.

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