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The Impact of Rainfall Shock on Child Labor

The Role of the Productive Safety Nets Program and Credit Markets in Ethiopia

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I. Introduction

Despite steady economic growth and a clear reduction in poverty[1], child labor remains a persistent challenge violating the fundamental rights of children in Africa. The majority of child laborers live in rural areas where livelihoods depend heavily on agriculture. This is the case also in Ethiopia, a country with one of the highest prevalence of child labor[2]. Since smallholder agriculture in Ethiopia, like in much of the rest of the Sub-Saharan Africa, is largely rain-fed and suffers from increasing incidences of drought and other environmental challenges (Mekonnen et al. 2019), variations in rainfall can be expected to have large impacts on child labor. This will in turn affect children's current well-being and future earnings.

However, the impact of rainfall shocks on child labor in agricultural households is theoretically ambiguous and context dependent. Two competing effects are expected. On the one hand, households may increase (decrease) child labor as a response to lower (higher) than usual rainfall because of an income effect. The extent of the income effect depends on what other means the households have to smooth consumption, including access to credit markets and social safety nets. On the other hand, a negative (positive) rainfall shock could make child labor on a farm less (more) productive, which is the productivity effect. The extent of the productivity effect will depend on the availability of an alternative labor market.

Findings in the empirical literature on the impact of rainfall shocks on child labor vary. Some studies find that less rain than normal increases child labor (Beegle et al., 2006; Gubert and Robilliard, 2008) while others find the opposite (Nordmann et al., 2022, Trong et al., 2020). Most studies use self-reported weather shocks and therefore risk being affected by reporting biases. The small emerging literature using geospatial rainfall data has so far found child labor, on average, to increase in response to positive rainfall shocks and not to respond to negative rainfall shocks, in rural Vietnam (Trong et al., 2020), Tanzania (Dumas, 2020) and India (Nordmann et al., 2022). Given the small number of existing studies on the impact of rainfall shocks on child labor using geo-spatial rainfall data, the theoretical ambiguity, and

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[1]The poverty headcount ratio fell from 60% in 2000 to 45% in 2011. The estimated share of African children aged 5 14 in employment was 28.8% in 2000, 26.4% in 2004, 28.4% in 2008, and 26.2% in 2012.
[2]According to a 2018 report by UNICEF and CSA, in Ethiopia 42% of children age 5–17 were engaged in child labor, compared to 28% for all of sub-Saharan Africa.

the scarcity of studies investigating theoretically relevant sources of heterogeneity, strong empirical evidence from other contexts is needed.

Against this background, we investigate the impact of rainfall shocks on child labor in agricultural households in Ethiopia, a country where child labor in rain-fed agriculture is unusually prevalent. There are reasons to expect that both the productivity effect and the income effect are important. A study by Shumetie and Mamo (2019) revealed that child labor increases with land and livestock ownership in Ethiopia, suggesting that child labor is affected by productivity effects and a limited labor market during normal times. We may therefore expect productivity effects to be important also for the child labor response to rainfall shocks. However, a report by UNICEF and ILO (2020) finds higher incidence of child labor in households that self-report natural disasters, including droughts and flooding, thus suggesting important income effects[3].

In addition to the estimation of average effects of rainfall shocks on child labor, we investigate heterogeneity with respect to local credit markets and, importantly, a large-scale public works program, named the Productive Safety Net Program (PSNP).[4] Public works programs have been suggested as an efficient way to provide benefits to the poor, which could improve the nutritional intake and school attendance of children and reduce child labor in poor communities (Woldehanna & Tafere, 2012)[5]. However, these programs also require labor, and the household may, therefore, use child labor as a substitute for activities in which an adult would otherwise have been engaged.

As explained, a local credit market is expected to mitigate the income effect, since farm households can use credit instead of child labor to smooth consumption (Dumas, 2020). It is a priori unclear how a public works programs may affect the child labor response to rainfall shocks. Like any social safety net program, they may be an alternative to child labor for consumption smoothening, and they could therefore mitigate possible income effects in the same way as a credit market. However, since they require adult labor, household may shift

[3]Colmer (2021) studies ex-ante adjustments to long-run rainfall variability in rural Ethiopia, a related but different topic. He finds less variability in increased time spent in agriculture and decreased time spent in education, perhaps suggesting that perceived future prospects in agriculture matter for human capital investment.
[4]We do not have any good measure of local labor markets. For the interested reader in Appendix (Table A6-Table A11) we investigate heterogeneity with respect to an arguably endogenous measure of local labor markets.
[5]Income effect: when households have more income, their demand for education for their children increases because they do not need children to work. Substitution effect: when households have to supply labor in return for benefits, the households may have to make children substitute for parents' time at home, in their own business or in the PSNP.

adult labor between the own farm and the public works program as a response to productivity impacts of rainfall variations, and thereby resort less to adjustments in using child labor. Like an improved labor market, they could therefore mitigate the productivity effect of rainfall variations on child labor. Even if farm households cannot more easily hire external labor when labor is more productive after a good rain, shifting own adult labor from the public works program to their own farm may work in a similar way.

Further, we utilize the timing of surveys and Ethiopia's two growing seasons to investigate both immediate effects of rainfall variation in the Belg (short rainy season) and more long-term (post-harvest) effects of rainfall variation in the Meher (long rainy season). The Meher season (June-September) is the main planting season, characterized by less rainfall variability (USAID, 2002; IFPRI, 2019). Since rural households generate most of their income from this season, we can expect the income effect to be important. Only some parts of the country receive rainfall during the Belg season (January-March). Moreover, this season has high rainfall variability and occurs when schools are open. The data that we use was collected during the Belg season, and we, therefore, expect to find immediate productivity effects. We believe that estimations using inter-annual rainfall variability may mask the mechanism through which the shock impacts child labor in the two seasons. Thus, we investigate rainfall shock for each of the two seasons.

We use data from three rounds of the Ethiopian Socio-economic Survey panel datasets (2011-2015) matched with monthly gridded time series of geospatial rainfall data (35-years) from the Climate Hazards group InfraRed Precipitation with Station (CHIRPS) to investigate the impact of both positive and negative rainfall shocks on total number of hours children spent on various work activities, including agricultural and non-agricultural and chores. In summary, we find that child labor is higher after a positive Meher-season rainfall shock and lower after a negative one. The productivity effect therefore appears to dominate in the harvesting and post-harvest period. Positive rainfall shocks increase both hours spent on agricultural activities (where harvesting, threshing and herding are likely to be key activities) and on household chores (fuel wood and water collection). The PSNP mitigates the child labor effects of positive Meher rainfall shocks. Credit market access does not appear to matter for the post-harvest response to Meher rainfall shocks.

The immediate child labor response to Belg season rainfall shocks is very different from the longer-term Meher season rainfall shocks. A negative Belg season rainfall shock increases child labor, probably because typical child tasks such as fetching water and herding takes longer during drought times. The PNSP does not affect the child labor response to negative Belg season rains. Access to local credit markets mitigate the increase in agricultural work but exacerbates the increase in household work after negative Belg season rainfall shocks. This could be because households use credit to invest in non-agricultural activities to compensate for expected lower incomes when rains are bad. We are not able to study positive Belg season rainfall shocks in our data.

This paper contributes to the wider literature on economic shocks and child labor (Bandara et al., 2014; Arslan et al., 2016; Shamma (2015); Blom et al., 2019; Beegle et al., 2006; Dendir, 2007; Guarcello et al., 2008; Woldehanna et al., 2008) and more specifically on exogenous rainfall shocks and child labor (Mina Zamand & AsmaHyder, 2016; Thomas et al., 2019; Beegle et al., 2006; Alvi and Dendir, 2011) in several ways. First, it is one of few studies using objective geospatial rainfall data to examine the impact of rainfall shocks on child labor, and it is the first such study for Ethiopia.

Second, it increases our understanding of heterogeneity of child labor responses to shocks. To the best of our knowledge, it is the first study to investigate how the presence of a large-scale public works program mitigate or exacerbate the child labor response to rainfall shocks. We also study heterogeneity of the child labor response with respect to credit markets. While heterogeneity with respect to local credit markets has been studied by Dumas (2020) and Nordmann et al (2022), there are still few studies investigating such heterogeneity.

Third, we exploit the timing of data collection and Ethiopia's two main rainfall periods and growing seasons to get a more nuanced understanding of how child labor reacts to rainfall shocks over time. Similar to e.g. Dammert (2008) we also decompose child labor into different child activities and estimate separate effects by gender. Our findings point to different impacts of rainfall shocks on different child work tasks, which also lead to different average effects over time. Immediately during a drought, child labor increases, in particular water and fuel wood collection, probably because these tasks take longer time during dry conditions. This would imply that child labor allocated to these tasks increases when productivity decreases, in line with models of income-targeting (Kőszegi and Rabin, 2006).

The more long-term effect of Meher season rainfall shocks on harvesting and post harvesting activities is pro-cyclical, that is, positive shocks increase child labor and negative shocks decrease child labor. This is best explained by a traditional productivity effect, where good harvests increase productivity in harvesting and post-harvest activities.

The rest of the paper is organized as follows: Section II describes the context of the study area, more specifically it provides background information on Ethiopian agriculture and the role of children in this activity. We also describe the nature and measures of heterogeneity variables used in our study, namely, Ethiopia's Productive Safety Net Program (PSNP) and the local credit market. Section III presents data and methods, pinpointing data type and sources, the empirical strategy and estimation methods. Section IV presents the results and, finally, section V concludes with policy implications.

II. Study Context

2.1 Background on Ethiopian agriculture and the role of children in it

In Ethiopia, agriculture accounts for 80% of employment but the sector is plagued by periodic drought, soil degradation, overgrazing and deforestation. Production is largely of a subsistence type practiced by subsistence farmers with smallholdings broken into several plots. Cultivation is often combined with livestock husbandry, and the country has the largest livestock population in Africa (Central Statistics Agency, CSA, 2020a). Livestock serves several purposes. It is a major source of animal protein power for crop cultivation, manure for farmland and household energy, and security in times of crop failure. It is also a means of transportation and wealth accumulation (World Bank, 2017). Around 86% households in our sample, engage in farming and livestock rearing while about 4.5% of households base their livelihood purely on livestock rearing.

As mentioned, there are two main crop growing seasons in Ethiopia: the b*elg* and m*eher* seasons which receive rainfall from January to May and from June to October, respectively The *meher* crop season is officially defined as any crop harvested between September and February, and the *belg* crop season is defined as any crop harvested between March and August. The *meher* crop season is the main season and produces 90-95 percent of the nation's total cereals output. Corn accounts for one-third to nearly one-half of the cereal production in the *belg* harvest. The remaining *belg* output comprises mostly short-cycle wheat, barley, and teff (UDA, 2008).

The decision to engage children in agricultural activities depends on several cultural and economic factors. For many, work is a marker of a key life transition for children. Working is considered an integral part of family life in which children are expected to participate to help their family and learn skills (Tafere and Camfield, 2009; Chuta, 2014). Children may be engaged in all types of work activities. However, in rural Ethiopia looking after livestock is normally considered the duty of children. Children are also likely to participate in fetching water and firewood collection. During times of drought, household members, including children, may be forced to travel longer distances in search of water and food for livestock and family (World Bank and CSA, 2015). In addition, children from poor households may have to participate in paid work to support the household (Tafere, 2014).

2.2 Ethiopia's Productive Safety Net Program (PSNP)

The PSNP is one of the largest social protection programs in Africa, launched by the Government of Ethiopia in January 2005 across 262 Woredas[6] which were selected from the rural areas of the regions of Amhara, Oromia, SNNP (Southern Nations, Nationalities and People) and Tigray. Around 43 percent of households in our main sample reside in villages that have access to the PSNP. In our smaller sample from areas with Belg-season cultivation, around 50 percent live in PSNP villages. The program aims to provide transfers to chronically food-insecure households, prevent asset depletion and create community assets that protect them from the effects of shocks such as drought, death of household members, inflation and death of livestock (Woldehanna and Tafere, 2012). The PSNP has two components, namely Public Works (PW) and Direct Support (DS). The public works program finances labor-intensive public works undertaken by able bodied individuals, such as building terraced fields on hill slopes to reduce soil erosion and increase water retention, and social services infrastructure (Pankhurst A, 2009). The direct support program involves food and cash transfers to those households without labor which mainly include the elderly and disabled (Porter and Goyal, 2016).

[6]Woredas are **the third level of the administrative divisions of Ethiopia** – after zones and the regional states.

2.3 Local Credit Markets

Like in many developing countries, financial institutions generally do not serve small-holder farmers. This is mainly attributable to the low profitability in the sector coupled with the multiple risks (including production failures, market fluctuation, and institutional and financial risks). Moreover, provision of financial services to agriculture is proven to have high transaction costs due to small transaction sizes, seasonal cash flows, illiquid and perishable collateral, high covariance across borrowers, and difficulties in reaching and monitoring smallholder farmers (CIMMYT, 2015). Consequently, rural households in Ethiopia are significantly underserved by financial services such as loans, savings, insurance, and local remittances. Microfinance institutions and financial cooperatives are the alternative credit providers to these households, but according to an Ethiopian Economics Associations (EEA) report they are able to reach only about 20 percent of the rural poor (EEA, 2011). 17.7 percent of households in our sample live in a village with access to any type of financial institution within five kilometers of the household. In our smaller sample of households who cultivate in the Belg season about 22 percent of households have access.

Although we do not analyze heterogeneous effects of rainfall shocks on child labor with respect to local labor markets, labor markets are theoretically important. In general labor markets are not very well developed in Ethiopia. In our sample the 18.9 percent of households hired at least one worker for a wage in the 12 months preceding the survey. Further information on labor markets, together with tentative results using admittedly endogenous measures of the labor market can be found in Appendix (Table A6-Table A11).

III. Data and Methods

3.1 Data

This study combines two data sources, the Ethiopian Socioeconomic Survey (ESS) and geospatial rainfall data obtained from CHIRPS. The Ethiopian Socioeconomic Survey is a collaborative project between the Central Statistics Agency of Ethiopia (CSA) and the World Bank Living Standards Measurement Study-Integrated Surveys of Agriculture (LSMS-ISA) designed to collect panel data on a wide range of household- and community level variables linked to agricultural activities. The ESS covers all regions of Ethiopia and all rural zones as well as small towns and urban areas. The panel survey was conducted in three waves. The first wave was conducted in 2011 and included only rural areas and small towns covering 333 enumeration areas (EAs) and 3,776 households. These enumeration areas represent the diversity of farming systems and capture climate differences across the country, showing significant spatial variability in climate conditions. In the second survey round conducted in 2013, the sample was expanded to include all urban areas and to make the sample nationally representative. The third survey round was conducted in 2015/16. Interviews were administered from January to March, during which Meher season harvest and post-harvest agricultural (harvesting, threshing, storing and marketing) activities and Belg-season pre-planting and planting activities are undertaken.[7]

Importantly, the ESS households are geo-referenced, allowing us to match the household coordinates with other geospatial data[8]. We matched the data from ESS to rainfall data from CHIRPS data. CHIRPS incorporates in-house climatology, CHPclim, 0.05° resolution satellite imagery, and in-situ station data to create gridded rainfall time series for trend analysis and seasonal drought monitoring.

Our samples include children in ESS households residing in rural areas and small towns whose livelihood is primarily based on agriculture. Accordingly, a total of 3,710 households (3,404 from rural and 306 from small towns) were included. ESS collected information on time use, including child labor activities, for each household member aged 7 years and above. Our sample therefore consists of children aged 7–17. In the estimations related to Belg season rainfall shocks we use only households living in enumeration areas where Belg cultivation is practiced. After data cleaning[9], we end up with a total of 17,160 and 4,100 child observations for Meher and Belg seasons respectively. About 52 percent are boys and 48 percent are girls.

[7] Ethiopian agriculture involves two related sequences of farming activities: pre-harvesting and harvesting and post harvesting agriculture. Pre-harvesting agriculture include land preparation, planting, ridging, weeding and fertilizing and harvesting and post harvesting agricultural activities include harvesting and threshing and storage and marketing activities (CSA, World Bank, 2017).

[8] To protect respondent anonymity, a small random offset is introduced into the household geographic coordinates: 0–5 km for 99 per cent of rural enumeration areas, with 1 per cent of enumeration areas given a random offset of 0–10 km. Given the spatial scale of rainfall patterns, however, this offset should not affect our analysis (CSA and World Bank, 2017).

[9] We use households residing in rural areas and small towns whose livelihood is primarily based on agriculture. Thus, households whose livelihood is not based on agricultural activities are excluded from the sample.

Measures of child labor

The ESS collected information on time spent on different activities broadly classified into agricultural activities (land preparation, tending crops, threshing and crop processing, looking after livestock and fishing), non-agricultural household business enterprises (engagement in the production of local food and drinks for household consumption and for sale; trade in food grain, manufactured goods, livestock and livestock products, grass, straw and charcoal), and household chores (collecting and selling of fuel wood, fetching of water). Each eligible household member (those aged 7 years and above) was asked to recall the number of hours they spent on each activity during the 7 days preceding the survey and the number of minutes spent on household chores the previous day.

The outcome variable in our main estimation is work intensity. We convert the time spent on all activities into its equivalent hours of work spent during the 7 days preceding the interview. We use a measure of child labor incidence in the robustness estimations, more specifically, the standard binary measure of child labor as defined by the ILO[10].

We find that, on average, children spend about 17 hours per week working. As expected, children spend much of their time in agriculture, 13 hours. Children spend 7 hours collecting fuel wood and fetching water and 1.2 hours in non-farm household business enterprises. While we acknowledge that household chores may include more tasks than these, they are likely to be the most time-consuming ones and we will use the terms household chores and fuel wood and water collection interchangeably. In terms of child labor participation, we find that about 72% of children were engaged in any child work, 51% participate in agricultural work, and 47% in household chores. Only about 8% of the children in our sample were engaged in work in non-farm household business enterprises (see Table A5 in the Appendix).

When disaggregated by gender, we find that about 60 percent of boys were engaged in agricultural work compared to 44 percent of girls. On the other hand, 38 percent of boys and 62 percent of girls reported spending some time on fuel wood collection and fetching water.

10 Following the ILO definition, children are considered to be involved in child labor if they are (a) aged 5–11 and carried out at least 1 hour of economic activity or at least 28 hours of household chores during the reference week or (b) aged 12–14 and carried out at least 14 hours of economic activity or at least 28 hours of household chores during the reference week.

Only 6 percent of boys and 7 percent of girls reported participation in non-farm household enterprise activities (details presented in Appendix Table A5).

Measure of Rainfall Shock

We construct our rainfall shock variable using the Standard Precipitation Index (SPI), the conventional measure of rainfall shock which measures the deviation of current year rainfall from the historical average for the same locality. The SPI is measured as follows:

$$SPI_{ivt} = \frac{(R_{ivt} - \bar{R}_{vi})}{{R_{iv}}^{SD}} \qquad (1)$$

where SPI_{ivt} –is the SPI in village v in during season i for year t; $\mathrm{R_{ivt}}$ measures precipitation in village v during season i for year t. $\bar{R}_{vi}$ is the historical average precipitation, and ${R_{iv}}^{SD}$- the historical standard deviation. Any deviation from the long-term mean is not necessarily a harmful shock. We measure rainfall shocks using ± 1 standard deviation from the historical mean:

$$Positive\ rainfall\ shock\ (PRS)_{ivt} = 1\ \ if \quad SPI_{ivt} \geq 1\ , \qquad 0\ otherwise \qquad (2)$$

$$Negative\ rainfall\ shock\ (NRS)_{ivt} = 1 \quad if \quad SPI_{ivt} \leq 1\ , 0\ otherwise \qquad (3)$$

These measures of rainfall shocks are constructed for Meher and Belg seasons separately. As a robustness check, we use a measure of the absolute value of the SPI if the deviation from the historical mean is at least ± 1 standard deviation and zero otherwise. The Meher rainfall shock is measured using rainfall observed from June to September and the Belg shock is measured using rainfall observed in the months of January and February. The Belg season runs from January to May, but we cannot use rainfall observed from March to May since these months post-date the ESS survey.

In our samples, around 21 percent of the villages have received a positive Meher season rainfall shock and 19 percent of the villages a negative one. In the Belg season sample, no village has experienced a positive Belg season rainfall shock, and around 11 percent have experienced a negative shock. Details can be seen in Table A5b and figures 1 in the Appendix section.

Access to the Productive Safety Net Program (PSNP) and to the credit markets are both measured at the village level. Village representatives were asked if PSNP has ever operated in their village. We use a binary variable equal to 1 if the village ever had access to the PSNP and zero otherwise. About 33 percent of the households that experienced positive Meher season rainfall shocks lived in a village with access to PNSP. About 47 percent of the households that experienced a negative Meher season rainfall shock live in PSNP villages. Around 32 percent of the households that experienced a negative Belg season shock lived in a PSNP village (See Appendix Table A5b).

Village representatives were also asked whether there is access to financial institutions (formal banks or informal institutions) within five kilometers of the village. We again use a binary variable equal to 1 if a village has access to any type of financial institution within a distance of five kilometers and zero otherwise. Around 20 percent of households who experienced any rainfall shocks (either a positive or negative Meher season shock or a negative Belg season shock) lived in villages with credit access (See Appendix Table A5b).

3.2 Empirical Estimation:

The Effect of Rainfall variation on Agriculture

We expect the impact of rainfall shocks on child labor to be largely mediated by change in agricultural productivity and income. Using ESS post-harvest crop-cut data, we estimate the effect of rainfall shock on agricultural output using the following model:

$$Yield_{chvt} = \beta_o + \beta_1 SPI_{vt} + \beta_2 X_{ht} + \varepsilon_{chvt} \quad (4)$$

where $Yield_{cht}$represents the agricultural yield of crop c measured as dry weight (in kilograms) from an area of 2mx2m agricultural land owned by household h during year t. The crop cut is done after the growing season but before the harvest season. SPI_{Vt}-measures SPI values observed in village v in year t as indicated in equations (1). X_{ht} include other control variables affecting agricultural yield, namely the use of productivity-enhancing external inputs like fertilizers, pesticides, herbicides, fungicides, and use of improved seeds, and ε_{ijt}captures the error term.

The impact of a rainfall shock on child labor could also be mediated through its effect on the livestock population. In rural Ethiopia, looking after livestock is normally considered children's duty[11]. Thus, we estimate the impact of rainfall variation on the livestock population at the household level as measured by total livestock units (TLU), using the following model.

$$TLU_{hvt} = \alpha_o + \alpha_1 SPI_{vt} + \alpha_2 \boldsymbol{X}_{ht} + \varepsilon_{hvt} \quad (5)$$

Where TLU_{hvt} is the number of total livestock units owned by household i living in village v during year t.The set of control variables,X_{ht}, includes household size, age of household head and level of education of household head. Note, however, that amount of livestock is not likely to capture the full impact of rainfall shocks on the time children spend tending to livestock, since the time needed to find water and food for a given number of livestock increases when it is dry.

The Impact of Rainfall Shocks on Child Labor

To estimate the effect of rainfall shocks on child labor, we use the following specification:

$$L_{ihvt} = \alpha + \beta \mathbf{RS}_{vt} + \delta \mathbf{H}_{vt} + \mathbf{RS}_{vt} \times \gamma H_{vt} + \theta \boldsymbol{X}_{ihvt} + \mu_v + \varepsilon_{ihct} \ (6)$$

Where subscript L_{ihvt} is the number of hours that child i from household h living in village v in year t spends on each activity per week. $\boldsymbol{RS}_{vt}$ is the rainfall shock observed in village v in year t and $\boldsymbol{H}_{Vt}$ represents aspects of heterogeneity (PNSP and credit markets). $\boldsymbol{X}_{ihvt}$ includes child and household covariates including the child's age and household size. Finally, μ_v captures village fixed effects and $\varepsilon_{\mathrm{ihvt}}$ represents the error term in the model.

[11]In line with the importance of child work in animal rearing, a study by Shumetie and Mamo (2019) revealed that in Ethiopia child labor increases with livestock ownership.

Ⅳ. Result

4.1 The effect of rainfall variation on agriculture

Before turning to the main results, we first confirm whether agricultural outputs (crop yield and livestock population) react to rainfall variations, as shown in Table 1. As expected, crop yield mostly increases with Meher season rainfall. However, the yield of maize, which is mostly grown in drought-prone and semi-arid areas, responds in the opposite direction[12]. Since Meher rains affect crop yields, we should expect resulting impacts on child labor, whether these are positive or negative depends on the relative strength of the income and the productivity effects. There is no statistically significant impact of rainfall shock on crop yields in the Belg season. We find no evidence on the impact of both Meher and Belg season rainfall shocks on the livestock population. Since, according to our data, the number of animals is not affected by the rainfall shocks, we expect children's time spent rearing animals to increase when drier conditions make it harder to find water and food for livestock.

Table1: The effect of rainfall shocks on agricultural production

Panel A: Meher season

	Barley	Maize	Teff	Sorghum	Wheat	TLU
Meher rainfall variation	0.150***	-0.153***	0.118***	-0.004	0.048**	.0270
	(0.054)	(0.045)	(0.036)	(0.024)	(0.021)	(0.169)
Observations	341	772	647	529	498	6,625
Number of villages	58	110	82	92	66	331

Panel B: Belg season

	Barley	Maize	Teff	Sorghum	Wheat	TLU
Belg rainfall variation	0.372	-0.232	0.323	-0.408	0.302	.981
	(0.995)	(0.727)	(0.342)	(0.502)	(0.506)	(2.792)
Observations	61	142	172	62	74	1,401
Number of villages	15	29	28	16	14	103

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note. In columns (1) through (5), the dependent variable is agricultural output per 2m×2m measured in kilograms. The additional control variables used are households' use of agricultural inputs, including fertilizers, improved seeds, pesticides, herbicides and fungicides. Standard errors are clusters at the village level. In column (6) the dependent variables and other controls are household size, and age and education level of household head.

[12] Maize is grown in a wide range of agro ecologies but is most important in the drought-prone arid and semi-arid parts of Ethiopia, known locally as Bereha ("Hot Arid"),(MoA, 1998)

4.2 The Impact of Rainfall Shocks on Child Labor – Meher Season

Table 2 shows the impact of Meher season rainfall shocks on total hours of child work. In model 1 (our baseline model), we estimate child work hours on positive and negative rainfall shocks using village fixed effects. In model 2, we control for the child's age and household size. In models 3 and 4 we estimate heterogeneous impacts of rainfall shocks with respect to the village's access to PNSP and credit markets, respectively.

Child labor is higher after a positive Meher-season rainfall shock and lower after a negative one, suggesting the productivity effect dominates over any income effect. This results suggest that much of the Meher season post-harvest agricultural activities such as harvesting, threshing and packaging which are carried out after the main season rains are over have significant contributions to child labor.

Positive rainfall shocks increase child work hours by just over 2 hours per week, as shown in Model 1. Negative rainfall shocks decrease child work hours by just over 2.5 hours. Adding control variables in model 2 does not change this result. As seen in model 3, access to the public works program mitigates the impact of positive rainfall shocks on child labor. This result is in line with a reallocation of adult labor from the public works program to the own farm after positive rainfall shocks. It is also possible that the income from the PSNP program strengthens the income effect of a positive rainfall shock, which would in turn decrease child labor. There is evidence that the small transfers from the PSNP cannot improve household welfare on its own unless it is augmented by household agricultural income earned, for example, from a good harvest (Tafere and Woldehanna, 2012).

We find no differential impact of rainfall shock on child labor related to credit market availability, as depicted in model 4. One reason could be that availability of banks and informal financial institutions in a village does not guarantee access to credit access for a household (Reyes and Lensink, 2011; Dumas, 2020). Since the productivity effect dominates the income effect, the result is supportive of the expectation that credit market access matters less in mitigating the impact of positive rainfall shocks on child labor.

Table 2: Impact of Meher season rainfall shocks on child work hours

	model 1	model 2	model 3	model 4
Positive shock	2.093*	2.268*	3.743**	2.349*
	(1.191)	(1.173)	(1.557)	(1.423)
Negative shock	-2.568**	-2.541**	-2.274*	-2.757**
	(1.010)	(1.013)	(1.368)	(1.162)
Positive shock *PSNP			-4.373**	
			(1.976)	
Negative shock *PSNP			-0.501	
			(2.007)	
Positive shock *CM				-0.364
				(2.327)
Negative shock *CM				1.106
				(2.314)
Control variables	No	Yes	Yes	Yes
Village fixed effects	No	Yes	Yes	Yes
Number of observations	17,160	17,160	17,160	17,160
Number of villages	328	328	328	328

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Note: The dependent variable is child work hours per week. Other control variables include a child's age, household size, and village access to PSNP and the credit market index. In model 1, we control for rainfall variables only, that is, positive and negative rainfall shocks. In model 2, we include the child's age, household size, and village access to credit markets and the safety net program (PSNP). In models 3 and 4, we repeat the estimation in model 2 by including the interaction of rainfall variables with village access to PSNP and credit markets, respectively, as additional controls.

4.3 The Impact of Rainfall Shock on Child Work Hours -Belg Season

In Table 3, we present the impact of Belg season rainfall shocks on child work hours per week. As mentioned, we are not able to estimate the impact of positive Belg season rainfall shocks since there are not enough observations for this in the data. Negative Belg season rainfall shocks increase child work hours. This is probably related to the fact that typical child tasks such as fetching water and herding are more time consuming when it is drier. According to OCHA (2017), rural households in general and pastoralists in particular are forced to travel longer distances in search of water and food for themselves and for their livestock during drought times. In our sample, around 86% of households engage in farming and livestock rearing while about 4.5% base their livelihood on livestock rearing only.

We find no differential impact of negative rainfall shocks related to PSNP access. There is weak evidence (at the ten percent level) that child labor increases more in response to negative Belg season rainfall shocks in villages with access to credit.

Table 3: Impact of Belg season rainfall shocks on child work hours

	model 1	model 2	model 3	model 4
Negative shock	10.871***	10.707***	11.006***	10.078**
	(3.548)	(3.575)	(3.491)	(3.866)
Negative shock *PSNP			-0.638	
			(7.344)	
Negative shock *credit market				6.925*
				(3.954)
Control variables	No	Yes	Yes	Yes
Village fixed effect	No	Yes	Yes	Yes
Number of observations	4,100	4,100	4,100	4,100
Number of villages	126	126	126	126

*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is child work hours. In model 1, we control for only rainfall variables, that is, positive and negative rainfall shocks. In model 2, we include the child's age, household size, and village access to credit markets and the safety net program (PSNP). In models 3 and 4, we repeat the estimation in model 2 by controlling the interaction of rainfall variables with village access to PSNP and credit markets, respectively.

4.4 Decomposition of the impact by child activity – Meher Season

To get a more detailed understanding of how rainfall shocks affect the allocation of children's time, we decompose child labor into: (1) agricultural work (farming, livestock, fishing, etc. for household consumption or sale), (2) non-farm household business enterprises (shops, making and selling of local foods and beverages, and trading such as selling goods on the street or in a market) and (3) household chores (time spent on fetching water and collecting fuel wood). We estimate the differential impact of rainfall shocks on time spent on each of these activities, depending on the availability of PSNP and access to the credit market, as shown in Table 4. In general, we find that a positive rainfall shock significantly increases the number of hours children spend working in agriculture and doing household chores. Children may be required to do more household chores if adult household members spend more time doing agricultural work. The result could also be because of complementarities between some household chores and agricultural work. More agricultural work may be supported by production of more food and drink for those who are working on agriculture, which in turn consumes more water and fuel wood, usually collected by children. The reverse holds when households receive a negative rainfall shock.

Table 4: Decomposition of impact by child activity –Meher Season

	Agricultural activity		Non-agricultural activity		Household chores	
	model 1	model 2	model 3	model 4	model 5	model 6
Positive shock	1.891**	1.091	0.189	0.180	1.554***	0.885*
	(0.993)	(0.965)	(0.560)	(0.489)	(0.538)	(0.505)
Negative shock	-1.212	-0.821	-0.307	-0.286	-0.649	-1.786***
	(1.120)	(1.001)	(0.313)	(0.209)	(0.420)	(0.388)
Positive shock *PSNP	-2.627*		-0.472		-1.347	
	(1.427)		(0.632)		(0.949)	
Negative shock *PSNP	0.903		0.189		-1.907***	
	(1.753)		(0.348)		(0.645)	
Positive shock *CM		-0.158		-0.689		0.731
		(1.589)		(0.791)		(1.176)
Negative shock *CM		0.185		0.327		1.067
		(1.976)		(0.602)		(0.817)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Village fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	17,160	17,160	17,160	17,160	17,160	17,160
Number of villages	328	328	328	328	328	328

*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is the number of hours children spend on each activity. Control variables include the child's age, household size, and village access to PSNP and to credit markets. For each activity, we control the interaction of rainfall shocks with village access to PSNP and credit markets, respectively.

Access to the PSNP mitigates the impact of positive Meher season rainfall shocks on children's agricultural work. It does not mitigate the increase in time spent on household chores after a positive shock. The results instead suggest that PSNP availability reduces time spent doing household chores after a negative Meher season rainfall shock. Indeed, the reduction in child work hours after a negative rainfall shock in the main results seems to be mostly driven by a reduction in time spent on household chores in villages with PSNP access. The reduction in agricultural work hours is not statistically significant. Similar to the main results, we find no evidence of differential effects of rainfall shocks related to credit market availability.

4.5 Decomposition of the Impact by Child Activity - Belg Season

Table 5 presents the impact of negative Belg season rainfall shocks on the number of hours children spend on different activities. Negative Belg-season rainfall shocks increase the number of hours children spend on both agricultural and household activities, with a particularly strong effect on time doing household chores. There is no heterogeneity of the response related to access to the PSNP. However, access to credit markets does affect the child labor response. Credit market access mitigates the impact on agricultural work (model 2) but strengthens the impact on household chores (model 6). One possible explanation could be that access to credit markets creates opportunities to start alternative income generating activities when agriculture fails (during drought times). More specifically, credit may be used to start income generating non-agricultural household businesses such as the making of locally prepared food and beverages[13] for sale to sustain livelihoods. For example, Fitsum and Holden (2005) find that access to credit increases off-farm income in rural Ethiopia. The production and selling of food and beverages requires increased use of firewood and water, which are our measure of household chores.

Table 5: Decomposition of impact by child activity – Belg Season

	Agricultural activity		**Non-agricultural activity**		**Household chores**	
	model 1	model 2	model 3	model 4	model 5	model 6
Negative shock	3.767	5.377*	-0.295	-0.277	7.615**	5.982***
	(2.490)	(2.860)	(0.533)	(0.389)	(2.919)	(1.498)
Negative shock *PSNP	2.146		0.184		-1.182	
	(5.441)		(0.477)		(3.167)	
Negative shock *CM		-6.661**		0.749		11.880***
		(2.824)		(0.558)		(1.839)
Village fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,100	4,100	4,100	4,100	4,100	4,100
Number of villages	126	126	126	126	126	126

*** p<0.01, ** p<0.05, * p<0.1

Note: The dependent variable is child work hours spent on each activity. Control variables include the child's age, household size, village fixed effect, access to PSNP and credit market index. To capture heterogeneity, we control the interaction of rainfall shocks with village access to PSNP and credit market respectively.

[13] Some Ethiopian indigenous traditional fermented beverage products are Cheka, Keribo, Borde, Areki, Tella, Shamita, Booka, and Korefe, the fermentation of which is natural and involves mixed cultures of microbes.

4.6 Decomposition of the impact by type of activity and gender - Meher Season

It is expected that boys are more likely to participate in agricultural activities and that girls are likely to participate more in household chores. For example, an ILO (2016) report on child labor in Ethiopia shows that girls are more likely to carry out household chores than boys (79.3% compared to 63.5%).

Table 6 presents the effect of Meher season rainfall shocks on child work hours by gender and type of child work activity. Panel A shows the heterogeneity of the impact by PSNP and Panel B shows heterogeneity by access to credit market.

In Panel A, positive Meher-season rainfall shock increases the number of hours that boys spend on household chores, and agricultural work activities. But the increase in work hours on household chores after a positive Meher shock is driven by girls. The magnitude of the effect on household chore is larger than for girls. We find no impact on time spend working in non-agricultural works for both boys and girls. Access to PSNP seems to mitigate the impact of positive and negative rainfall shock that girls spend working in agricultural and household chores respectively.

In Panel B, the increase number of hours children spend working in household chores after positive Meher season rainfall shocks is driven by boys, while the reduction in the same activity after negative shock is driven by both boys and girls with stronger effect for girls. We find no differential effect with respect to access to credit market for both gender categories.

Table 6: Decomposition by activity and gender - Meher season

Panel A: Heterogeneity by PSNP	**Boys**			**Girls**		
Variables	Agricultural	Non-agricultural	Household Chores	Agricultural	Non-agricultural	Household Chores
Positive shock	2.599*	0.729	1.446***	1.225	0.277	1.731**
	(1.448)	(0.956)	(0.497)	(0.835)	(0.229)	(0.739)
Negative shock	-2.192	-0.497	-0.452	-0.611	-0.222	-0.853
	(1.408)	(0.513)	(0.440)	(1.115)	(0.216)	(0.577)
Positive shock*PSNP	-2.879	-0.833	-1.181	-2.520**	-0.205	-1.415
	(1.947)	(1.005)	(0.923)	(1.269)	(0.457)	(1.491)
Negative shock*PSNP	0.859	0.200	-1.260*	1.208	0.162	-2.522***
	(2.324)	(0.545)	(0.657)	(1.602)	(0.279)	(0.900)
Panel B: Heterogeneity by CM	**Boys**			**Girls**		
Variables	Agricultural	Non-agricultural	Household Chores	Agricultural	Non-agricultural	Household Chores
Positive shock	1.379	0.607	0.952**	0.637	-0.301	0.866
	(1.308)	(0.809)	(0.451)	(0.884)	(0.200)	(0.761)
Negative shock	-1.438 -	0.385	-1.318***	-0.283	-0.135	-2.205***
	(1.361)	(0.345)	(0.381)	(0.907)	(0.143)	(0.546)
Positive shock*CN	1.184	-0.884	0.166	-1.099	-0.102	1.361
	(2.091)	(1.184)	(1.342)	(1.474)	(0.510)	(1.434)
Negative shock*CM	-1.042	0.357	1.130	1.298	0.201	1.143
	(2.449)	(0.919)	(0.860)	(2.054)	(0.488)	(1.076)
Observations	8,866	8,866	8,866	8,291	8,291	8,291
No. of villages	317	317	317	326	326	326
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Villages fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note. The dependent variable is number of hours spent by children on various activities. The additional control variables are the child age, household size, village access to PSNP and credit market imperfections and interaction of shocks with village PSNP and credit market. Standard errors are clustered at the village level.

Table 7 presents the impact of negative Belg season rainfall shocks on the number of hours that boys and girls spend working in different types of activities. In Panels A and B, we find that a negative Belg season rainfall shock increases the number of hours that boys and girls spend working in household chores. There is no heterogeneity with respect to PSNP for both gender categories. But access to credit market seems to dampen the positive impact of negative shock Belg season rainfall shock on agricultural child labor for boys while it significantly increases the engagement of both boys and girls in household chores.

Table 7: Decomposition by activity and gender - Belg season

Panel A: Heterogeneity by PSNP	**Boys**			**Girls**		
	Agricultural	Non-agricultural	Household Chores	Agricultural	Non-agricultural	Household Chores
Negative shock	4.591	-0.306	6.410**	1.791	-0.272	9.773***
	(4.397)	(0.415)	(3.219)	(2.393)	(0.632)	(3.486)
Negative shock*PSNP	2.152	0.194	-0.621	1.724	0.148	-2.580
	(7.202)	(0.382)	(3.417)	(3.863)	(0.535)	(4.225)
Panel A: Heterogeneity by CM	**Boys**			**Girls**		
	Agricultural	Non-agricultural	Household Chores	Agricultural	Non-agricultural	Household Chores
Negative shock	6.452*	-0.303	4.694***	3.520	-0.446	7.644***
	(3.705)	(0.271)	(1.273)	(2.364)	(0.516)	(2.317)
Negative shock*CM	-9.922***	0.432	15.753***	-3.905	0.489	6.876***
	(3.731)	(0.272)	(1.262)	(2.383)	(0.459)	(2.295)
Observations	2069	2069	2069	2031	2031	2031
No. of villages	123	123	123	126	126	126
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Villages fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note. The dependent variable is number of hours spent by children on various activities. The additional control variables are the child's age, household size, village access to PSNP and credit market imperfections and interaction of shocks with village access to PSNP and credit markets. Standard errors are clustered at the village level.

4.7 Impact of rainfall shocks on children's education

Since time spent on child labor activities may affect educational investment, we examine the impact of rainfall shocks on child education as measured by school attendance and absence from school. Perhaps contrary to common perceptions, many studies show that the time children spend working may not necessarily be at the expense of time spent on schooling since there are also other things that children do (Ravallion and Wodon, 2000; Congdon Fors, 2012; Rosati and Hoop, 2014)

Around 87.53 percent of the children in our sample were attending school and only about 11 percent of them were absent for more than a week the month preceding data collection. We find no effects of positive or negative rainfall shock on neither child school attendance nor on school absenteeism. Detail estimation results can be seen in the Appendix section (Table A1-Table A4).

V. Robustness checks

We carry out three robustness checks. First, we use incidence of child labor[14] instead of child work hours as the outcome variable. There are claims that not all child work is harmful for children, and that a few hours of child work should not be considered child labor. The results, in Appendix Table A6 and Table A7 for Meher and Belg seasons respectively, are qualitatively the same as in those in the main analysis. We next use two alternative measures of rainfall shocks. The first is a continuous measure of rainfall shocks, more precisely, the absolute SPI value if it exceeds ±1 and zero otherwise. Results for Meher and Belg seasons are presented in Appendix Table A8 and Table A9. The results remain qualitatively similar, that is, the impact of negative rainfall shocks is larger and more statistically significant than the impact of positive rainfall shocks. This result perhaps suggests that very large positive rainfall shocks have different effects to less extreme ones, while the impact of negative rainfall shocks increases monotonically with the size of the shock. The second alternative measure is a binary one that includes more moderate variations in rainfall. We define deviations in rainfall by a ±0.5 standard deviation from the historical mean as positive and negative rainfall shocks. The results are presented in Appendix Table A10 and A11. Again, we obtain consistent results, but with stronger effects for positive shocks. This result perhaps suggests that more moderate positive rainfall shocks on average increase farm productivity more than very large positive rainfall shocks. Again, the results remain qualitatively the same.

[14]UNICEF's standard indicator for child labor is :
At least 1 hour of economic work or 21 hours of unpaid household services per week, for children age 5-10; At least 14 hours of economic work or 21 hours of unpaid household services per week for children age 12-14; At least 43 hours of economic work per week for children age 15-17.

VI. Conclusion and policy implications

We investigate the impact of rainfall shocks on child labor in Ethiopian households relying on rain-fed agriculture. We consider heterogeneity in the child labor response of households to rainfall shocks with respect to the availability a large-scale public works program called the Productive Safety Net Program (PNSP) and the availability of local credit markets. Our measure of child labor is based on time use data collected during the Belg growing season, a time when agricultural households perform Meher season harvesting and post-harvesting activities and Belg season post planting activities. We find robust evidence that child labor is higher after positive rainfall shocks in the main (Meher) season and lower after negative shocks, suggesting the productivity effect to dominate any possible income effect. This is in line with results in Dumas (2020), Trong et al (2020), and Nordmann et al (2022). However, the immediate impact of a Belg season negative rainfall shock is to increase child labor, probably because typical tasks allocated to children, such as fetching water and herding, are more time consuming in dry conditions. This could be interpreted as an income effect. That is, the water and fuel wood `income´ collected in a given number of hours is lower and households therefore choose to spend more work hours collecting fuel wood and water. It could also be interpreted as a reverse productivity effect. Labor productivity in herding and fuel wood and water collection is lower after a drought. Given the necessity of water and fuel collection, households will still choose to allocate more hours to these tasks. Farm households' labor supply to these tasks may then be driven by income targeting. [15]The literature presents evidence for `income targeting´ among, for example, piece rate agricultural workers (Richards, 2020)[16].

Availability of the PSNP in the village appears to be effective in mitigating the impact of positive Meher season rainfall shocks on child labor. However, more detailed analysis shows that it is only effective in mitigating an increase in agricultural child labor after a positive Meher season rainfall shock. It does not mitigate the increase in household chores. This mitigating effect is similar to the effect we would expect from access to an efficient labor market where farm households can rent labor when labor productivity is high after good

[15] A model of reference-dependent preferences can explain income targeting labor supply (Kőszegiand Rabin, 2006).
[16] There is quite an extensive corpus of literature on whether labor supply of taxi drivers is driven by income-targeting (see e.g. Loewenstein and Thaler, 1997; Farber, 2015; Duong et al. (2023).

harvests. The alleviating effect could also be driven by a shift out of public works and into own farm work by adult household members after a good harvest. Although the PSNP is aimed primarily at improving the welfare of households, including of children during times of drought, we find very limited evidence that it mitigates the impact of negative rainfall shocks on child labor in the Belg season. We find no impact of availability of credit markets on the child labor response to Meher-season rainfall shocks. This is in line with the finding by Dumas (2020) in rural Tanzania. However, the availability of credit appears to mitigate the immediate increase in agricultural work after negative Belg-season shocks and to strengthen the immediate increase in hours spent collecting fuel wood and water. This pattern could be explained by increased possibilities to engage in off-farm income generating activities as a response to negative shocks if credit is available. Hence, access to credit may not only work as a direct consumption smoothing device, it can also be used to invest in alternative income generating activities which require labor.

Summing up, neither the PNSP nor credit markets appear to be fully effective in protecting children during weather shocks. The PNSP does not protect children from the immediate increase in child work hours during droughts. While it mitigates the increase in child work hours after a good harvest, this may be from a baseline level where children work more during normal times, when adult household members work on the public works program. Since PSNP targets households rather than children, it appears to be overlooking the significance of reducing children's vulnerability to shocks under the presumption that all members of the household will benefit equally. Adopting child-sensitive social protection initiatives beyond the PSNP is necessary for reducing the impact of shocks on children’s development of human capital. This could be achieved by implementing comprehensive social protection programs that are sensitive to the needs of children and safeguard their rights while shielding them from the effects of weather shocks. Although more research may be needed to fully understand the specifics of these child-sensitive social protection programs, empirical evidence suggests that adopting integrated child-focused social protection programs incorporating considerations of of international child rights such as school feeding schemes and cash transfers works better in fostering the development of human capital.

Appendix

A1. Supplementary outputs

Impact of rainfall shocks on children's education

A. Impact on school attendance

Table A1: Meher shock and school attendance

	model 1	model 2	model 3	model 4
Positive shock	0.003	0.020	0.050	0.069
	(0.091)	(0.090)	(0.113)	(0.104)
Negative shock	0.106	0.090	0.027	0.063
	(0.080)	(0.082)	(0.118)	(0.093)
Village PSNP		-0.149	-0.157	-0.147
		(0.105)	(0.117)	(0.105)
Credit market		-0.083	-0.079	-0.068
		(0.101)	(0.101)	(0.122)
Child age		-0.320***	-0.320***	-0.320***
		(0.012)	(0.012)	(0.012)
Household size		0.063***	0.064***	0.063***
		(0.015)	(0.015)	(0.015)
Positive shock *PSNP			-0.104	
			(0.187)	
Negative shock *PSNP			0.123	
			(0.163)	
Positive shock *CM				-0.201
				(0.217)
Negative shock *CM				0.109
				(0.204)
Observations	11,724	12,566	12,566	12,566
Number of villages	283	327	327	327

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note. The dependent variable is a dummy variable indicating whether a child living in household i is attending school at the time of survey. Thus, we use a logit model to estimate the impact. In model 1, we control for rainfall variables only, that is, positive and negative rainfall shocks. In model 2, we include the child's age, household size, and village access to credit market and safety net program (PSNP) as additional control variables. In models 3 and 4, we repeat estimations in model 2 by adding the interaction of rainfall variables with village access to PSNP and a credit market, respectively. We cannot estimate the impact of a Belg season positive rainfall shock as no villages received rainfall amounts higher than 1 standard deviation from the historical mean.

Table A2: Belg shocks and school attendance

	model 1	model 2	model 3	model 4
Negative shock	-0.010	0.014	0.048***	0.009
	(0.033)	(0.022)	(0.017)	(0.029)
Village PSNP		-0.025	-0.016	-0.024
		(0.016)	(0.020)	(0.020)
Credit market		0.001	-0.001	-0.002
		(0.018)	(0.016)	(0.018)
Child age		-0.026***	-0.026***	-0.026***
		(0.002)	(0.003)	(0.003)
Household size		0.003	0.004	0.003
		(0.003)	(0.003)	(0.003)
Negative shock *PSNP			-0.093*	
			(0.055)	
Negative shock *CM				0.024
				(0.046)
Observations	2,971	2,971	2,971	2,971
Number of villages	124	124	124	124

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note. The dependent variable is a dummy variable indicating whether a child living in household i is attending school at the time of survey. Thus, we use a logit model to estimate the impact. In model 1, we control for rainfall variables only, that is positive and negative rainfall shocks. In model 2, we include the child's age, household size, and village access to a credit market and safety net program (PSNP) as additional controls. In models 3 and 4, we repeat the estimation in model 2 by adding the interaction of rainfall variables with village access to the PSNP and credit markets, respectively. We cannot estimate the impact of a Belg season positive rainfall shock as no villages in the study received rainfall amounts higher than 1 standard deviation from the historical mean.

B. Impact on school absenteeism

Table A3. Meher shock and school absenteeism

	model 1	model 2	model 3	model 4
Positive shock	-0.076	-0.081	-0.031	-0.230*
	(0.113)	(0.113)	(0.133)	(0.127)
Negative shock	0.120	0.117	0.179	-0.075
	(0.091)	(0.092)	(0.127)	(0.105)
Village PSNP		-0.066	-0.008	-0.048
		(0.144)	(0.159)	(0.144)
Credit market		0.070	0.072	-0.323**
		(0.121)	(0.122)	(0.155)
Child age		-0.016	-0.016	-0.016
		(0.012)	(0.012)	(0.012)
Household size		-0.048***	-0.048***	-0.049***
		(0.018)	(0.018)	(0.018)
Positive shock *PSNP			-0.156	
			(0.250)	
Negative shock *PSNP			-0.129	
			(0.183)	
Positive shock *CM				0.780***
				(0.276)
Negative shock *CM				0.936***
				(0.231)
Observations	10,985	10,985	10,985	10,985
Number of villages	324	324	324	324

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note. The dependent variable is a dummy variable indicating whether a child living in village V from household i was absent from school for more than a week in the month preceding the interview. Thus, we use a logit model to estimate the impact, and the results are marginal effects. In model 1, we control only for rainfall variables, that is, positive and negative rainfall shocks. In model 2, we add child, household and village characteristics including the child’s age, household size, and village access to credit market and safety net program (PSNP). In models 3, 4, and 5, we repeat the estimation in model 2 by adding the interaction of rainfall variables with village access to the PSNP and credit market respectively.

Table A4. Belg shock and school absenteeism

	model 1	model 2	model 3	model 4	model 5
Negative shock	0.004	0.011	0.054	0.011	-0.001
	(0.027)	(0.023)	(0.036)	(0.038)	(0.045)
Village PSNP		0.006	0.016	0.007	0.009
		(0.020)	(0.021)	(0.020)	(0.020)
Credit market		0.041**	0.041	0.041	0.042
		(0.020)	(0.029)	(0.031)	(0.029)
Labor market		-0.093**	-0.099	-0.094	-0.101
		(0.044)	(0.090)	(0.090)	(0.095)
Child age		-0.001	-0.001	-0.001	-0.001
		(0.002)	(0.002)	(0.002)	(0.002)
Household size		-0.005**	-0.005*	-0.005*	-0.005*
		(0.003)	(0.003)	(0.003)	(0.003)
Negative shock *PSNP			-0.105		
			(0.065)		
Negative shock *CM				0.001	
				(0.074)	
Observations	2,580	2,580	2,580	2,580	2,580
Number of villages	124	124	124	124	124

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note. The dependent variable is a dummy variable indicating whether a child living in village v from household i was absent from school for more than a week in the month preceding the interview. Thus, we use a logit model to estimate the impact, and the results are marginal effects. In model 1, we control only for rainfall variables, that is, positive and negative rainfall shocks. In model 2, we add child, household and village characteristics including the child's age, household size, and village access to credit market and safety net program (PSNP). In models 3, 4, and 5, we repeat the estimation in model 2 by adding the interaction of rainfall variables with village access to the PSNP and credit market respectively.

Table A5a: Descriptive statistics

	Meher season		Belg season	
Child characteristics	Mean	Sd.	Mean	Sd.
Child age	11.60	3.04	11.48	3.04
Child sex (male=1)	0.52	0.50	0.50	0.50
Total work hours	16.59	21.02	15.62	19.49
Agriculture work hours/week	11.18	17.22	9.67	15.61
Household chores work hours/week	4.8	10.16	5.40	10.83
Non-agricultural work hours/week	0.76	6.16	0.66	4.94
C**hild labor participation (0/1)**				
Child total labor	0.72	0.45	0.75	0.43
Child agriculture	0.51	0.50	0.49	0.50
Child household chores	0.47	0.50	0.53	0.50
Child non-agricultural business	0.08	0.27	0.07	0.26
Prevalence of rainfall shock (0/1)				
Meher positive shock	0.20	0.40	-	-
Meher negative shock	0.19	0.39	-	-
Belg positive shock	-	-	0.00	0.00
Belg negative shock	-	-	0.11	0.31
Village characteristics				
Credit access	0.18	0.38	0.22	0.42
Access to PSNP	0.43	0.49	0.50	0.50
Number of observations 17,160	17,160		4100	

Note. Standard errors are clustered at the village level

Table A5b: Descriptive statistics

		Meher Shock		Belg Shock	
		Positive	Negative	Positive	Negative
Rainfall Shock **(0/1)**	No. observations	17160	17160	4100	4100
	Mean (%)	.197	.189	0.000	.110
	Standard deviation	.398	.392	0.000	.313
Access to PSNP **(0/1)**	No. observations	3388	3249	0.000	450
	Mean (%)	0.33	0.474	0.000	.322
	Standard deviation	0.47	0.499	0.000	.467
Access to credit market **(0/1)**	No. observations	3388	3249	0.000	450
	Mean (%)	0.195	0.206	0.000	.204
	Standard deviation	0.397	0.404	0.000	.403

Note. Standard errors are clustered at the village level

Fig 1. Rainfall distribution (SPI)- Meher Season

Wave 1 Wave 2 Wave 3

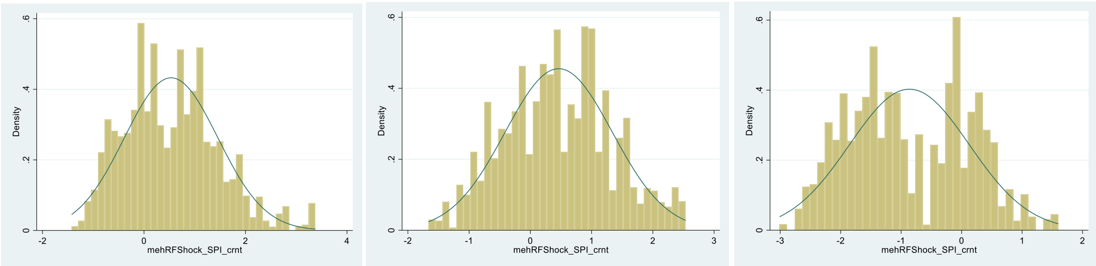
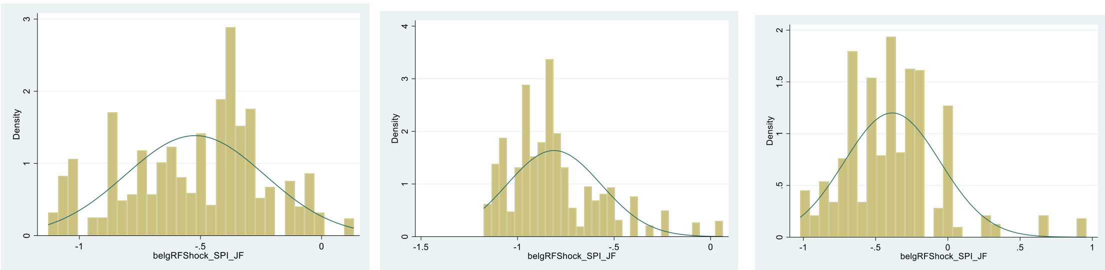


Figure 2. Rainfall distribution (SPI)- Belg Season

Wave 1 Wave 2 Wave 3



3. Robustness Checks

Table A6: The impact of Meher season rainfall shocks on child labor-logit model

	model 1	model 2	model 3	model 4	model 5
Positive shock	0.135**	0.155***	0.260***	0.158**	0.150*
	(0.058)	(0.060)	(0.074)	(0.067)	(0.077)
Negative shock	-0.160***	-0.165***	-0.114	-0.190***	-0.254***
	(0.052)	(0.054)	(0.076)	(0.060)	(0.071)
Village PSNP		-0.015	0.059	-0.012	-0.011
		(0.104)	(0.109)	(0.104)	(0.104)
Credit market		-0.175**	-0.167**	-0.203**	-0.165**
		(0.078)	(0.078)	(0.091)	(0.078)
Labor market		0.516***	0.517***	0.516***	0.417**
		(0.150)	(0.150)	(0.150)	(0.178)
Child age		0.157***	0.157***	0.157***	0.157***
		(0.006)	(0.006)	(0.006)	(0.006)
Household size		-0.103***	-0.103***	-0.103***	-0.103***
		(0.010)	(0.010)	(0.010)	(0.010)
Positive shock *PSNP			-0.300**		
			(0.124)		
Negative shock *PSNP			-0.106		
			(0.108)		
Positive shock *CM				-0.006	
				(0.157)	
Negative shock *CM				0.135	
				(0.145)	
Positive shock *LM					0.044
					(0.242)
Negative shock *LM					0.454*
					(0.242)
Observations	17,120	17,120	17,120	17,120	17,120
Number of villages	315	315	315	315	315

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note. The dependent variable is a dummy variable indicating whether a child from village V living in household i has participated in child labor. Thus, we use a logit model to estimate the impact. In model 1, we control for only rainfall variables, that is, positive and negative rainfall shocks. In model 2, we add child, household and village characteristics including the child's age, household size, and village access to the labor market, credit market and safety net program (PSNP). In models 3, 4, and 5, we repeat the estimation in model 2 by adding the interaction of rainfall variables with village access to the PSNP, credit market, and labor market, respectively. Standard errors are clustered at the village level.

Table A7: The impact of Belg season rainfall shocks on child labor-logit model

	model 1	model 2	model 3	model 4	model 5
Negative shock	0.705***	0.697***	1.211***	0.622**	0.550*
	(0.239)	(0.255)	(0.393)	(0.266)	(0.298)
Village PSNP		-0.251	-0.194	-0.259	-0.221
		(0.240)	(0.243)	(0.240)	(0.242)
Credit market		-0.194	-0.175	-0.205	-0.176
		(0.211)	(0.213)	(0.211)	(0.212)
Labor market		-0.403	-0.507	-0.426	-0.515
		(0.467)	(0.474)	(0.468)	(0.485)
Child age		0.164***	0.165***	0.165***	0.164***
		(0.014)	(0.014)	(0.014)	(0.014)
Household size		-0.131***	-0.129***	-0.131***	-0.130***
		(0.020)	(0.020)	(0.020)	(0.020)
Negative shock *PSNP			-0.947*		
			(0.512)		
Negative shock *CM				0.829	
				(0.918)	
Negative shock *LM					0.779
					(0.854)
Observations	4,098	4,098	4,098	4,098	4,098
Number of villages	124	124	124	124	124

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note. The dependent variable is a dummy variable indicating whether a child from village V living in household i has participated in child labor. Thus, we use a logit model to estimate the impact. In model 1, we control only for rainfall variables, that is, positive and negative rainfall shocks. In model 2 we add child, household and village characteristics including the child's age, household size, and village access to the labor market, credit market and safety net program (PSNP). In models 3, 4, and 5, we repeat the estimation in model 2 by adding the interaction of rainfall variables with village access to the PSNP, credit market, and labor market, respectively.

Table A8: The impact of actual Meher season rainfall shocks on child work hours (±1SD)

	model 1	model 2	model 3	model 4	model 5
Positive shock	1.240*	1.329*	2.236**	1.308	2.297**
	(0.720)	(0.710)	(0.942)	(0.850)	(0.976)
Negative shock	-1.582***	-1.542***	-1.265*	-1.782***	-1.313**
	(0.533)	(0.531)	(0.674)	(0.624)	(0.617)
Village PSNP		1.815	2.632	1.852	1.740
		(2.188)	(2.218)	(2.189)	(2.216)
Credit market		-1.393	-1.269	-1.815	-1.473
		(1.180)	(1.158)	(1.312)	(1.191)
Labor market		3.332	3.553	3.356	6.474*
		(2.848)	(2.879)	(2.853)	(3.320)
Child age		0.808***	0.807***	0.808***	0.808***
		(0.088)	(0.088)	(0.088)	(0.088)
Household size		-0.391***	-0.388***	-0.392***	-0.389***
		(0.115)	(0.116)	(0.115)	(0.115)
Positive shock *PSNP			-2.708**		
			(1.172)		
Negative shock *PSNP			-0.600		
			(1.073)		
Positive shock *CM				0.113	
				(1.303)	
Negative shock *CM				1.026	
				(1.156)	
Positive shock *LM					-5.921**
					(2.683)
Negative shock *LM					1.657
					(2.274)
Village fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	17,160	17,160	17,160	17,160	17,160
Number of villages	328	328	328	328	328

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note. The dependent variable is the number of hours children spend on various work activities. A rainfall shock is measured as the absolute value of actual rainfall shocks observed in villages if the rainfall is 1 standard deviation above/ below the historical mean. In model 1, we control for rainfall shock variables only, positive and negative. In model 2, we include additional controls, including the child's age, household size, and village access to credit markets, labor markets and the safety net program (PSNP). In models 3, 4, and 5, we repeat the estimation in model 2 by adding the interaction of rainfall variables with village access to the PSNP and credit market and labor market, respectively.

Table A9: The impact of actual Belg season rainfall shocks on child labor hours (±1SD)

	model 1	model 2	model 3	model 4	model 5
Negative shock	9.909***	9.777***	9.707***	9.233***	7.002
	(3.200)	(3.219)	(3.192)	(3.529)	(4.239)
Village PSNP		-4.900*	-4.912*	-4.972*	-4.042*
		(2.587)	(2.579)	(2.620)	(2.422)
Credit market		-0.062	-0.068	-0.176	0.598
		(2.460)	(2.492)	(2.478)	(2.348)
Labor market		-9.131	-9.122	-9.411	-11.290*
		(6.405)	(6.405)	(6.449)	(6.506)
Child age		0.845***	0.845***	0.845***	0.843***
		(0.136)	(0.136)	(0.136)	(0.136)
Household size		-0.522**	-0.522**	-0.521**	-0.505**
		(0.219)	(0.221)	(0.219)	(0.220)
Negative shock *PSNP			0.155		
			(6.747)		
Negative shock *CM				5.285	
				(3.587)	
Negative shock *LM					15.526**
					(7.755)
Village fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	4,100	4,100	4,100	4,100	4,100
Number of villages	126	126	126	126	126

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note. The dependent variable is the number of hours children spend on various activities. Rainfall shock is measured as the absolute value of actual rainfall shocks observed in villages if rainfall is 1 standard deviation above/ below the historical mean. In model 1, we control only for rainfall shock variables, positive and negative. In model 2, we include additional controls, including the child's age, household size, and village access to the credit market, labor market and safety net program (PSNP). In models 3, 4, and 5, we repeat the estimation in model 2 by adding the interaction of rainfall variables with village access to the PSNP and credit market and labor market, respectively.

Table A10: The impact of Meher season rainfall shocks on child labor (shock=±0.5sd)

	(1) model 1	(2) model 2	(3) model 3	(4) model 4	(5) model 5
Positive shock	1.015	1.154*	2.047**	1.103	1.960**
	(0.650)	(0.642)	(0.842)	(0.723)	(0.840)
Negative shock	-1.167**	-1.079**	-0.913	-1.298**	-0.999
	(0.534)	(0.536)	(0.691)	(0.621)	(0.626)
Village PSNP		1.607	2.774	1.609	1.516
		(2.182)	(2.272)	(2.185)	(2.232)
Credit market		-1.456	-1.314	-2.052	-1.404
		(1.193)	(1.179)	(1.476)	(1.192)
Labor market		3.609	3.843	3.650	6.671*
		(2.858)	(2.867)	(2.861)	(3.631)
Child age		0.808***	0.807***	0.808***	0.809***
		(0.088)	(0.088)	(0.088)	(0.088)
Household size		-0.386***	-0.383***	-0.387***	-0.385***
		(0.116)	(0.116)	(0.115)	(0.115)
Positive shock *PSNP			-2.601**		
			(1.137)		
Negative shock *PSNP			-0.361		
			(1.040)		
Positive shock *CM				0.309	
				(1.335)	
Negative shock *CM				0.988	
				(1.229)	
Positive shock *LM					-5.124*
					(2.718)
Negative shock *LM					-0.880
					(2.335)
Village fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	17,160	17,160	17,160	17,160	17,160
Number of villages	328	328	328	328	328

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Note. The dependent variable is the number of hours children spend on various activities. Rainfall shock is measured as the absolute value of actual rainfall shocks observed in villages when rainfall is 0.5 standard deviations above or below the historical mean. In model 1, we control for rainfall shock variables only, positive and negative. In model 2, we include additional controls, including the child's age, household size, and village access to the credit market, labor market and safety net program (PSNP). In models 3, 4, and 5, we repeat the estimation in model 2, adding the interaction of rainfall variables with village access to the PSNP and credit market and labor market, respectively.

Table A11: The impact of Belg season rainfall shocks on child labor (shock=±0.5sd)

VARIABLES	(1) model 1	(2) model 2	(3) model 3	(4) model 4	(5) model 5
Positive shock	3.663***	3.596***	3.596***	3.596***	3.597***
	(0.000)	(0.014)	(0.014)	(0.014)	(0.014)
Negative shock	5.865***	5.611***	5.190**	6.305***	2.304
	(1.847)	(1.710)	(2.064)	(2.219)	(2.532)
Village PSNP		-6.327**	-6.762**	-6.086**	-6.165**
		(2.821)	(3.351)	(2.867)	(2.643)
Credit market		-1.772	-1.822	-0.866	-1.078
		(2.214)	(2.270)	(2.887)	(1.836)
Labor market		-3.715	-3.642	-3.510	-12.531*
		(5.930)	(5.999)	(5.913)	(6.619)
Child age		0.843***	0.845***	0.845***	0.833***
		(0.135)	(0.135)	(0.136)	(0.135)
Household size		-0.534**	-0.535**	-0.534**	-0.523**
		(0.218)	(0.219)	(0.218)	(0.220)
SPI_belg_nshockdmy1_PSNP			0.948		
			(3.988)		
SPI_belg_nshockdmy1_CM				-2.781	
				(4.174)	
SPI_belg_nshockdmy1_LM					15.056**
					(6.458)
Village fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	4,100	4,100	4,100	4,100	4,100
Number of villages	126	126	126	126	126

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note. The dependent variable is the number of hours children spend on various activities. Rainfall shock is measured as the absolute value of actual rainfall shocks observed in villages where the rainfall is 0.5 standard deviations above or below the historical mean. In model 1, we control only for rainfall shock variables, positive and negative. In model 2, we include additional controls, including the child's age, household size, and village access to the credit market, labor market, and safety net program (PSNP). In models 3, 4, and 5, we repeat the estimation in model 2, by adding the interaction of rainfall variables with village access to the PSNP and credit market and labor market, respectively.

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