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# Impact of Ethiopia's 2015 drought on child undernutrition

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## ABSTRACT

In 2015, Ethiopia experienced one of its worst droughts in decades. Using nationally representative data from before and after this event, we find that this drought did not lead to widespread increases in chronic or acute child undernutrition rates in the country. However, chronic undernutrition rates increased due to the drought in areas characterized by limited road network. Moreover, the share of households receiving humanitarian aid doubled in drought-affected areas. Together, these findings highlight the role of road infrastructure in contributing to resilience as well as the efficiency of the humanitarian system in delivering and targeting aid in the country.


## 1. INTRODUCTION

Recent research in the area of climate change suggests that droughts will become more frequent phenomena in many sub-Saharan African countries (Dai 2013). Therefore, one of the key questions that these developing country governments and the development community faces is how to build resilience against these recurrent weather anomalies.

This question is particularly relevant for Ethiopia – a country still remembered by the drought-triggered famines in the 1970s and early 1980s. Econometric evidence suggests that these droughts had a devastating effect on child growth outcomes. Using long panel data from rural Ethiopia, Dercon and Porter (2014) find that children who were exposed to the 1984 drought ended up about 5 cm shorter as adults compared to their peers who were not affected. Research by Tafere (2016) suggests that the same famine negatively affected the growth and educational outcomes even of the next generation. Furthermore, other research shows how less widespread rainfall shocks in 1990s had a considerable – and persistent – impact on child growth outcomes (Yamano, Alderman, and Christiaensen 2005) and household consumption (Dercon 2004; Dercon, Hoddinott, and Woldehanna 2005; Porter 2012) in rural Ethiopia.

But Ethiopia has come a long way since the 1980s and 1990s. Indeed, the country has witnessed a remarkable transformation in many economic and socio-economic sectors over the last 15 years. For example, the real growth of Gross Domestic Product (GDP) averaged about 11 percent per annum between 2004 and 2014 (World Bank 2015). During the same period, both official and unofficial agricultural data show considerable improvements in staple crop yields (Bachewe et al. 2017). Moreover, poverty rates fell (Stifel and Woldehanna 2016), living conditions improved (Hirvonen 2017), and the share of chronically undernourished (stunted) children declined from 52 percent in 2000 to 38 percent in 2016 (CSA and ICF 2016). Meanwhile, the government of Ethiopia together with its development partners made considerable investments in social safety nets (e.g., Wiseman, Van Domelen, and Coll-Black 2010), health systems (e.g., Workie and Ramana 2013) and road infrastructure (Minten, Stifel, and Tamru 2014). If development contributes to resilience (Hoddinott 2014; Béné et al. 2016), Ethiopia may well be more equipped to face such droughts now than two or three decades ago.

This paper sets out to test this hypothesis. In 2015, Ethiopia experienced one its worst droughts in recent decades. Lack of rainfall during the main cropping seasons led to poor harvests, especially in the eastern part of the country. The rains failed in the Afar region and in parts of the Ethiopian highlands and the northern part of the Somale region, leading to extremely poor harvests in these areas (CSA 2016). A major humanitarian response followed, with more than 10 million people[1] reported to be in need of food aid (GoE and Ethiopia Humanitarian Country Team 2016).

[1] This number does not include those 8 million people who were benefitting from Productive Safety Net Programme during 2015.

Using nationally representative data collected before (2014) and after (2016) the drought, we assess how this drought affected growth outcomes of children less than 5 years of age. The focus on this outcome, child undernutrition, is important in its own right, but also has implications for the long-term growth and development of the country through its implications on the human capital and economic productivity of future generations (Behrman, Alderman, and Hoddinott 2004). Reflecting these ideas, Horton and Steckel (2013) estimate that each year sub-Saharan Africa countries lose, on average, 11 per cent of their Gross National Product because of poor nutrition. Therefore, improving child undernutrition may translate into better resilience in the future.

Based on a difference in difference estimator on nationally representative data before and after the drought, we cannot reject the hypothesis that drought had no impact on children's heights (relative to age) or weights (relative to height), measured approximately 6 months after the drought. These results are remarkably robust to different ways of defining drought.

Overall, this finding is in stark contrast with the earlier research on the droughts that occurred in the 1980s and 1990s. In unpacking these results further, our results indicate that better road infrastructure may have mitigated the impact of the drought. We find that the 2015 drought had a negative impact in districts characterized by limited primary road networks. Moreover, we also find that the share of households receiving food aid increased considerably in the drought affected areas, providing suggestive evidence on the effectiveness of the humanitarian response system in delivering food aid in Ethiopia, at least with respect to targeting.

This paper is organized as follows. Section 2 provides an overview of the context. In Section 3 we discuss the data used in the analysis and present some descriptive analysis. Section 4 outlines the econometric strategy, and section 5 presents the results. Robustness of the core findings are discussed in Section 6. In Section 7 we assess heterogeneity by road access and study how the drought affected aid flows in the country. Section 8 concludes.

## 2. CONTEXT

About 80 percent of the near 100-million Ethiopians reside in rural areas and more than 80 percent of the adult population engage in agricultural activities (CSA 2005, 2010). Ethiopian farmers mainly rely on rain-fed agriculture (Awulachew, Erkossa, and Namara 2010), and as a result, agricultural output remains highly vulnerable to weather anomalies. The main agricultural areas of the country have two rainy seasons. The small rainy season (*belg*) typically occurs between March and May and the main rainy season (*meher*) between June and September. *Meher* is the most important season for agricultural production with more than 90 percent of the total cereal production in the country taking place during this season (Taffesse, Dorosh, and Gemessa 2012).

To date, a small number of studies has attempted to understand the welfare impacts of the 2015 drought in Ethiopia. The Central Statistical Agency (CSA) of Ethiopia estimates that, compared to the previous year, the grain production in the country decreased only by 1.3 percent (3.5 million quintals) during the main agricultural season (meher) in 2015 (CSA 2016). Of note, however, is that this national level estimate masks considerable regional variation. The grain output in Oromia and Amhara – the two regions responsible for about 80 percent of the total grain production in the country – remained the same compared to the previous season. At the same time, production fell by 66 percent in Afar, 30 percent in the Gambella region, 25 percent in Somale, and 10 percent in Tigray (CSA 2016). Finally, Bachewe et al. (2016) find no evidence of large-scale effects of the drought on cereal prices. These results suggest that the cereal markets in Ethiopia are relatively well integrated – a finding also documented in earlier work (Rashid and Negassa 2011; Minten et al. 2014). An alternative hypothesis is that the food aid – which is largely imported – received by the affected areas (see AKLDP 2016b) was sufficient to stabilize cereal prices.

## 3. DATA AND DESCRIPTIVE ANALYSIS

Our data come from the Ethiopian Socioeconomic Survey (ESS). ESS is a longitudinal survey conducted by the CSA and the World Bank Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) team (CSA and World Bank 2013, 2015). The survey now spans three rounds: 2012, 2014 and 2016.[2]

For the current study, we use the latest two rounds of data from 2014 and 2016. In what follows, we use these data to compare the anthropometric outcomes (heights, weights) of a cohort of young children before (2014) and after (2016) the 2015 drought. Moreover, the survey is widespread, having been implemented in all 11 administrative regions of Ethiopia. As a result, our data set covers communities that were seriously exposed to the 2015 drought and communities that were less exposed. Our difference in difference approach exploits both the temporal nature and the wide geographical coverage of the survey. We restrict the analysis to rural areas, as the populations there are highly reliant on rainfed agriculture for their main livelihood. Further details on sampling can be found in CSA, NBE, and World Bank (2017).

One of the key decisions in this type of analysis is how to measure drought. Previous literature from Ethiopia has adopted a variety of measures to capture weather anomalies ranging from respondent self-reports (Dercon et al. 2005; Porter 2012; Dercon and Porter 2014) to local weather observations obtained from local weather stations or satellites (Yamano et al. 2005; Thiede 2014). For our main drought measure[3], we use the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) rainfall estimates (see Funk et al. 2015).[4] These data come with different spatial and temporal resolutions. We opt for a spatial resolution of around 5 km (at the equator) and a temporal resolution of one month. We then merge these rainfall data with household latitude and longitude coordinates using an inverse-distance weighted average of the four nearest satellite observations. Following previous literature, we define drought using rainfall z-scores observed in 2015.[5] We focus on the rainfall observed during the meher season between June and September. In order to minimize the role of measurement error in household GPS-coordinates, we further take the mean z-score at the Enumeration Area (EA) level.

Figure 3.1 maps this z-score value together with the survey locations (enumeration areas). We see that the central and north-east parts of the country was particularly badly hit by the drought. Figure 3.2 shows how the total rainfall during the meher season was well below historical averages. Compared to historical rainfalls, the rainfall during the belg season was also below average, but less so compared to the meher season. In what follows, we define drought-exposed areas as those for which the annual rainfall during the meher season was below -2 standard deviations. Assuming a normal distribution, such a drought occurs approximately once in every 40 years, on average.

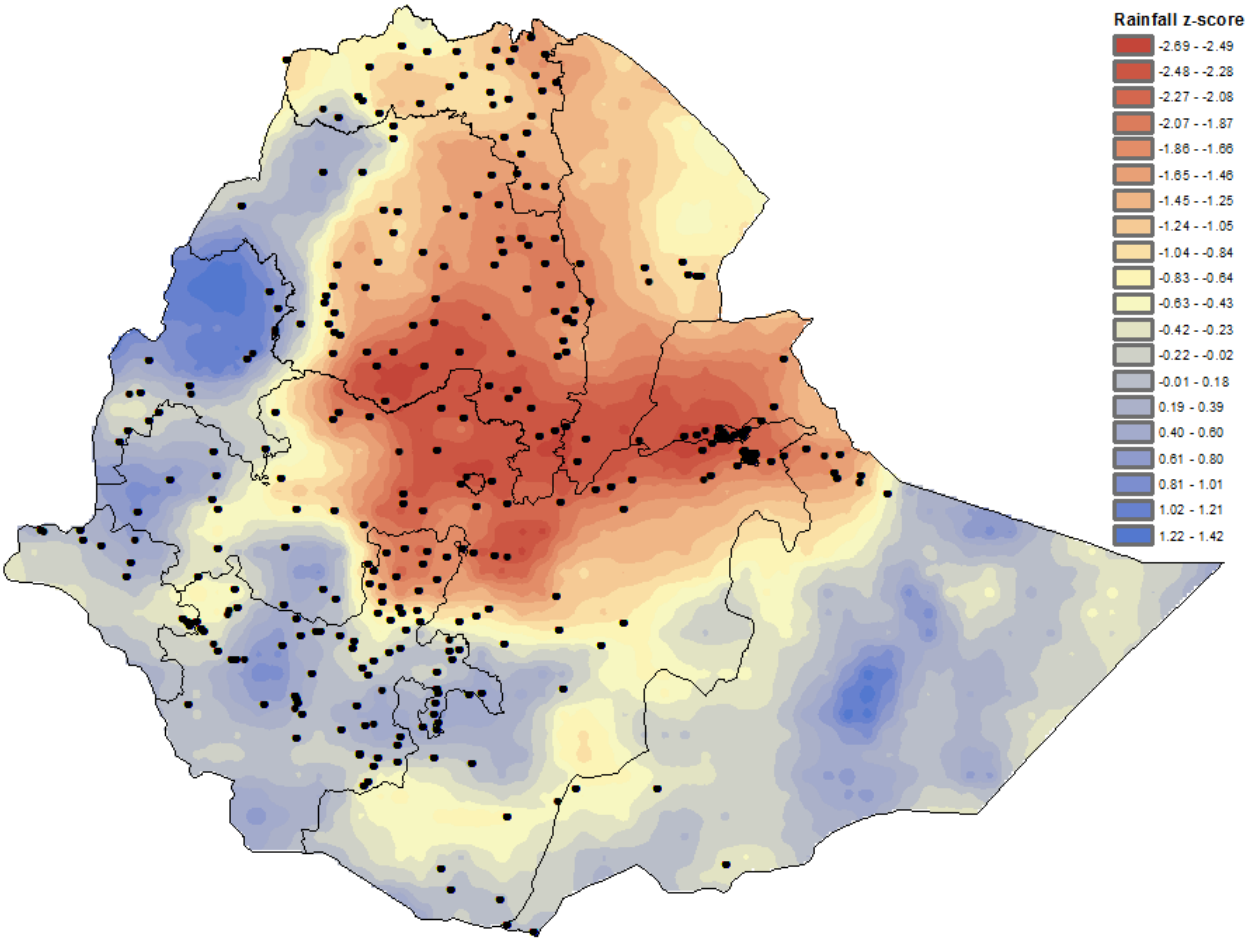
[2] The 2012 round is representative of rural and small-town areas of the country, the two recent ones are representative of the whole country, including large urban areas.

[3] We consider several alternative drought measures in Section 6.

[4] For a given geographical area, the quality of the weather data depends on the number of active weather stations. Across the globe, including Africa, the number of active weather stations has been in steady decline over the past decades (Lorenz and Kunstmann 2012). Thus, satellite observations provide a valuable resource for areas with a sparse station network.

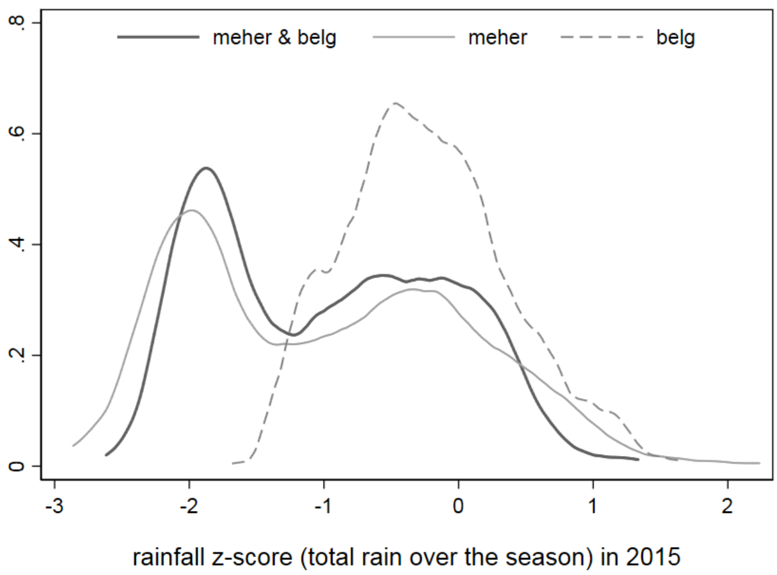
[5] We calculate rainfall z-scores by subtracting long-term mean rainfall for the season from the observed rainfall for the season and dividing this difference by the location specific standard deviation of rainfall calculated from the long-term rainfall series.

**Figure 3.1. Rainfall deviations during the meher season in 2015, z-score**




Source: Authors' calculation from CHIRPS rainfall data. The dark dots are survey locations (Enumeration Areas).

**Figure 3.2. Distribution of rainfall in 2015 in the sample, z-score**




Source: Authors' calculation from CHIRPS rainfall data.

The survey instrument also included a module on shocks that the household experienced in the past 12 months. Table 3.1 shows how the share of households reporting a drought shock increased markedly between 2014 and 2016 in areas affected by the 2015 drought (based on the CHIRPS rainfall data).[6] Elsewhere in the questionnaire, the respondents were asked whether, in the last 12 months, they experienced a situation where they did have enough food to feed the household. Interestingly, food security *improved* in this sample between 2014 and 2016 despite the drought (Table 3.2). Moreover, regional comparison of Tables 3.1 and 3.2 suggests that the 2015 drought did not substantially increase (self-reported) food insecurity in drought-affected areas.

**Table 3.1. Share of households exposed to drought, by data source and region**

| Data source: | CHIRPS | Household self-reports: | | |
|---|---|---|---|---|
| Region | 2015 | 2014-round | 2016-round | difference |
| Afar | 0.44 | 0.14 | 0.72 | 0.58 |
| Amhara | 0.59 | 0.11 | 0.27 | 0.17 |
| Benishangul-Gumuz | 0.00 | 0.00 | 0.00 | 0.00 |
| Dire Dawa | 0.94 | 0.23 | 0.82 | 0.59 |
| Gambella | 0.00 | 0.00 | 0.07 | 0.07 |
| Harari | 0.63 | 0.01 | 0.77 | 0.76 |
| Oromia | 0.26 | 0.07 | 0.23 | 0.16 |
| SNNP | 0.04 | 0.03 | 0.24 | 0.21 |
| Somali | 0.07 | 0.51 | 0.75 | 0.24 |
| Tigray | 0.12 | 0.14 | 0.41 | 0.27 |

Note: These estimates are based on sampling weights. Rainfall shock in CHIRPS column is defined as rainfall z-score below -2 standard deviations from the long-term mean. SNNP= Southern Nations, Nationalities, and Peoples' Region.

**Table 3.2. Share of households reporting hunger in the past 12 months, by survey round and region**

| Region | 2014-round | 2016-round | difference |
|---|---|---|---|
| Afar | 0.17 | 0.24 | 0.06 |
| Amhara | 0.33 | 0.16 | -0.18 |
| Benishangul-Gumuz | 0.33 | 0.17 | -0.16 |
| Dire Dawa | 0.50 | 0.40 | -0.10 |
| Gambella | 0.11 | 0.22 | 0.11 |
| Harari | 0.15 | 0.16 | 0.01 |
| Oromia | 0.29 | 0.33 | 0.04 |
| SNNP | 0.47 | 0.48 | 0.01 |
| Somali | 0.46 | 0.47 | 0.02 |
| Tigray | 0.33 | 0.22 | -0.11 |
| All regions | 0.35 | 0.31 | -0.04 |

Note: These estimates are based on sampling weights. SNNP= Southern Nations, Nationalities, and Peoples' Region.

The survey team took anthropometric measures (height and weight) of children between 6 and 59 months of age in all rounds. We converted these data – children's heights and weights – into z-scores using the WHO growth standards (WHO 2006; de Onis et al. 2007). These growth standards permit us to assess child height and weight relative to well-nourished children of the same age and sex. [7] As our main outcome variables we use height-for-age z-score (HAZ) and weight-for-height (WHZ). Low HAZ is a marker for chronic undernutrition – an outcome of prolonged inadequate food intake or infection. Programmatically, children are considered chronically undernourished (stunted) if their HAZ is below -2. In contrast, low WHZ value is a

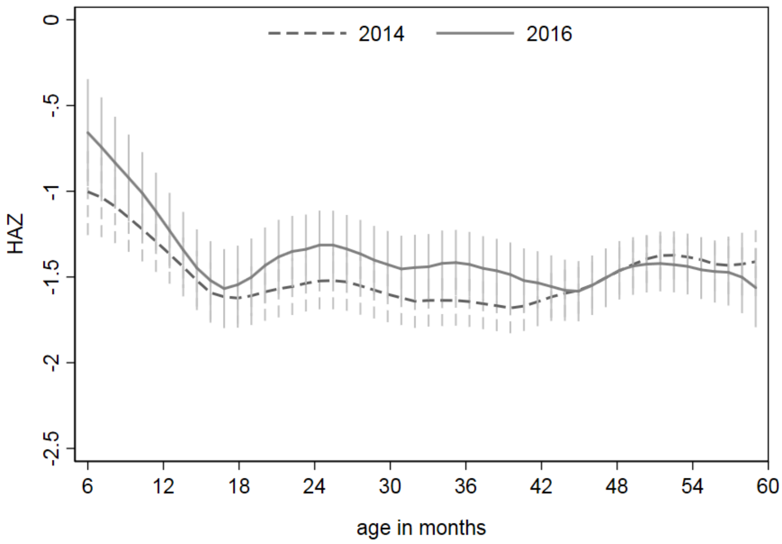
[6] It is likely that households are more likely to report shocks that had a negative welfare effect on them (Dex 1995; De Weerdt 2008). If so, this will lead to an upward bias in estimating the negative welfare impacts of droughts. It is for this reason, we measure drought using satellite observations. However, in the online appendix we show that our results are also robust to defining drought using household self-reports.

[7] We used the user-written *zanthro06* command (Leroy 2011) in Stata 15.0 to construct the Z-scores. Z-score values below -5 and above +5 were considered as biologically implausible and not used in the analysis.

marker for acute undernutrition capturing inadequate nutritional intakes during the period immediately before the measurements. Children whose WHZ is below -2 are classified as wasted. While child stunting and wasting share some of the same causal factors (e.g., inadequate diet, infectious diseases), the direct relationship between them remains poorly understood. The available evidence, reviewed in Khara and Dolan (2014), suggests that wasting in the previous 3 months or so will negatively affect attained height.

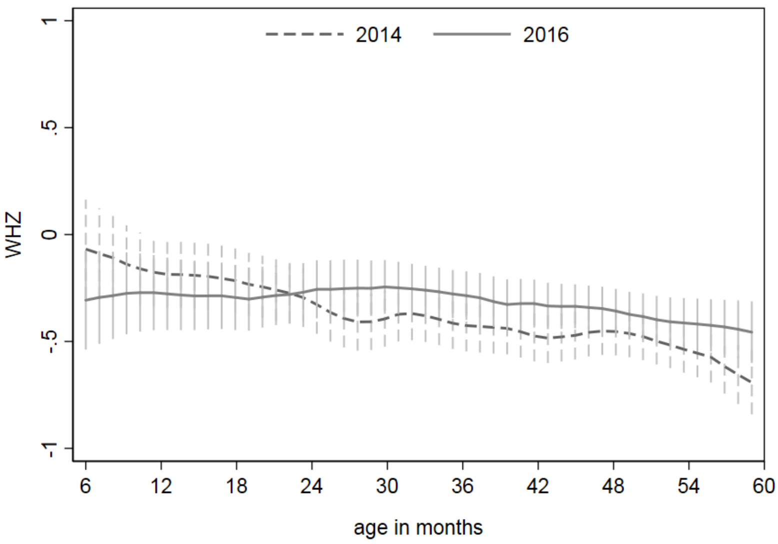
Figure 3.3a shows the HAZ-age relationship for the cohort measured in 2014 before the drought and the cohort measured in 2016 after the drought. First, we see that the children in our sample follow the usual dynamics of growth faltering observed in other low income countries (Victora et al. 2010): HAZ declines rapidly during the first 2 years of life after which it stabilizes. Second, for almost all age groups, the average HAZ curve for 2016 lies above the corresponding curve for the 2014 cohort. While the confidence intervals overlap, this suggest that the impacts of the 2015 drought on chronic undernutrition were – if anything – marginal. Figure 3.3b shows the same relationship for WHZ. Again, there is little convincing evidence that the post-drought cohort is worse-off compared to the pre-drought cohort.

**Figure 3.3a. Height-for-age z-score by child age**




Note: Local polynomial regression. Sample is formed of 1,913 children 6-59 months in 2014 and 1,745 children 6-59 months in 2016 round. The grey vertical bars represent 95%-confidence intervals.

**Figure 3.3b. Weight-for-height z-score by child age**



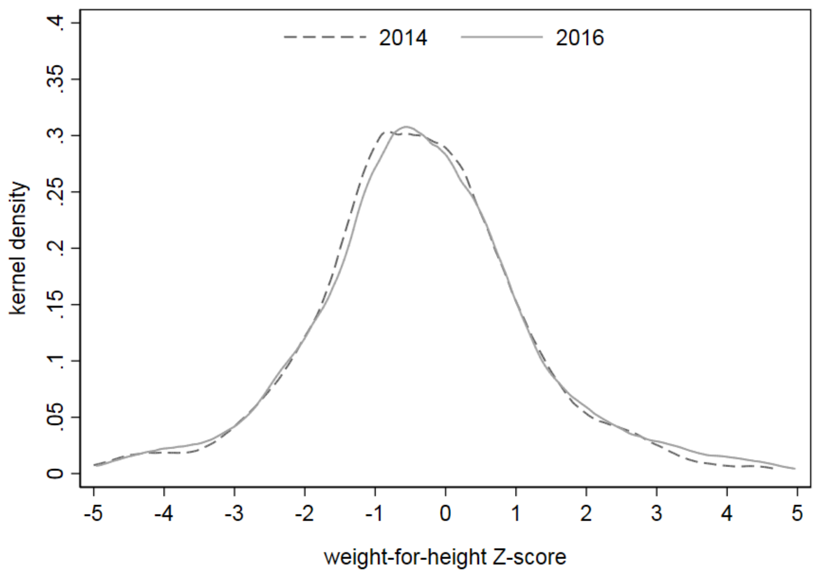

Note: Sample is formed of 1,998 children 6-59 months in 2014 and 1,854 children 6-59 months in 2016 round. The grey vertical bars represent 95%-confidence intervals.

Figure 3.4a further displays the HAZ distributions for both cohorts. Both distributions are skewed to the left. The distributions lie almost on top of each other again suggesting that the 2015 drought did not have a widespread impact on children's HAZ scores. Figure 3.4b shows the same for WHZ.

**Figure 3.4a. Height-for-age z-score distributions by survey round**


Note: Sample is formed of 1,913 children 6-59 months in 2014 and 1,745 children 6-59 months in 2016 round.

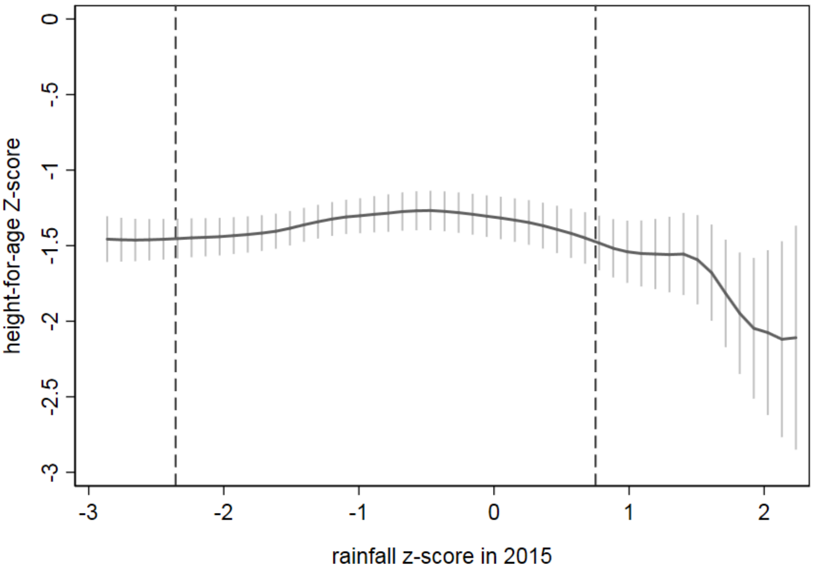
**Figure 3.4b. Weight-for-Height z-score distributions by survey round**




Note: Sample is formed of 1,998 children 6-59 months in 2014 and 1,854 children 6-59 months in 2016 round.

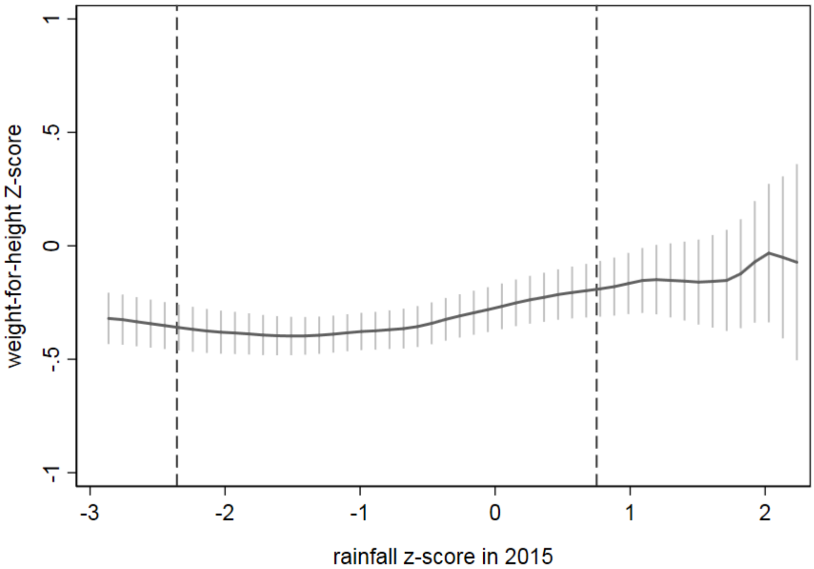
In Figure 3.5a we look at the association between the HAZ scores in 2016 and rainfall in 2015. The local polynomial regression line is nearly flat implying that children residing in drought-exposed areas did not have worse HAZ scores in 2016 compared to children who were not (or were less) exposed to the 2015 drought. The same local polynomial regression based on WHZ also shows a relatively a flat relationship between WHZ and rainfall z-score. However, we see a small increase for the better part of the rainfall distribution (rainfall z-score>-1). In the subsequent sections, we test whether the story arising from these simple associations holds when we control for various factors that may be correlated with children's HAZ and drought exposure.

**Figure 3.5a. Association between children's HAZ in 2016 and rainfall in 2015**




Note: Local polynomial regression. Sample: 1,745 children 6-59 months in 2016 round. The grey vertical bars represent 95%-confidence intervals. Dashed lines represent bottom and top 5% of the rainfall z-score distribution.

**Figure 3.5b. Association between children's WHZ in 2016 and rainfall in 2015**




Note: Local polynomial regression. Sample: 1,854 children 6-59 months in 2016 round. The grey vertical bars represent 95%-confidence intervals. Dashed lines represent bottom and top 5% of the rainfall z-score distribution.

## 4. METHODS

The data available to us give rise to a difference in difference (DiD) estimator (e.g., Meyer 1995). The DiD estimator requires data for at least two time periods and from both the treated and un-treated groups. Here, the 'treated group' refers to cohorts of children who reside in drought-exposed areas and the 'un-treated group' to cohorts of children who reside in other, non-exposed, areas. For both groups, we have observations before, i.e., 2014, and after the drought, i.e., 2016. As a result, we can compare the change in anthropometric outcomes in 2014 and 2016 between the treated and un-treated cohorts of children. [8]

More formally, we use the following specification to model the anthropometric outcome (height-for-age or weight-for-age z-score) of a child *i* residing in EA *w* of region *r* and observed in year *t* ($Y_{irwt}$):

$$Y_{irwt} = \beta_1 D_{irw} + \beta_2(\mathrm{T}_t * D_{irw}) + (\mathrm{T}_t * R_r)'\delta + X'_{irw}\gamma + \omega + \varepsilon_{irwt}, \qquad (1)$$

where $D_{irw}$ is a binary variable capturing a value of 1 if the 2015 rainfall z-score for the EA was below -2 and zero otherwise. $T_t$ is a binary variable obtaining a value of 1 if the child is observed in 2016 round, and zero otherwise and $R_r$ is a vector of binary variables for each region. The interaction of these two sets of variables ($T_t * R_r$) controls for region-specific time trends. The impact of the drought on a child's HAZ is measured by $\beta_2$; the coefficient on the interaction between $D_{iwr}$ and $T_t$ variables.

Furthermore, $X'_{irw}$ is a vector of child and household specific characteristics; spline function of child age in months[9] and sex, household size, the dependency ratio, highest education level in household, and gender and the age of the household head.[10] We also include enumeration area fixed effects (ω) to the equation that control for time-invariant characteristics fixed to the EA. The last term in the equation, $\varepsilon_{irwt}$, is the error term. Finally, we cluster our standard errors at the EA level.

Table 4.1 provides summary statistics for 2014 for children residing in areas that were not affected and were affected, respectively, by the 2015 drought. Comparison of the summary statistics across the two sub-samples shows that the sample is well balanced for our outcome variable – the difference in the anthropometric outcomes (HAZ, stunting, WHZ, wasting) are not statistically different from zero. This suggests that the 2015 drought did not hit (sampled) localities that had higher (or lower) chronic or acute undernutrition rates to begin with. However, we do see differences in some household characteristics. Households residing in localities that were affected by the 2015 drought had marginally lower dependency ratios, older household heads, and better access to electricity and safe water sources, but poorer access to toilets. In what follows, we control for these differences in our regression analysis.

[8] Of note is that conventional panel methods (i.e. child or household level fixed effects) are not suited to this exercise. This is because children 'age-out' of the sample; the older children observed in 2014 were not measured in 2016. Moreover, growth faltering typically occurs in the first two years of life (Victora et al. 2010) and therefore studying the impacts on older children is considered less informative. It is for this reason that randomized controlled trials involving children in the nutrition literature are often based on cohort comparisons, rather than on longitudinal samples.

[9] Due to inadequate diets or repeated infections (or both), rapid growth faltering typically occurs in the first two years of life. As a result, in poor countries, HAZ has a non-linear relationship with child age (Victora et al. 2010), roughly until the 24 months, after which the HAZ scores stabilize. Failure to model this properly may lead to biased estimates of $\beta_3$ (Cummins 2013). Here, we model this relationship using a spline function of child's age in months with knots at 12, 18 and 24 months.

[10] We are careful not to include variables that may have been affected the treatment (drought). For example, households in Ethiopia typically respond to shocks by selling off their assets; e.g., livestock and durable assets. Including variables that could be considered themselves as outcome variables are labelled as 'bad controls' in the literature. The inclusion of such variables mean that the coefficient on our treatment variable would no longer have a causal interpretation (see Angrist and Pischke 2009, pp. 64-68).

**Table 4.1. Summary statistics in 2014 before the drought**

| | non-drought mean (std. dev.) | drought mean (std. dev.) | difference |
|---|---|---|---|
| height-for-age z-score (HAZ) | -1.502 | -1.537 | 0.035 |
| | (1.764) | (1.635) | |
| child is stunted (0/1) | 0.413 | 0.407 | 0.006 |
| | (0.492) | (0.492) | |
| weight-for-height z-score (WHZ) | -0.469 | -0.401 | -0.068 |
| | (1.408) | (1.354) | |
| child is wasted (0/1) | 0.118 | 0.0964 | 0.022 |
| | (0.323) | (0.295) | |
| age in months | 33.44 | 34.06 | -0.620 |
| | (15.21) | (15.17) | |
| female child (0/1) | 0.496 | 0.482 | 0.014 |
| | (0.500) | (0.500) | |
| household size | 6.252 | 6.198 | 0.054 |
| | (2.097) | (1.901) | |
| dependency ratio | 0.590 | 0.573 | 0.017** |
| | (0.133) | (0.126) | |
| highest level of education (in years) in household | 4.290 | 4.248 | 0.042 |
| | (3.369) | (3.411) | |
| female headed household (0/1) | 0.111 | 0.0867 | 0.024 |
| | (0.314) | (0.282) | |
| age of the household head | 38.63 | 40.34 | -1.710*** |
| | (11.26) | (11.79) | |
| household has access to electricity (0/1) | 0.137 | 0.224 | -0.087*** |
| | (0.344) | (0.417) | |
| household has access to safe water source (0/1) | 0.528 | 0.573 | -0.045* |
| | (0.499) | (0.495) | |
| household uses a toilet (0/1) | 0.570 | 0.470 | 0.100*** |
| | (0.495) | (0.500) | |
| Number of observations (children 6-59 months) | 1,459 | 415 | |

Note: (0/1) indicates a binary (dummy) variable. Equality in means tested using a two-sample t test with unequal variances. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1. Standard deviations in parentheses.

## 5. RESULTS

Table 5.1 provides the results. Column 1 estimates Equation (1) without controls for child and household level characteristics ($X'_{iw}$) and EA-level fixed effects (ω). In column 2, we include EA-level fixed effects, but exclude child and household level controls. In column 3, we add the child and household level controls but exclude the EA-level fixed effects. Finally, column 4 provides the results based on the full specification based on Equation (1).

**Table 5.1. Impact of the 2015 drought on children's height-for-age and weight-for-height z-scores**

| Panel A: Dependent variable: HAZ | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Drought * 2016 round | -0.055 | -0.027 | -0.096 | -0.077 |
| | (0.170) | (0.172) | (0.166) | (0.168) |
| Drought | 0.092 | n/a | 0.092 | n/a |
| | (0.147) | | (0.141) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.022 | n/a | 0.048 | n/a |
| Within-$R^2$ | n/a | 0.007 | n/a | 0.027 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |
| **Panel B: Dependent variable: WHZ** | **(5)** | **(6)** | **(7)** | **(8)** |
| Drought * 2016 round | 0.166 | 0.227 | 0.136 | 0.208 |
| | (0.142) | (0.157) | (0.143) | (0.157) |
| Drought | 0.074 | n/a | 0.060 | n/a |
| | (0.114) | | (0.114) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.057 | n/a | 0.071 | n/a |
| Within-$R^2$ | n/a | 0.012 | n/a | 0.022 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Unit of observation is a child 6-59-months. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

In panel A, we use HAZ as our outcome variable. The $\beta_2$ coefficient capturing the impact of the drought appears with *a priori* correct sign; children residing in areas exposed to the drought have lower height-for-age z-scores. However, in each column the magnitude of the coefficient is small and, importantly, not statistically different from zero. [11] This means that we cannot reject the (null) hypothesis that the 2015 drought had no impact on children's (age and sex adjusted) height. In panel B, we use WHZ as our outcome variable. The coefficient is counter-intuitively positive in all specifications but remains statistically insignificant. [12]

In Table 5.2 we look at stunting and wasting instead of HAZ and WHZ. Here the outcome variable obtains a value of one if child's HAZ or WHZ is below -2, and zero otherwise. In panel A (stunting), the coefficient is small (ranging between 3 to 4 percentage points) and not statistically different from zero. The results in panel B (wasting) are similar: the estimated impact is small and not statistically significant.

[11] The p-values range between 0.310 and 0.586 across the four columns in Panel A.

[12] The p-values range between 0.148 and 0.344 across the four columns in Panel B.

**Table 5.2. Impact of the 2015 drought on child stunting and wasting**

| Panel A: Dependent variable: 1 child is stunted, 0 otherwise | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Drought * 2016 round | 0.033 | 0.013 | 0.042 | 0.023 |
| | (0.046) | (0.046) | (0.045) | (0.046) |
| Drought | -0.039 | n/a | -0.031 | n/a |
| | (0.038) | | (0.036) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.024 | n/a | 0.047 | n/a |
| Within-$R^2$ | n/a | 0.006 | n/a | 0.021 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |
| **Panel B: Dependent variable: 1 child is wasted, 0 otherwise** | **(1)** | **(2)** | **(3)** | **(4)** |
| Drought * 2016 round | -0.009 | -0.011 | -0.007 | -0.010 |
| | (0.029) | (0.031) | (0.029) | (0.031) |
| Drought | -0.026 | n/a | -0.020 | n/a |
| | (0.023) | | (0.022) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.026 | n/a | 0.036 | n/a |
| Within-$R^2$ | n/a | 0.007 | n/a | 0.013 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Unit of observation is a child 6-59-months. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

## 6. ROBUSTNESS

We explored the robustness of these findings in various ways.

- These results are robust to different ways of defining drought. These include measuring drought using a vegetation (or greenness) index, household or community self-reports, government and donor categorization of food insecure *woredas* (districts), or considering rainfall during the belg season. All these results are provided and discussed in the Appendix A.
- Our results are robust to using the sampling weights that come with the survey (Appendix B).
- The impact on child growth outcomes will likely depend on the child's age. The nutrition literature places a strong focus on children less than 24 months of age. This is a period during which child's physical development is most vulnerable to poor nutrition. Here, the choice of the age range is difficult because we cannot accurately pinpoint the period during which the drought started to have an impact on household's or children's food consumption. We therefore restricted the sample to different age intervals to assess whether some age-cohorts were negatively affected by the drought. Across seven different age intervals, we cannot reject the null hypothesis that the drought had no impact on anthropometric outcomes (Appendix C).
- We assessed whether the impact differs by child's sex, but find no statistically significant impacts (Appendix D).
- We considered an alternative anthropometric outcome, weight-for-age z-scores, but found no evidence that the drought had a statistically significant effect on this outcome either (Appendix E).

- We repeated the exercise using the Ethiopia Demographic and Health Survey data. Using the 2011 and 2016 DHS rounds, we again do not detect any significant impacts of the drought on children's anthropometric outcomes – even if we split the sample to narrow age brackets (Appendix F).

## 7. EXTENSIONS: THE ROLE OF ROAD NETWORKS, SAFETY NETS, AND HUMANITARIAN RELIEF

In contrast to the devastating droughts witnessed in earlier decades, the analysis carried out so far suggest that the 2015 drought did not lead to widespread increases in chronic or acute undernutrition rates in the drought-exposed areas. In this section, we attempt to understand why by considering three aspects – road infrastructure, safety nets, and humanitarian relief (food aid) – that may have contributed to improved resilience against droughts.

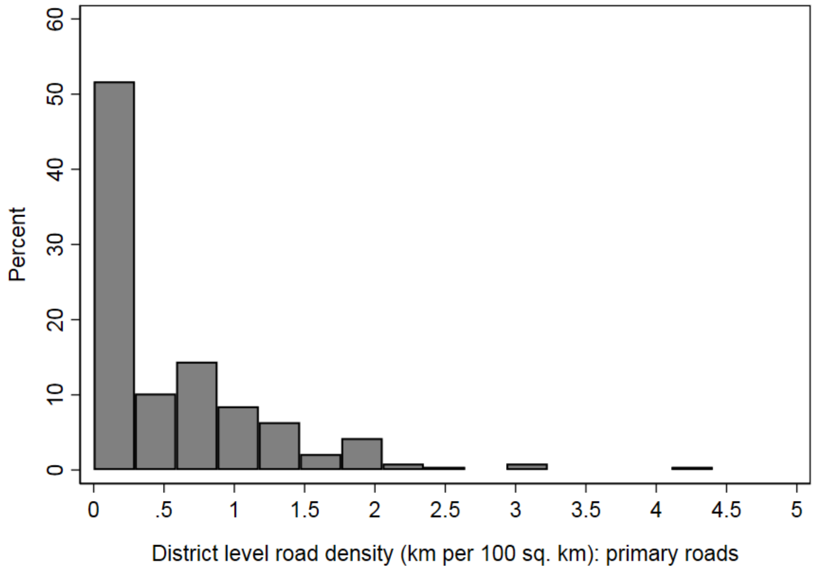
Over the past decade, the Ethiopian government has invested heavily in improving the road infrastructure in the country (Minten et al. 2014). Better road networks are typically associated with lower transactions costs for traders to move food across the country (Minten and Kyle 1999; Khandker, Bakht, and Koolwal 2009). This is likely to also apply to aid organizations. Using data from Nepal and Uganda, Shively (2017) shows how better transportation infrastructure mitigates the negative impact of rainfall shocks on child undernutrition rates. The econometric evidence presented by Hill and Fuje (2016) suggests that past weather shocks in Ethiopia had a smaller impact on grain prices in woredas that saw improvements in road infrastructure compared to those that did not. Shively and Thapa (2017) find similar evidence from Nepal.[13]

To explore heterogeneity across road access, we first use the density of primary roads (or highways) in woredas. Figure 7.1 shows the corresponding distribution across the 236 rural woredas in our sample. We see that more than 50 percent of the woredas have no primary roads. To explore whether the impact of the drought varies by the road network in the district, we split the sample into woredas that have no primary road network and woredas with some primary road network.[14] We then re-estimated Equation (1) by interacting this binary road density variable with the treatment variable. Table 7.1 provides the results. We find that the drought had a negative impact on child undernutrition rates in districts characterized by poor primary road network. In these districts, HAZ scores declined, on average, by 0.5 units of standard deviation because of the drought ($p = 0.057$). The corresponding impact on stunting is about 13 percentage points ($p = 0.042$). Meanwhile, the F-tests show that the estimated impacts on HAZ and stunting are not statistically different from zero in districts that had a relatively better road network. Interestingly, we find no negative impacts when we look at measures of acute undernutrition: WHZ and wasting. Counter-intuitively, WHZ increased in districts with poor road network. This raises some concerns about the robustness of this finding.

[13] Previous work from rural Ethiopia finds that improvements in road infrastructure are associated with better consumption outcomes and food security (Dercon et al. 2009; Stifel, Minten, and Koru 2016).

[14] 63 % of the drought-affected children were located in districts with some primary roads. The corresponding figure for children whore resided in unaffected areas is 54 %.

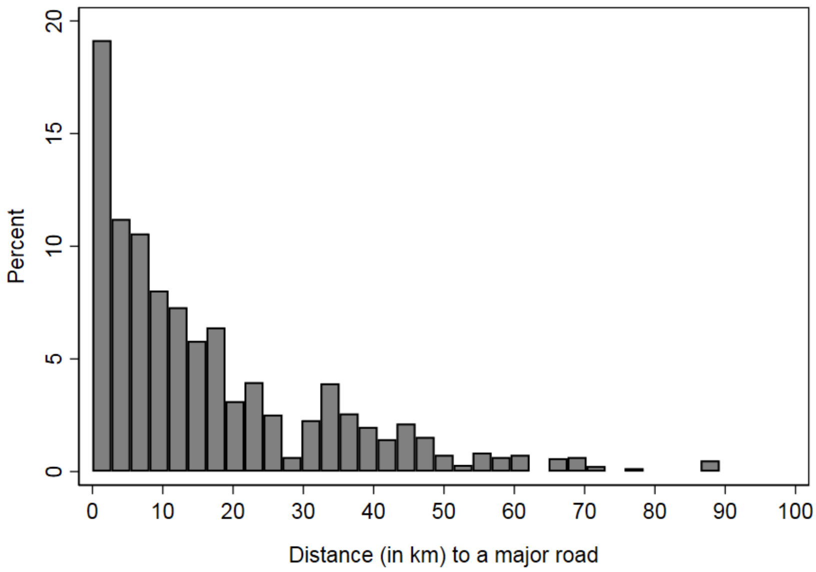
**Figure 7.1. Distribution of woreda-level road density**




Note: Data are at the woreda (district) level.

Fortunately, the survey offers an alternative road access measure: distance to the nearest major road, measured at the household level. Figure 7.2 shows the distribution of this variable. We see that the distribution loosely follows a log-normal distribution. This motivates us to interact our treatment variable with the (natural) log of the distance to the nearest road for each household. Table 7.2 presents the results. As before, we find that children residing in households with poorer access to major roads were negatively affected by the drought, whereas children located in better connected households were not. [15] But this only holds for measures of chronic undernutrition (HAZ and stunting). We see no heterogenous impacts (positive or negative) on acute undernutrition (wasting).

**Figure 7.2. Distribution of household's distance to a major road**




Note: Data are at the household level. Horizontal axis truncated at 100 km, the 99th percentile of the distance distribution.

[15] Interpretation of these impacts is cumbersome due to the log transformation of the distance variable in Table 7.2. For stunting (column 2), the turning point is at 4.8 km distance. This is roughly the 25th percentile in the distance distribution. After this point, the impact turns negative, though slowly. For households at 43 km distance (75th percentile), the estimated impact is a 10 percentage point increase in stunting rate (p=0.069).

**Table 7.1. Impact of the 2015 drought on child anthropometric outcomes by district primary road density**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dependent variable: | HAZ | Child is stunted | WHZ | Child is wasted |
| Drought * 2016 round (A) | -0.457* | 0.131** | 0.416** | -0.037 |
| | (0.239) | (0.064) | (0.209) | (0.045) |
| Drought * 2016 round * district with primary roads (B) | 0.657** | -0.186** | -0.372 | 0.046 |
| | (0.310) | (0.083) | (0.281) | (0.059) |
| 2016 round * district with primary roads | -0.047 | 0.031 | -0.073 | -0.005 |
| | (0.179) | (0.046) | (0.131) | (0.027) |
| Child and household level controls | Yes | Yes | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | Yes | Yes | Yes | Yes |
| F-test (A+B) | p = 0.349 | p = 0.344 | p = 0.829 | p = 0.824 |
| Within-$R^2$ | 0.028 | 0.022 | 0.024 | 0.013 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Unit of observation is a child 6-59-months. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

**Table 7.2. Impact of the 2015 drought on child anthropometric outcomes by household's distance to a major road**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Dependent variable: | HAZ | Child is stunted | WHZ | Child is wasted |
| Drought * 2016 round | 0.220 | -0.066 | 0.170 | -0.003 |
| | (0.229) | (0.069) | (0.211) | (0.040) |
| Drought * 2016 round * (ln) distance to a major road | -0.150* | 0.047** | -0.003 | 0.002 |
| | (0.082) | (0.023) | (0.075) | (0.015) |
| Drought * (ln) distance to a major road | -0.104 | 0.045 | 0.017 | 0.014 |
| | (0.095) | (0.036) | (0.103) | (0.021) |
| 2016 round * (ln) distance to a major road | 0.086 | -0.021 | -0.062 | 0.016* |
| | (0.054) | (0.015) | (0.040) | (0.008) |
| Drought | 0.024 | -0.007 | -0.014 | -0.013 |
| | (0.070) | (0.019) | (0.082) | (0.017) |
| Child and household level controls | Yes | Yes | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | Yes | Yes | Yes | Yes |
| Within-$R^2$ | 0.029 | 0.023 | 0.024 | 0.014 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Unit of observation is a child 6-59-months. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

As a response to recurrent droughts, in 2005 Ethiopia together with international donors initiated a geographically widespread safety net program; the Productive Safety Net Program (PSNP). The program operates in 330 woredas in eight regions of the country. [16] With 7 million beneficiaries, the PSNP the second largest safety net program in Africa. The program has two main components: a public works component for households with sufficient labor capacity and a direct support component for households with limited labor capacity. The beneficiary households receive monthly payments typically over a 6-month period either in food or cash equivalent of 15kg of cereal and 4kg of pulses (GFDRE 2014). Recent

[16] Afar; Amhara; Harari; Dire Dawa; Oromia; Somali; Southern Nations, Nationalities, and Peoples (SNNP); and Tigray.

evaluations of the PSNP show that the program is well targeted towards the most vulnerable households with fewer assets (Berhane et al. 2014; Berhane et al. 2016). Moreover, research shows that the PSNP has reduced household food insecurity and distress sales of assets, increased household expenditures, and boosted uptake of agricultural inputs (Hoddinott et al. 2012; Berhane et al. 2014; Berhane et al. 2016). Research by Knippenberg and Hoddinott (2017) suggests that the program has improved resilience against negative shocks among beneficiary households. Apart from addressing chronic food insecurity, the PSNP can also be seen as a platform during drought years from which to operationalize relief. Indeed, other forms of humanitarian assistance also take place, especially during drought years.

The analysis that follows is largely descriptive in nature. Indeed, it is often difficult to conduct rigorous impact assessments of assistance in humanitarian contexts (Puri et al. 2017). This is because the selection into humanitarian assistance is not random. Rather, it is likely that the aid is allocated to the poorest and most vulnerable households or to those that are on a downward trajectory along these dimensions. Therefore, given the data available to us, we cannot convincingly carry out an analysis on the role of aid in mitigating the negative impacts on child undernutrition. Instead we opt for assessing the geographic targeting of aid during the 2015 drought.

Table 7.3 shows that the PSNP caseload increased only marginally from 10 percent to 12 percent among the sampled households between 2014 and 2016. Meanwhile, the share of households that received humanitarian assistance (unconditional cash/food) in the previous 12 months more than doubled. The regional disaggregation suggests that this aid was directed to areas exposed to the drought. For example, in the 2016 round, 72 percent of the households in Afar reported to have received aid in the past 12 months, up from 35 percent in 2014.[17]

**Table 7.3. Share of households enrolled in PSNP and receiving free food by survey round and region**

| | PSNP: | | | Unconditional food/cash: | | |
|---|---|---|---|---|---|---|
| **Region** | **2014** | **2016** | **difference** | **2014** | **2016** | **difference** |
| Afar | 0.63 | 0.55 | -0.08 | 0.35 | 0.72 | 0.37 |
| Amhara | 0.09 | 0.15 | 0.06 | 0.04 | 0.12 | 0.08 |
| Benishangul-Gumuz | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | -0.01 |
| Dire Dawa | 0.59 | 0.82 | 0.23 | 0.30 | 0.42 | 0.12 |
| Gambella | 0.00 | 0.00 | 0.00 | 0.24 | 0.43 | 0.18 |
| Harari | 0.17 | 0.17 | 0.00 | 0.01 | 0.26 | 0.25 |
| Oromia | 0.03 | 0.05 | 0.02 | 0.06 | 0.12 | 0.06 |
| SNNP | 0.13 | 0.13 | 0.00 | 0.00 | 0.03 | 0.03 |
| Somali | 0.17 | 0.15 | -0.02 | 0.40 | 0.57 | 0.17 |
| Tigray | 0.36 | 0.30 | -0.06 | 0.05 | 0.14 | 0.09 |
| **All regions** | **0.10** | **0.12** | **0.02** | **0.05** | **0.12** | **0.06** |

Note: These estimates are based on sampling weights. SNNP= Southern Nations, Nationalities, and Peoples' Region.

Fortunately, the data allow us to assess this more rigorously. First, we use a binary outcome variable that obtains a value of one if the household benefitted from the PSNP in the previous year (and zero otherwise). We construct a similar variable for humanitarian assistance. Moreover, we transform the data to household level and use the same DiD approach, except now we can use household fixed effects instead of EA fixed effects. Column 4 of Table 7.4 shows that households residing in drought exposed areas were about 7.5 percentage points more likely to receive free food in 2015 compared to households residing

[17] Table 7.2 largely corroborates the anecdotal evidence presented in AKLDP (2016b). According to that report, the Government of Ethiopia distributed more than 600,000 tons of food aid between August and December 2015 to drought affected area in Afar, Amhara, Oromia, and Tigray.

elsewhere in the country. In contrast to the evidence from mid-1990s (Clay, Molla, and Habtewold 1999; Yamano et al. 2005), this finding implies that the humanitarian aid was geographically well targeted in 2015. We do not find a similar impact on PSNP caseload after controlling for regional macro-economic trends: the coefficient in column 2 is nearly zero and not statistically significant. [18]

**Table 7.4. Impact of the 2015 drought on the likelihood that the household was enrolled in PSNP or received free food in the past 12 months**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| **Dependent variable:** | **PSNP** | **PSNP** | **Food aid** | **Food aid** |
| drought * 2016 round | 0.048*** | 0.008 | 0.101*** | 0.075*** |
| | (0.017) | (0.018) | (0.018) | (0.023) |
| Household level controls | No | Yes | No | Yes |
| Survey round dummy | Yes | No | Yes | No |
| Survey round and region interaction terms | No | Yes | No | Yes |
| Household Fixed Effects? | Yes | Yes | Yes | Yes |
| Within-$R^2$ | 0.005 | 0.025 | 0.071 | 0.111 |
| Number of observations | 6,494 | 6,494 | 6,494 | 6,494 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Unit of observation is a household. Standard errors clustered at the household level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1. Aid refers to unconditional food/cash payments that are not related to PSNP.

## 8. CONCLUSIONS

Our results suggest that the 2015 drought in Ethiopia did not lead to widespread increases in chronic or acute child undernutrition rates. This result is remarkably robust to using a wide variety of different drought indicators as well as using other large national level data set. Overall, our findings suggest that the *meteorological* drought that occurred in 2015 did not translate into widespread catastrophe in terms of child undernutrition.

Our further analysis highlights the mitigating role of road networks and the response of the government and donor community in the form of humanitarian assistance. First, the null result documented in this paper seems to originate from districts that had a relatively better road network. Indeed, when we look at heterogeneity along this dimension, we find that the drought increased chronic undernutrition rates in districts that had a poor road network. Second, the drought was followed by a major humanitarian response (AKLDP 2016a, 2016b). This also becomes evident in our data – the number of food/cash aid recipients doubled in 2015 relative to 2013 and this increased aid was largely directed to the areas hit by the drought.

Due to global warming, severe droughts are likely to become more frequent in Africa, including Ethiopia. This will likely put the financing of the humanitarian response system into considerable stress, possibly risking the sufficient financing of humanitarian aid in the future (World Bank 2017). Our results give suggestive evidence that investments in sectors that support development and economic growth (here road infrastructure) may also assist in building long-term resilience against droughts, thereby decreasing the share of people in need of food aid.

[18] This does not imply that PSNP woredas – or PSNP beneficiary households – did not benefit from additional aid. Our further analysis (not reported here) suggests that also PSNP households received this aid – as did other (poor) households in PSNP localities. Finally, this result is robust to restricting the data to regions in which the PSNP operates or only considering the PSNP public work component. Results are available upon request.

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# APPENDIX

## Appendix A: Alternative drought measures

We defined drought using the -2-standard deviation cut-off. This may seem arbitrary and also discards potentially useful information. In Appendix Table A1 we replicate Table 5.1 using a continuous z-score variable. The results remain the same; all coefficients remain statistically insignificant.

### Appendix Table A1. Replicating Table 5.1 using a continuous drought measure

| Panel A: Dependent variable: HAZ | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Z-score of rainfall * 2016 round | -0.019 | 0.001 | 0.002 | 0.020 |
| | (0.085) | (0.088) | (0.085) | (0.086) |
| Z-score of rainfall | -0.051 | n/a | -0.046 | n/a |
| | (0.066) | | (0.065) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.023 | n/a | 0.048 | n/a |
| Within-$R^2$ | n/a | 0.007 | n/a | 0.027 |
| Number of observations | 3,568 | 3,568 | 3,568 | 3,568 |
| **Panel B: Dependent variable: WHZ** | **(5)** | **(6)** | **(7)** | **(8)** |
| Z-score of rainfall * 2016 round | -0.056 | -0.098 | -0.041 | -0.088 |
| | (0.060) | (0.064) | (0.060) | (0.063) |
| Z-score of rainfall | 0.017 | | 0.019 | |
| | (0.051) | | (0.051) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.057 | n/a | 0.071 | n/a |
| Within-$R^2$ | n/a | 0.012 | n/a | 0.022 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

Recent literature has used changes in vegetation density (or greenness) as a proxy for weather anomalies (e.g. Mulmi et al. 2016). The Normalized Difference Vegetation Index (NDVI) captures changes in vegetation density – a combination of rainfall, temperature, and soil – relying upon satellite images. We use MODIS Terra satellite data (see Huete et al. 2010) to construct a z-score variable of NDVI for the enumeration areas, again considering only the meher season (June-September). Appendix Table A2 shows the results based on this drought measure. As before, the coefficient on the interaction term appears with an insignificant coefficient in all columns.

### Appendix Table A2. Replicating Table 5.1 using NDVI

| **Panel A: Dependent variable: HAZ** | **(1)** | **(2)** | **(3)** | **(4)** |
|---|---|---|---|---|
| Z-score of NDVI * 2016 round | -0.091 | -0.085 | -0.070 | -0.073 |
| | (0.098) | (0.102) | (0.100) | (0.104) |
| Z-score of NDVI | 0.013 | | -0.012 | |
| | (0.079) | | (0.076) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.022 | n/a | 0.048 | n/a |
| Within-$R^2$ | n/a | 0.007 | n/a | 0.027 |
| Number of observations | 3,568 | 3,568 | 3,568 | 3,568 |
| **Panel B: Dependent variable: WHZ** | **(5)** | **(6)** | **(7)** | **(8)** |
| Z-score of NDVI * 2016 round | 0.099 | 0.106 | 0.094 | 0.107 |
| | (0.085) | (0.089) | (0.084) | (0.088) |
| Z-score of NDVI | 0.043 | | 0.055 | |
| | (0.069) | | (0.068) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.059 | n/a | 0.073 | n/a |
| Within-$R^2$ | n/a | 0.012 | n/a | 0.022 |
| Number of observations | 3,568 | 3,568 | 3,568 | 3,568 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

In Appendix Table A3 we use household self-reports to define drought. This variable obtains a value of one if the household reported a drought shock in 2015, and zero otherwise. As before, the coefficients on the treatment variables remain statistically insignificant.

### Appendix Table A3. Replicating Table 5.1 using household self-reported drought

| **Panel A: Dependent variable: HAZ** | **(1)** | **(2)** | **(3)** | **(4)** |
|---|---|---|---|---|
| Household reported drought * 2016 round | -0.102 | -0.096 | -0.163 | -0.109 |
| | (0.205) | (0.152) | (0.206) | (0.154) |
| Household reported drought | -0.156 | | -0.088 | |
| | (0.169) | | (0.163) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.024 | n/a | 0.049 | n/a |
| Within-$R^2$ | n/a | 0.007 | n/a | 0.027 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |
| **Panel B: Dependent variable: WHZ** | **(5)** | **(6)** | **(7)** | **(8)** |
| Household reported drought * 2016 round | 0.119 | 0.007 | 0.082 | 0.008 |
| | (0.174) | (0.131) | (0.167) | (0.129) |
| Household reported drought | -0.114 | | -0.058 | |
| | (0.132) | | (0.125) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.055 | n/a | 0.070 | n/a |
| Within-$R^2$ | n/a | 0.011 | n/a | 0.022 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

In Appendix Table A4, we use self-reported drought obtained from community level questionnaires (= 1 if the community reports to have experienced a below average rainfall in the past two years, zero otherwise). In the case of HAZ, the coefficients on the treatment variables appear with a priori correct sign, but are not statistically different from zero. In the case of WHZ, the coefficients appear with a priori incorrect signs and are significant in columns (5) and (6).

**Appendix Table A4. Replicating Table 5.1 using community self-reported drought**

| **Panel A: Dependent variable: HAZ** | **(1)** | **(2)** | **(3)** | **(4)** |
|---|---|---|---|---|
| Community reported drought * 2016 round | -0.181 | -0.188 | -0.175 | -0.188 |
| | (0.153) | (0.159) | (0.150) | (0.159) |
| Community reported drought | 0.108 | | 0.074 | |
| | (0.114) | | (0.112) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.022 | n/a | 0.048 | n/a |
| Within-$R^2$ | n/a | 0.008 | n/a | 0.027 |
| Number of observations | 3,575 | 3,575 | 3,575 | 3,575 |
| **Panel B: Dependent variable: WHZ** | **(5)** | **(6)** | **(7)** | **(8)** |
| Community reported drought * 2016 round | 0.253** | 0.192 | 0.222** | 0.188 |
| | (0.113) | (0.118) | (0.112) | (0.117) |
| Community reported drought | -0.197** | | -0.196** | |
| | (0.084) | | (0.083) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.058 | n/a | 0.072 | n/a |
| Within-$R^2$ | n/a | 0.012 | n/a | 0.023 |
| Number of observations | 3,575 | 3,575 | 3,575 | 3,575 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

While meher is the main cropping season for most Ethiopian farm households, in some areas, the shorter rainy season (belg) is the main season. Using data from community questionnaires on harvesting times, we categorized villages by their main cropping season. About 9 percent of the children originate from villages for which belg is the main cropping season. Next, for these children, we only consider rainfall between March and May, while for the remaining children we only consider rain during the meher season (June-September). Appendix Table A5 shows the results based on this refined rainfall variable. For HAZ, in all columns, the coefficient appears with a negative sign but is not statistically significantly different from zero. For WHZ, the coefficients appear with positive signs. In column (6), the coefficient is statistically significant at 10 percent level. In other columns, the coefficients on the treatment variable are statistically insignificant.

**Appendix Table A5. Replicating Table 5.1 using a z-score of rainfall during the main cropping in the EA**

| Panel A: Dependent variable: HAZ | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Z-score of rainfall (main season) * 2016 round | -0.176 | -0.208 | -0.213 | -0.248 |
| | (0.171) | (0.170) | (0.167) | (0.166) |
| Z-score of rainfall (main season) | 0.117 | | 0.129 | |
| | (0.145) | | (0.139) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.022 | n/a | 0.048 | n/a |
| Within-$R^2$ | n/a | 0.008 | n/a | 0.027 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |
| **Panel B: Dependent variable: WHZ** | **(5)** | **(6)** | **(7)** | **(8)** |
| Z-score of rainfall (main season) * 2016 round | 0.206 | 0.260* | 0.178 | 0.240 |
| | (0.140) | (0.148) | (0.142) | (0.149) |
| Z-score of rainfall (main season) | 0.057 | | 0.047 | |
| | (0.113) | | (0.112) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.057 | n/a | 0.071 | n/a |
| Within-$R^2$ | n/a | 0.012 | n/a | 0.023 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

Next, we again consider a continuous rainfall z-score variable, but this time truncate the positive deviations to zero (Appendix Table A6). This drought measure puts more weight on negative rainfall deviations. Since our treatment variable obtains only negative values, a positive coefficient on the treatment variable would imply a negative impact on undernutrition status. For HAZ, we again get insignificant coefficients. For WHZ, all coefficients on the treatment variable appear with counter-intuitive signs and some are statistically significant at the 10-percent level.

### Appendix Table A6. Replicating Table 5.1 using a z-score with negative deviations only

| **Panel A: Dependent variable: HAZ** | **(1)** | **(2)** | **(3)** | **(4)** |
|---|---|---|---|---|
| Z-score of rainfall (negative deviations) * 2016 round | 0.023 | 0.045 | 0.048 | 0.069 |
| | (0.100) | (0.102) | (0.098) | (0.100) |
| Z-score of rainfall (negative deviations) | -0.025 | | -0.023 | |
| | (0.085) | | (0.083) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.022 | n/a | 0.048 | n/a |
| Within-$R^2$ | n/a | 0.007 | n/a | 0.027 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |
| **Panel B: Dependent variable: WHZ** | **(5)** | **(6)** | **(7)** | **(8)** |
| Z-score of rainfall (negative deviations) * 2016 round | -0.111 | -0.145* | -0.090 | -0.133* |
| | (0.074) | (0.080) | (0.074) | (0.079) |
| Z-score of rainfall (negative deviations) | 0.021 | | 0.022 | |
| | (0.065) | | (0.065) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.056 | n/a | 0.071 | n/a |
| Within-$R^2$ | n/a | 0.012 | n/a | 0.023 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

Finally, the government of Ethiopia together with various donors periodically categorize woredas into ones that require urgent humanitarian response. This *hotspot* categorization is based on multisectoral indicators that include nutrition, agriculture, market, water and hygiene, health, and education. As such, the hotspot indicator captures factors that are not necessarily caused by drought. We use woreda hotspot categorization from August 2015 and create a binary indicator that obtains a value of one if the woreda in which the child resides was categorized as Priority 1, and zero otherwise. Nearly 19 percent of the children reside in areas that fell into this category in August 2015. In Appendix Table A7, we use this variable as our drought measure. As before, we cannot reject the (null) hypothesis that the drought had no impact on children's anthropometric outcomes.

**Appendix Table A7. Replicating Table 5.1 using the Hotspot categorization to define drought**

| **Panel A: Dependent variable: HAZ** | **(1)** | **(2)** | **(3)** | **(4)** |
|---|---|---|---|---|
| Woreda is hotspot category 1 * 2016 round | 0.012 | -0.092 | -0.011 | -0.121 |
| | (0.205) | (0.207) | (0.200) | (0.206) |
| Woreda is hotspot category 1 | -0.220 | | -0.211 | |
| | (0.163) | | (0.158) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.023 | n/a | 0.049 | n/a |
| Within-$R^2$ | n/a | 0.007 | n/a | 0.027 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |
| **Panel B: Dependent variable: WHZ** | **(5)** | **(6)** | **(7)** | **(8)** |
| Woreda is hotspot category 1 * 2016 round | 0.222 | 0.192 | 0.205 | 0.180 |
| | (0.159) | (0.172) | (0.157) | (0.172) |
| Woreda is hotspot category 1 | -0.109 | | -0.088 | |
| | (0.113) | | (0.109) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.056 | n/a | 0.071 | n/a |
| Within-$R^2$ | n/a | 0.012 | n/a | 0.022 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

## Appendix B: Sampling weights

The ESS data come with survey weights that permit researchers to report nationally representative estimates. Since the purpose of this analysis is to estimate causal effect of the drought on child undernutrition and the sampling probabilities do not vary endogenously, estimates based on weighted and un-weighted regressions should yield similar results (see Solon, Haider, and Wooldridge 2015). Still, it is considered good practice to report results also based on the survey weights. Appendix Table B1 reports the β_2 coefficient based on the Weighted Least Squares (WLS) estimator. The estimated coefficient for the impact on HAZ based on the WLS estimator is somewhat larger in magnitude, but, importantly, not statistically significantly different from zero (p-values range between 0.353 and 0.576 in columns 1 to 4). Similarly, in the case of WHZ, the coefficients are not statistically different from zero.

### Appendix Table B1. Replicating Table 5.1 using survey weights

| **Panel A: Dependent variable: HAZ** | **(1)** | **(2)** | **(3)** | **(4)** |
|---|---|---|---|---|
| Drought * 2016 round | -0.126 | -0.142 | -0.208 | -0.223 |
| | (0.226) | (0.235) | (0.224) | (0.231) |
| Drought | -0.062 | | -0.065 | |
| | (0.175) | | (0.167) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.022 | n/a | 0.050 | n/a |
| Within-$R^2$ | n/a | 0.006 | n/a | 0.026 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |
| **Panel B: Dependent variable: WHZ** | **(5)** | **(6)** | **(7)** | **(8)** |
| Drought * 2016 round | 0.012 | 0.116 | -0.044 | 0.069 |
| | (0.178) | (0.194) | (0.179) | (0.201) |
| Drought | 0.186 | | 0.176 | |
| | (0.179) | | (0.184) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.033 | n/a | 0.057 | n/a |
| Within-$R^2$ | n/a | 0.011 | n/a | 0.036 |
| Number of observations | 3,582 | 3,582 | 3,582 | 3,582 |

Notes: Based on Weighted Least Squares (WLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

## Appendix C: Results by child age

In Appendix Table C1, we restrict the sample to different age groups to explore sensitivity along that dimension. The coefficients remain insignificant across all sub-samples.

### Appendix Table C1a. Replicating Column 4 in Table 5.1, Panel A using different age intervals

| **Dependent variable: HAZ** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** |
|---|---|---|---|---|---|---|---|
| ***Age range in months:*** | ***6-18*** | ***6-24*** | ***6-30*** | ***12-24*** | ***12-36*** | ***18-30*** | ***18-42*** |
| Drought * 2016 round | 0.052 | -0.047 | 0.246 | -0.146 | 0.021 | 0.576 | -0.042 |
| | (0.419) | (0.339) | (0.310) | (0.332) | (0.295) | (0.553) | (0.273) |
| Child and household level controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| EA fixed effects? | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Within-$R^2$ | 0.088 | 0.080 | 0.054 | 0.080 | 0.027 | 0.064 | 0.027 |
| Number of observations | 798 | 1,080 | 1,544 | 748 | 1,522 | 825 | 1,682 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

### Appendix Table C1b. Replicating Column 4 in Table 5.1, Panel B using different age intervals

| **Dependent variable: WHZ** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** |
|---|---|---|---|---|---|---|---|
| ***Age range in months:*** | ***6-18*** | ***6-24*** | ***6-30*** | ***12-24*** | ***12-36*** | ***18-30*** | ***18-42*** |
| Drought * 2016 round | 0.076 | 0.258 | 0.119 | 0.413 | 0.175 | 0.233 | 0.283 |
| | (0.356) | (0.304) | (0.269) | (0.415) | (0.247) | (0.403) | (0.204) |
| Child and household level controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| EA fixed effects? | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Within-$R^2$ | 0.077 | 0.052 | 0.039 | 0.052 | 0.037 | 0.036 | 0.027 |
| Number of observations | 798 | 1,080 | 1,544 | 748 | 1,522 | 825 | 1,682 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

## Appendix D: Results by child sex

Splitting the sample by child's sex does not yield significant coefficients either (Appendix Tables D1 and D2).

### Appendix Table D1. Girls

| **Panel A: Dependent variable: HAZ** | **(1)** | **(2)** | **(3)** | **(4)** |
|---|---|---|---|---|
| Drought * 2016 round | -0.001 | 0.127 | -0.072 | 0.052 |
| | (0.245) | (0.264) | (0.245) | (0.268) |
| Drought | -0.078 | | -0.102 | |
| | (0.184) | | (0.177) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.031 | n/a | 0.059 | n/a |
| Within-$R^2$ | n/a | 0.008 | n/a | 0.032 |
| Number of observations | 1,759 | 1,759 | 1,759 | 1,759 |
| **Panel B: Dependent variable: WHZ** | **(5)** | **(6)** | **(7)** | **(8)** |
| Drought * 2016 round | 0.196 | 0.293 | 0.149 | 0.254 |
| | (0.224) | (0.247) | (0.224) | (0.245) |
| Drought | 0.023 | | -0.011 | |
| | (0.163) | | (0.161) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.059 | n/a | 0.086 | n/a |
| Within-$R^2$ | n/a | 0.011 | n/a | 0.038 |
| Number of observations | 1,759 | 1,759 | 1,759 | 1,759 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

### Appendix Table D2. Boys

| Panel A: Dependent variable: HAZ | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Drought * 2016 round | -0.135 | -0.109 | -0.176 | -0.150 |
| | (0.211) | (0.209) | (0.202) | (0.203) |
| Drought | 0.255 | | 0.284* | |
| | (0.158) | | (0.154) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.024 | n/a | 0.053 | n/a |
| Within-$R^2$ | n/a | 0.015 | n/a | 0.033 |
| Number of observations | 1,823 | 1,823 | 1,823 | 1,823 |
| **Panel B: Dependent variable: WHZ** | **(5)** | **(6)** | **(7)** | **(8)** |
| Drought * 2016 round | 0.118 | 0.174 | 0.111 | 0.199 |
| | (0.185) | (0.205) | (0.183) | (0.203) |
| Drought | 0.147 | | 0.117 | |
| | (0.129) | | (0.130) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.065 | n/a | 0.076 | n/a |
| Within-$R^2$ | n/a | 0.019 | n/a | 0.029 |
| Number of observations | 1,823 | 1,823 | 1,823 | 1,823 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

## Appendix E: Alternative anthropometric outcomes

We used an alternative anthropometric measure to capture chronic undernutrition. In Appendix Table E1 we report estimates based on weight-for-age (WAZ). WAZ is considered a composite index of height-for-age and weight-for-height, thus capturing both chronic and acute undernutrition. The coefficients on the treatment variable (Drought * 2016 round) appear consistently with *a priori* incorrect signs and are not statistically significantly different from zero.

### Appendix Table E1. Impact of the 2015 drought on weight-for-age z-score (WAZ)

| **Dependent variable: Weight for Age z-score** | **(1)** | **(2)** | **(3)** | **(4)** |
|---|---|---|---|---|
| Drought * 2016 round | 0.087 | 0.141 | 0.049 | 0.109 |
| | (0.101) | (0.102) | (0.102) | (0.102) |
| Drought | 0.094 | | 0.074 | |
| | (0.080) | | (0.078) | |
| Child and household level controls | No | No | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes |
| EA fixed effects? | No | Yes | No | Yes |
| $R^2$ | 0.035 | n/a | 0.071 | n/a |
| Within-$R^2$ | n/a | 0.007 | n/a | 0.033 |
| Number of observations | 3,579 | 3,579 | 3,579 | 3,579 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

## Appendix F: Ethiopia Demographic and Health Survey data

We also replicated Tables 5.1 (HAZ/WHZ) and 5.2 (stunting/wasting) using the Ethiopia Demographic and Health Survey data for rural areas. The latest round was administered in first half of 2016, i.e., after the 2015 drought, while the earlier DHS round was administered during the same calendar months in 2011. We replicate our DiD approach using the two latest rounds of DHS data. We take advantage of the large sample size in these data and report our results for different age groups. As before, the coefficients are not statistically significantly different from zero across all age groups for measures of chronic undernutrition (HAZ in Appendix Table F1 or stunting in Appendix Table F2). For WHZ, the coefficients are statistically significant – but positive – for two age-groups (Appendix Table F1). However, all coefficients are insignificant when we look at impacts on wasting (Appendix Table F2).

**Appendix Table F1. Replicating Table 5.1 using Ethiopia Demographic and Health Survey data**

| **Dependent variable: HAZ** | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** | **(8)** |
|---|---|---|---|---|---|---|---|---|
| ***Age range (months):*** | ***0-59*** | ***6-59*** | ***6-12*** | ***6-18*** | ***6-30*** | ***12-24*** | ***12-36*** | ***18-42*** |
| drought * round = 2016 | 0.178 | 0.153 | -0.093 | 0.051 | 0.181 | 0.036 | 0.188 | 0.215 |
| | (0.125) | (0.132) | (0.301) | (0.216) | (0.167) | (0.220) | (0.166) | (0.161) |
| drought | -0.129 | -0.114 | 0.168 | 0.066 | -0.156 | -0.141 | -0.196* | -0.291*** |
| | (0.080) | (0.082) | (0.190) | (0.145) | (0.110) | (0.151) | (0.113) | (0.106) |
| Child and household level controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Zone dummies? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.208 | 0.147 | 0.180 | 0.192 | 0.198 | 0.139 | 0.123 | 0.084 |
| Number of observations | 14,110 | 12,604 | 1,747 | 3,210 | 5,869 | 2,972 | 5,728 | 5,840 |
| **Dependent variable: WHZ** | **(9)** | **(10)** | **(11)** | **(12)** | **(13)** | **(14)** | **(15)** | **(16)** |
| ***Age range (months):*** | ***0-59*** | ***6-59*** | ***6-12*** | ***6-18*** | ***6-30*** | ***12-24*** | ***12-36*** | ***18-42*** |
| drought * round = 2016 | 0.093 | 0.144 | 0.280 | 0.354* | 0.159 | 0.362** | 0.125 | 0.033 |
| | (0.086) | (0.089) | (0.255) | (0.191) | (0.132) | (0.173) | (0.118) | (0.110) |
| drought | -0.144** | -0.190*** | -0.144 | -0.277** | -0.207** | -0.327*** | -0.192** | -0.143* |
| | (0.062) | (0.062) | (0.163) | (0.130) | (0.089) | (0.111) | (0.080) | (0.078) |
| Child and household level controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Zone dummies? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.061 | 0.065 | 0.132 | 0.109 | 0.079 | 0.096 | 0.075 | 0.077 |
| Number of observations | 14,160 | 12,672 | 1,744 | 3,212 | 5,884 | 2,976 | 5,752 | 5,872 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Unit of observation is a child. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

### Appendix Table F2. Replicating Table 5.2 using Ethiopia Demographic and Health Survey data

| Dependent variable:<br>1 child is stunted, 0 otherwise | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| ***Age range (months):*** | ***0-59*** | ***6-59*** | ***6-12*** | ***6-18*** | ***6-30*** | ***12-24*** | ***12-36*** | ***18-42*** |
| drought * round = 2016 | -0.010 | -0.013 | 0.001 | -0.025 | -0.009 | 0.030 | 0.021 | 0.026 |
| | (0.033) | (0.036) | (0.074) | (0.054) | (0.043) | (0.064) | (0.048) | (0.049) |
| drought | 0.028 | 0.033 | -0.050 | -0.012 | 0.024 | 0.029 | 0.035 | 0.062* |
| | (0.022) | (0.023) | (0.051) | (0.037) | (0.029) | (0.041) | (0.031) | (0.032) |
| Child and household level controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Zone dummies? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.133 | 0.101 | 0.133 | 0.150 | 0.159 | 0.118 | 0.098 | 0.065 |
| Number of observations | 14,110 | 12,604 | 1,747 | 3,210 | 5,869 | 2,972 | 5,728 | 5,840 |
| **Dependent variable:<br>1 child is wasted, 0 otherwise** | **(9)** | **(10)** | **(11)** | **(12)** | **(13)** | **(14)** | **(15)** | **(16)** |
| ***Age range (months):*** | ***0-59*** | ***6-59*** | ***6-12*** | ***6-18*** | ***6-30*** | ***12-24*** | ***12-36*** | ***18-42*** |
| drought * round = 2016 | -0.002 | -0.006 | 0.028 | -0.025 | -0.002 | -0.060 | -0.008 | -0.008 |
| | (0.023) | (0.024) | (0.074) | (0.054) | (0.037) | (0.051) | (0.033) | (0.031) |
| drought | 0.013 | 0.022 | -0.016 | 0.015 | 0.016 | 0.028 | 0.017 | 0.035 |
| | (0.015) | (0.016) | (0.050) | (0.038) | (0.024) | (0.033) | (0.022) | (0.022) |
| Child and household level controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Survey round and region interaction terms | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Zone dummies? | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.046 | 0.049 | 0.091 | 0.072 | 0.058 | 0.081 | 0.057 | 0.050 |
| Number of observations | 14,160 | 12,672 | 1,744 | 3,212 | 5,884 | 2,976 | 5,752 | 5,872 |

Notes: Based on Ordinary Least Squares (OLS) regression method. Unit of observation is a child. Standard errors clustered at the Enumeration Area (EA) level in parentheses. Statistical significance noted at *** p<0.01, ** p<0.05, * p<0.1.

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