Misfortunes never come singly:
structural change, multiple shocks and child malnutrition in rural Senegal

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Abstract

This study considers the two most pronounced shocks Senegalese subsistence farmers struggle with, namely increasing purchase prices and droughts. We assess the impact of these shocks on child health in a multi-shock approach to account for concomitance of adverse events from the natural, biological, economic and health sphere. We employ a unique dataset of children living in poor, rural households in eight regions of Senegal in 2009 and 2011 and account for structural changes occurring between survey periods. By zooming in to the micro level we demonstrate that Senegal as a Sahelian country, mainly reliant on natural resources and subsistence agriculture, is very vulnerable to climate variability and international price developments: According to our conservative estimates, the occurrence of a drought explains 28% of the pooled weight-for-age standard deviation, income losses 23%. Our multi-shock analysis reveals that the shocks are perceived as more severe in 2011 with droughts explaining up to 43% of the standard deviation of child health, increased prices up to 24%. Yet, accounting for the concomitance of droughts and increased prices after the structural change indicates that the health of children experiencing both shocks in 2011 is left unaffected. We argue that these results are driven by the increase in rural household income as theoretically outlined in the agricultural household model. Thus, adequate policy responses to shocks do not only depend on the nature but also on the concomitance of hazardous events.

Keywords: (multiple) shocks; Weight-for-age Z-scores; Senegal.

JEL: O12; Q54; I12.

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1. Introduction

The proverb "Misfortunes never come singly" claims that adverse events are correlated and develop their full potential due to their joint occurrence. The proverb reminds us that natural, biological, economic and health shocks are often concomitant. Accounting for multiple shocks is especially relevant when studying the conditions of poor, shock-prone households in developing countries as they affect the people's welfare in terms of income, consumption and health. The existing literature mainly focuses on the effects of a single or limited set of shocks (Yilma et al., 2014; Bengtsson, 2010; Dercon, 2004; Hoddinott and Kinsey, 2001), notable exceptions are de Janvry et al. (2006) and Échevin and Tejerina (2013). With this work we further add to the academic discussion on the effects of natural and non-natural shocks adopting a multi-shock framework for the case of rural Senegal. We contribute to the understanding of the economic consequences of environmental problems, while accounting for international price developments and national macro-economic responses.

Senegal as a Sahelian country is mainly reliant on natural resources and subsistence agriculture. Thus, vulnerability to climate variability is high. Projections on the effects of climate change on crop yields in Sahelian countries and qualitative studies of farmer perceptions on the effects of climate change raise concerns about the future development path of the country (Dieye and Roy, 2012; Parry et al., 2004). Moreover, droughts and increasing climate and weather variability are not the only adverse events faced by rural Sahelian households. International food prices peaked in mid-2008 and early 2011 leading to decreasing income and increasing hunger rates in the developing world (McMichael and Schneider, 2011). This is particularly true in Senegal where 20% of the population is undernourished; almost 30% of the population does not have adequate access to food; and food imports account for more than 50% of the total merchandise exports (FAO, 2013).

To better understand the impact of environmental and price shocks on subsistence agriculture, we zoom in to the micro-level. It is difficult to detect the impact of adverse events as the likelihood of exposure to shocks may be correlated with unobservable characteristics at the household and individual level (Alderman et al., 2006). Timing and simultaneity of shocks may further increase vulnerability and exposure, worsening the effects of a single shock. On the other hand, households may adopt a variety of strategies in response to shocks (Heltberg et al., 2012; Murdoch, 1995). There is ample evidence for *ex-ante* diversification strategies (Rosenzweig and Udry, 2013; Dercon, 1996) and *ex-post* behavior-, asset- and assistance-based coping mechanisms (Heltberg and Lund, 2009). Therefore, especially in shock-prone areas, a multi-shock analysis is required to better understand the impact of shocks (Wagstaff and Lindelow, 2014). For one, the occurrence of multiple shocks at the same time may worsen household welfare more than a single shock analysis would predict. At the same time, heterogeneity in the type of shocks experienced by the household as a whole and heterogeneity in the individuals being particularly affected may be a source of differential net effects.[1]

Children are among the most vulnerable individuals in poor households in developing countries (Bengtsson, 2010; Hoddinott and Kinsey, 2001; Kinsey et al., 1998; Martorell, 1999). Therefore, we study child wellbeing in response to multiple shocks by means of child anthropometrics for children below 5 years as child health measures are considered credible representations of household welfare due to the objectivity of the measurement procedure (Carter and Maluccio, 2003). Moreover, getting exact indicators for child nutritional status is less challenging than getting similar measures for adults. Indeed, when assessing the wellbeing of adults, one needs to jointly account for consumption, productivity and income (Dercon and Krishnan, 2000). In addition, low child growth affects individual health and working performance in adulthood emphasizing the relevance of child health responses to shocks also in a long-term perspective (Maccini and Yang, 2008; Hoddinott and Kinsey, 2001). Existing child health studies further suggest that it is rather environmental than ethnic markers that explain differences in child growth (WHO and UNICEF, 2009). Next to the impact of environmental hazards on child health (Baez and Santos, 2007; del Ninno and Lundberg, 2005; Yamano et al., 2005), the impact of macro-economic shocks (Ferreira and Schady, 2009; Pongou et al., 2006; Paxson and Schady, 2005; Block et al., 2004) and commodity price changes (Cogneau and Jedwab, 2012; de Braw, 2011; Miller and Urdinola, 2010; Thomas et al., 1996) have been identified by the literature. We allow for the concomitance of both environmental hazards and economic shocks and the combined effect on child health.

We base our analysis on a repeated cross-section of children measured in the context of a household survey in rural Senegal in the second quarter of 2009 and 2011 after the second international food price spike (February 2011). In the absence of a 'cleaner' natural experiment, the dataset is particularly suitable to conduct a multi-shock analysis since it contains a very rich shock module for vulnerable, rural households. The shock module relies on self-reported shocks. We show that drought and income/price shocks have the most adverse effects on child weight-for-age whereas the loss of a household member has a positive impact representing a per capita increase in food. Crop pests or periods of extreme cold weather are not identified as having significant impact on child health. According to our conservative estimates, the occurrence of a drought explains 28% of the pooled weight-for-age standard deviation, income losses 23%, and loss of a household member 13%. Moreover, in 2011 we observe important structural improvements in child anthropometrics due to nation-wide food and agricultural programs that may counteract the negative impact

[1] Clearly, shocks per se are not necessarily negative events; e.g. an increase in price could be beneficial to a net producer. We adopt the definition of a shock as adverse event as the data exploited in the paper results from survey questions about events that are most likely to have had a negative impact on households.

of the shocks. Including interaction terms between the year dummy and the two most pronounced shocks in 2011, namely increasing purchase prices and droughts, we find that these shocks explain up to 24% and 43% of the standard deviation of child health, respectively. But concomitance of the drought and the price shock suggests competing price and income effects for poor farming households. Analogous to the simple agricultural household model for net producers we find that higher prices for home-produced goods increase income; this price effect is particularly visible in times of scarcity such as a drought. As the exogeneity of shocks might be mitigated due to recall bias and differences in perceptions, we employ several robustness and sub-sample tests: Including geo-referenced precipitation data in the analysis, we also find that multiple shocks have to be carefully dealt with because of their interdependencies. Controlling for access to markets, child health history, and farming decisions, i.e. households growing peanuts, the main results hold as well. Moreover, children living in households that depend on farming as main occupation of the male breadwinner suffer more from drought shocks and it is the asset-poor that are most hit by both drought and price shocks.

The remainder of the paper is structured as follows. Section 2 describes the conceptual framework. Section 3 presents the Senegalese country context, survey indicators and descriptive statistics. Section 4 outlines the empirical strategy. Results are reported in Section 5 and robustness checks are presented in Section 6. Section 7 concludes.

2. Conceptual framework

Theoretically, we base the analysis on an inter-temporal utility model with income uncertainty (Sadoulet and de Janvry, 1995; Townsend, 1994; Deaton, 1992). Risk aversion is assumed and an inter-temporal household utility function over consumption. At each point in time the realized utility level is unsecured as an idiosyncratic natural, biological, economic or health shock can occur and reduce consumption. Imposing the standard resource and feasibility constraints it can be shown that transitory idiosyncratic shocks do not reduce consumption if risk sharing is possible. Thus, consumption is smoothed and follows permanent income. However, Townsend (1994) demonstrated that consumption smoothing and thus risk sharing is not perfect within villages. Whenever household consumption is influenced by contemporaneous own income and transitory shocks, households are not fully able to insure against risk and bear (some of) the consequences of idiosyncratic shocks, which results in variations in the instantaneous utility. Instead of focusing on direct measures of consumption we take child health as it can be more accurately measured. Thus, we follow the approach of Thomas (1994) in that we consider health as input to the utility function.

The pathways through which multiple shocks can affect child health are several. First, if household food security is not well ensured and households are net buyers of food, an increase in (produced and imported) food prices may be a large income and eventually health shock to the household members. If food becomes more expensive and credit constraints are binding, households may be unable to provide the necessary nutrition to children. Yet, child health remains unaffected if households have enough assets/savings to cope with the food price increases. *Economic shocks* such as a decline in sales prices and the loss of a key income source can trigger similar effects.

Second, *natural disasters* affect household welfare and child health through their impact on agriculture, food security and health (IPCC, 2001). Droughts, floods and extreme cold are likely to affect agriculture and rangeland productivity while potentially triggering losses of lives and infrastructures (IPCC, 2001). In contexts of subsistence agriculture, household food security will be affected and this worsens individual health outcomes depending on the intra-household allocation of resources (Thomas, 1990).

Third, indirect effects on agricultural productivity and health outcomes may also come from the development of vector/water/food-borne diseases (*biological shocks*). Natural hazards may provide particular conditions that allow pathogens already existing in the environment to develop and spread or make their life longer than their usual historic range, thus increasing the likelihood of biological hazards such as crop pests and livestock diseases (Piao et al., 2010; Anderson et al., 2004). This applies to parasites affecting human beings as well (Haines et al., 2006). Hence, individual health may be affected in different ways following complex extreme events such as floods, droughts and cold waves (Skoufias and Vinha, 2012; McMichael and Haines, 1997).

Finally, note that depending on the context, wetter/drier and warmer/colder weather may result also in *positive* effects on household welfare (Hsiang et al., 2013). Moreover, shocks may result in positive effects through resource redistribution within the household. For example, the migration of an unemployed member and/or the death of an unproductive member may allow resources previously allocated to that member to be redistributed to the remaining members. Depending on the additional income from the migrated member, pre-death medical expenses or funeral costs, and the earnings' ability of the dead member, household food security and welfare may improve (de Braw, 2011; Grimm, 2010).

In light of this discussion, analyzing the impact of shocks as stand-alone events may provide an unclear and incomplete picture of what is occurring to household welfare in shock prone areas due to concomitance of shocks. A multi-shock analysis is needed to explore the combined effect of shocks on child health outcomes.

3. Country context, survey indicators and descriptive statistics

3.1 Country context

Senegal is a Sahelian country in West Africa classified by the World Bank as a low-income nation. The country has a poverty headcount ratio of 46.7% for the 2$ cut-off. The poverty headcount is more than 20 percentage points higher for rural households (57 against 33%) and food insecurity is a major concern: 20% of the population is undernourished (FAO, 2013).

Starting from 2002 the government of Senegal has been running a large-scale nutrition program (Programme de Renforcement Nutritionnel, NEP) to tackle the problem of child malnutrition. In 2007 the program was extended from urban to rural areas where malnutrition was particularly high (Natalicchio, 2011) with coverage surpassing 50% in 2011 (Mulder-Sibanda, 2011). Besides, after the 2008 economic crisis the Government of Senegal has been adopting multiple measures to improve food security and to reduce household vulnerability to shocks including price controls, subsidies, rice redistribution and the Grand Agricultural Offensive for Food and Abundance (GOANA) to foster agricultural productivity. However, the prevalence of both stunting and undernourishment among children below 5 years has worsened between 2005 and 2010 following a combination of food price fluctuations and natural disasters (World Food Programme, 2013).

Food security was further challenged in the year 2011 with a surge in the price of domestic and international food products leading the government to set ceilings for the price of rice, sugar and milk (FAO, 2013). Figure 1 shows the evolution of consumer prices between the survey years. The increase in the domestic and international food prices in 2008 constituted a major shock to Senegalese households but the good 2008/2009 harvests helped to reduce household vulnerability by reducing the share of imported food (République du Sénégal, 2010). After the peak in June 2008, food prices rapidly declined reaching pre-crisis levels when the first survey round was taking place in 2009. Accordingly, in Figure 1 the Harmonized Average Food Price Index is below the Harmonized Average CPI. However, starting from June 2009 food prices began again to increase peaking at the end of 2010-beginning of 2011 and fairly stabilizing at a new high level throughout the first half of 2011 (the food price index now dominating the CPI). Given these evolutions we expect households to be more food insecure in 2011 resulting in worse health conditions for children living in these households.

>>Insert Figure 1 about here<<

Moreover, Senegal is particularly prone to natural shocks. An overall disaster profile of Senegal is drawn from EM-DAT (2012) and shows that droughts and floods are the hazards that have most affected the Senegalese population while epidemics are the phenomenon with the highest reported deaths. From 2004 to 2013, an estimated 1.3 million people were affected by droughts and floods and more than 350 people died as a consequence of these natural disasters (EM-DAT, 2012). Hence, we expect households to be most adversely affected by price and drought shocks.

3.2 Survey indicators and descriptive statistics

Child health information is provided by a household survey carried out in eight regions of Senegal.[2] The survey was part of the program evaluation of a rural electrification initiative by the UNDP known as multifunctional platform.[3] Two rounds of data were collected: the baseline survey was conducted between May and June 2009 and the follow-up survey between April and May 2011, after the international food price peak recorded in February 2011. Note that seasonal effects are minimized since both the surveys were conducted during the same agricultural season. Randomization of the households occurred at the village level. Hence the sample is representative for rural Senegal in eight of 12 regions, in which income is most prevalently generated from subsistence agriculture (see Figure 2). The analysis is restricted to children who were between 12 and 60 months and for whom anthropometric data are available. After excluding cases with z-scores beyond the [-6, +6] range, a total of 1,694 and 2,116 children are measured in 2009 and 2011, respectively. As the primary sampling units are households, we observe attrition at the individual child level. But no systematic difference is found when comparing the characteristics of the children with and without anthropometric data.[4]

>>Insert Figure 2 about here<<

Table 1 presents the descriptive statistics of the children in the dataset for which anthropometric data are available. The sample is fairly gender balanced. In 2009, the children are 30 months old on average. As outcome we employ the weight-for-age (WAZ) Z-score. We use the 2006 growth standards for attained weight (WHO & UNICEF, 2009). As the metric for Z-scores is standard deviations, they can be easily

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[2] The regions are Diourbel, Fatick, Kaolack, Kedougou, Kolda, Louga, Tambacounda, and Thies according to the 2009 regional subdivision.

[3] Further information on the program evaluation can be found in the report by CERDI, IHEID and UGB (2009).

[4] Children without anthropometric data and/or anthropometric data out of range are 1,515 in 2009 and 1,179 in 2011. Mean tests on observables do not suggest systematic differences between children with and without z-scores. Detailed tables with group comparisons on observables are available upon request. Children with repeated observations were only 661 with some loss of representativeness; hence we preferred to use pooled cross-sections.

interpreted. A child with a Z-score of zero has no deviation of its health status with respect to the reference population. Yet, with an average WAZ (HAZ) of -1.45 (-1.20) the children in the sample are underweight (stunted). Moreover, we observe that weight-for-age (height-for-age) improves over time. We attribute this to the nation-wide programs implemented in response to the international economic crisis. Moreover, some changes occurring between the survey rounds hint at a gradual structural change in household socio-economic conditions as outlined below.

The households the children are living in have on average 14 to 15 members; in both rounds about 25% of the members are children below 5 years. In 2011 less children live in households without their mothers, similarly maternal literacy has increased between rounds. The presence of the mother is likely to increase the attention towards the health needs of the child both at the individual child and the household level, while maternal literacy and education account for higher abilities in processing health and nutrition information (Christiaensen and Alderman, 2004; Glewwe, 1999). Wealth and connectedness also improved in the sampled households: On average households own more poultry, mobile phones and radios. The combined effect of increasing maternal education and connectedness would also have positive effects on child health by increasing the access to available nutrition information (Glewwe, 1999; Thomas et al., 1991) and facilitating risk management in the event of shocks.

>>Insert Table 1 about here<<

Next we turn to the shock module. Respondents were *asked* whether the household had experienced a shock within a list of possible adverse events.[5] We set up a dummy variable that takes the value 1 if the household experienced the shock in the survey years, zero otherwise. We consider shocks that occurred in the period January-June 2009 and in the same months in 2011. Table 2 presents the economic, natural, biological and health shocks considered in the module with the number of households that reported having experienced an adverse event in the year of the survey. Thus, we have to rely on *self-reported shocks* making the reporting of adverse events susceptible to recall and preference bias. We aim at addressing this issue by implementing a threefold strategy. First, we compare the responses to our shock module with shock data for Senegal collected by other surveys (République du Senegal, 2010). Second, we construct household level

[5] In the shock module households were asked the following questions: (1) Does the household recall having been affected by one of the following events? (followed by a list of events); (2) In which year did this event take place for the last time?; (3) On a scale from 0 to 10, what was the intensity of the event for the household?; (4)How did the household cope with this situation?; (5) On a scale from 1 to 10, how do you estimate the frequency of this event?.

climate indices by making use of externally supplied weather data.[6] Third, we employ sub-sample analyses to address the robustness and coherence of the results.

Comparing our shock data with similar data collected by the World Food Programme in 2010 confirms the external validity of the self-reported survey shock data (République du Senegal, 2010).[7] Moreover, in line with the overall macro-economic conditions during the period, an increase in purchase prices is the adverse event that has mostly affected rural households in Senegal: 41% (76%) of the households report having experienced price increases in 2009 (2011). Droughts are reported by 3 to 6% of the households in both rounds. Across shock categories we observe that significantly more adverse events are reported in 2011. We attribute the more sensitive perception of negative events in 2011 to the overall hazardous climate induced by the high food prices.

>>Insert Table 2 about here<<

The extent of interdependencies between different shock categories is presented in Tables 3 and 4 for the two survey years. Notably, in 2009 droughts are positively and significantly correlated with the occurrence of crop pests, loss of a key income source and price variations. Similarly, extreme cold events are correlated with price increases. Increasing purchase prices are also positively correlated with crop pests. Pairwise correlations slightly differ in 2011. Except for extreme cold, natural shocks are not significantly correlated with increases in purchase prices in 2011, while loss of a key income source is positively and significantly correlated with the occurrence of all other shocks. The differences in the pair-wise correlations already hint at differences in the perception of shocks over time. Consequently, a possible reason of concern in the econometric model stems from the dynamic nature of individual perceptions. Yet, the two shocks we focus on (drought and increasing prices) are not significantly correlated in 2011 when the second surge of food prices took place indicating that they are exogenous to each other.[8]

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[6] We do not have information about prices at the village level.

[7] Note that the reference period for our shock variables (January-June) is not the key drought period for Senegal. Droughts are usually reported for the period June to October when the main crops are grown. At the time of the interview the planting, growing and harvesting of the primary cash and food crops already took place and households mainly rely on food from the period prior to our reference period for consumption and trade. Although our reference period does not cover the main agricultural season, between January and June Senegalese households still produce some crops for the local and export market. Therefore lean season droughts may also have negative effects in terms of lower agricultural production and amplification of food scarcity (Maccini and Yang, 2008). We argue that our drought shock variable captures precisely this effect. Thus, if households report droughts during the period January to June, they report against their own expectations and it is very likely that a deviation from "normal" and expected weather was experienced.

[8] Additionally we investigated the determinants of the reported increase in purchase price. We estimate a probit model with the price shock dummy as dependent variable and several explanatory variables. Reported drought does not seem to be a significant determinant of an increase in purchase price.

>>Insert Table 3 and 4 about here<<

The econometric model employed in the multivariate shock analysis is introduced in the next section. Here, we already discuss non-parametric estimates for the 2009 and 2011 cross-sections of children with available weight-for-age information; we focus on price increases and drought shocks. Children living in households that experienced a drought shock in 2009 have lower weight-for-age (-1.511) than the non-drought shock children (-1.445, Table 1). Child weight-for-age in 2011 is lower for children living in households that experienced an increase in purchase prices (WAZ with price shock: -0.632; WAZ without price shock: -0.402) or a drought (WAZ with drought: -1.407; WAZ without drought: -0.526), and the simple comparison across periods also supports the overall negative effect of price increases and droughts on child weight-for-age (Table 1). In a simple comparison of means over time and across affected versus unaffected children, the drought estimate is most significant and accounts for 42% of the pooled weight-for-age standard deviation, the price shock for 19%. However, these simple comparisons do not account for other determinants of child health, such as child-specific characteristics, socio-economic status, environmental quality and other community characteristics. In the multivariate analysis that follows, we include these determinants as well and allow for concomitance of the shocks.

4. Econometric Model

We set up a model with two periods and location fixed effects for a repeated cross-section of children to analyze the impact of adverse events on child anthropometrics. The dependent variable is the weight-for-age (WAZ) Z-score as short-term indicator of child health. The main effect we are interested in is the impact of drought and price shocks in concomitance with other types of shocks from the natural, biological, economic and health sphere. The estimation procedure follows three steps.

4.1 Basic model: Multi-shock analysis

Considering that child, household and community characteristics could be correlated with child health we initially estimate a simple child health model including observable child, mother, and household characteristics to avoid omitted variables bias. The basic estimation equation can then be written as:

$$Health_{ihvt} = \alpha + \beta\, CC_{ihvt} + \gamma\, HH_{hvt} + \delta_1\, NAT_{hvt-1} + \delta_2\, BIO_{hvt-1} + \delta_3\, ECN_{hvt-1} + \delta_4\, HLT_{hvt-1} + \lambda_{vt} + \varepsilon_{ihvt} \qquad (1)$$

where $Health_{ihvt}$ is the weight-for-age Z-score pertaining to child *i* in household *h* and village *v* in year *t*. CC_{ihvt} is a vector of child and maternal characteristics; HH_{hvt} contains the household characteristics and asset wealth. The occurrence of shocks is observed at the household level; NAT_{hvt-1} is the vector of natural hazards experienced by the household in the survey year, BIO_{hvt-1} represents biological hazards, economic shocks are collected in ECN_{hvt-1} and health-related shocks in HLT_{hvt-1}. Structural change at the village level is captured by the village-year fixed effects λ_{vt} and ε_{ihvt} is the idiosyncratic error term. In the absence of a 'cleaner' natural experiment, we rely on the discussion above on the external validity of the survey shock data (République du Senegal, 2010) and implement various robustness checks to assert the exogeneity of shocks with respect to observable child, household and community characteristics. We are thus confident that OLS estimates of the average impact of shocks on child health are unbiased.

4.2 Interactions of price and drought shocks with the structural change

Descriptive statistics already indicate structural improvements in 2011 but also the increased incidence of droughts and the increase in purchase prices. Therefore, we also analyze the wellbeing of children living in households that experienced the price (drought) shock before and after the structural change. Hence we estimate an augmented model:

$$Health_{ihvt} = \alpha + \beta\, CC_{ihvt} + \gamma\, HH_{hvt} + \delta_1\, NAT_{hvt-1} + \delta_2\, BIO_{hvt-1} + \delta_3\, ECN_{hvt-1} + \delta_4\, HLT_{hvt-1} + \sigma\, PriceIncrease_{2011} + \lambda_{vt} + \varepsilon_{ihvt} \qquad (2)$$

where the additional term $PriceIncrease_{2011}$ interacts the increase in purchase prices with the dummy variable for the year 2011. Other variables are defined as above. A similar model is also estimated to compare a drought shock before and after the structural change, introducing the additional term $Drought_{2011}$ (interacting the drought shock with the dummy for the year 2011) in place of $PriceIncrease_{2011}$.

4.3 Misfortunes never come singly: Triple interactions accounting jointly for structural changes, price and drought shocks

As a final step we consider the effects of concomitantly increasing prices and experiencing drought shocks across children and survey rounds:

$$Health_{ihvt} = \alpha + \beta\, CC_{ihvt} + \gamma\, HH_{hvt} + \delta_1\, NAT_{hvt-1} + \delta_2\, BIO_{hvt-1} + \delta_3\, ECN_{hvt-1} + \delta_4\, HLT_{hvt-1} + \sigma_1\, PriceXDrought_{hvt-1} + \sigma_2\, PriceIncrease_{2011} + \sigma_3\, Drought_{2011} + \sigma_4\, PriceXDrought_{2011} + \lambda_{vt} + \varepsilon_{ihvt} \qquad (3)$$

where *PriceXDrought*$_{hvt-1}$ interacts the increase in purchase prices with the occurrence of a drought (concomitance effect), *PriceIncrease*$_{2011}$ interacts the purchase price shock with the dummy for the year 2011 and *Drought*$_{2011}$ interacts the drought shock with the dummy for the year 2011. The variable of interest is *PriceXDrought*$_{2011}$ interacting both the purchase price and drought shock dummies with the dummy for the year 2011. Hence σ_4 will account for shock concomitance while considering the structural change. Other variables are defined as above.

Across specifications standard errors are clustered at the village level to account for within village correlation of the error term.

5. Results

The results for the impact of adverse events on child anthropometrics are presented in Table 5. In columns 1 to 7 we include the shocks one by one (Equation 1); we include dummies accounting for economic, natural, biological and health shocks. Negative and significant coefficients associated with a shock variable indicate that the occurrence of the respective shock affects child health negatively. The non-significance of the coefficient pertaining to a shock variable does not necessarily suggest that the specific shock did not have any effects on child nutritional status or on other indicators of household welfare. It rather suggests that, on average, households have been able to mitigate the adverse effects of the shock thanks to (*ex-ante*/*ex-post*) successful coping strategies. In column 8 we include the shocks jointly (Equation 1) and in columns 9 to 11 we allow for concomitance of shocks (Equation 2 and 3). Concerning other control variables, we account for household size and composition (share of children below 5 years in the household), parental characteristics, access to water and sanitation, and wealth indicators (poultry, livestock and land ownership). Indicator variables for the ownership of a radio and/or mobile phone in the household are included as both indicators of wealth and connectedness. These devices allow the household to get access to news and information about health, and shocks occurring within and outside the country. We also include a dummy variable indicating whether the household has migrants to control for possible endogeneity of household localization.[9] We expect households located in the same areas to have similar characteristics, risk and food

[9] Migration of entire households did not occur. In the second survey round we successfully found the households back in the villages. While we can thus rule out migration of complete households, we do not rule out migration of individual members. Thus, we can only assess the impact of shocks on the children left behind. However, this is not a major concern for the analysis of child wellbeing as we observe in the migration module of the survey that it is mainly adult household members who migrated. Note that accounting for migrated members is also important to consider further income flows to the household that may help mitigating

security profiles. Following the approach of Cogneau and Jedwab (2012) and Senne (2013) we control for village-year fixed effects by including dummies for the village of residence interacted with the year dummy for 2011 to control for all unobserved village-specific characteristics and trends related to shocks and child health. This specification allows us to account for structural changes at the village level. The village-year fixed effects also imply that the shock effect that influences child health is only the one differentially affecting children that did or did not experience the structural change and the specific shock analyzed in the same environment. We verified that the village-year fixed effects are relevant. They are jointly significant and support the occurrence of a structural trend as observed in the descriptive statistics. Furthermore, when including village and year fixed effects separately we observe a positive and significant coefficient estimate associated with the year dummy supporting the occurrence of a structural change between the survey rounds.

>>Insert Table 5 about here<<

Results show that droughts have a substantial negative impact on child health explaining 29.7% of the pooled variation in weight-for-age according to the stand-alone specification (Table 5, Column 1) and 27.9% when all shocks are jointly included (Table 5, Column 8). The hazards extreme cold and crop pests do not have a significant impact on child health. The economic shock that coherently does not affect child health is a decrease in sales prices. However the loss of a key income source reduces child health explaining between 23.4 and 24.2% of the pooled variation in weight-for-age (Table 5, Columns 6 and 8). The increase in purchase prices does not have a direct impact, when however interacted with the year dummy for 2011 to account for the international food price peak in that year we find a substantial negative effect (Table 5, Column 9). The health shock we account for is the death of a household member. We find a positive impact on child health (Table 5, Columns 7 and 8). This is in line with Grimm (2010), who shows that the death of unproductive household members is compensated by the increase in available resources in the household. In our sample 58% of the deaths can be clearly attributed to unproductive members suggesting that per capita resources are increased in response to a death. Across specifications, the sign and level of significance of the shocks remain stable indicating that we analyze coherent shock-health pathways across the different models.

As the natural hazard drought and the economic shock pertaining to income have the most pronounced impact on child health, we further exploit their dynamics in light of the structural change

the effects of adverse events. In line with our expectations, having migrant household members significantly improves child weight-for-age. The authors provide detailed coefficient estimates upon request.

occurring between the two survey rounds. Specifications (9) and (10) of Table (6) present the multi shock estimates for increased prices and the drought shock conditional on the usual child, household and village observables and the survey year to consider fundamental changes occurring between 2009 and 2011. Conditional estimates (the year-shock interaction) suggest a negative effect of both increased prices and droughts on underweight despite the considerable overall improvements in 2011 explaining up to 24% and 43% of the pooled variation in weight-for-age, respectively. These findings are in line with the non-parametric estimates for child weight-for-age deduced from the descriptive statistics. They highlight the need to implement measures to protect child health from certain adverse events even during periods of overall growth and expansion.

Is it the case that misfortunes never come singly? Finally, we consider a triple interaction term to account for competing effects of shocks. In particular, we focus on the concomitance of an increase in purchase prices and drought episodes after 2011. We find that concomitance has a positive but insignificant effect on child weight-for-age (Table 5, Column 11). This is an interesting finding given the improvements in child health observed in 2011 but the higher incidence of shocks during the same period. In the analysis with triple interactions we observe that both the price-year and drought-year interaction terms are negative and significant mimicking the analysis with simple interaction terms but showing higher magnitudes. More importantly, the effects of the concomitance of increased prices and drought shocks in 2009 and 2011 are captured by the price-drought interaction term and the triple interaction term, respectively. Both these terms are positive and insignificant. In economic terms this suggests competing price and income effects. Analogous to the simple agricultural household model for net producers (Bardhan and Udry, 1999), we find that higher prices for consumption of home-produced goods increase income; this is particularly the case in times of scarcity such as a drought. Thus, our results suggest that the concomitance of drought and price shocks does not increase the severity of these shocks but can be mitigating the individual shocks.

6. Robustness checks and sub-sample analysis

In this section we present the results of robustness checks for the previous analysis. To this end we replicate specifications 8 to 11 of Table 5 for (i) redefined shock measures, (ii) additional control variables, and (iii) sub-samples. For the sake of brevity we do not present the corresponding results tables in the main text. They are available in the appendix.

We start by replacing the shock dummy with the reported shock intensity on a 1 to 10 Likert scale. The results are virtually identical with drought shocks displaying a direct negative impact and the negative impact of the price shock showing up when interacted with the year dummy. The triple interaction is again positive and statistically insignificant. As expected the coefficient estimates are smaller implying that the more severe a shock is, the worse is the anthropometric outcome. While these estimates reinforce the previous findings, they have to be interpreted with even more caution since the scaling of the severity of a shock is even more dependent on the perception of the respondent (Appendix, Table A.1, Panel A).

Therefore, we further complement our main results with objective drought measures thus ensuring the exogeneity of the drought shock.[10] We collected household level precipitation data based on geo-referenced climatic information from the African Drought and Flood Monitor (AFDM, 2014). The coefficient associated with the objective drought index is not significant. However, results pertaining to triple interactions confirm our main argument that multiple shocks have to be carefully dealt with because of their interdependencies. The F-test for joint significance of the coefficients involving the drought shock variable is significant. Even this approach needs to be considered with caution as we only know the GPS codes of the households but the plots used for crop production are not necessarily located right next to the household. When analyzing the average time the household needs to go to the plot, we observe that they are located at an average walking distance of 27 minutes: Given that we do not have GPS information about plots, we cannot rule out variation in precipitation intensity related to the land cultivated (Appendix, Table A.1, Panel B).

Next we include additional control variables in the analysis that might mitigate the impact of the shocks. As we rely on a repeated cross-section of children we also need to account for their health profile. Therefore, we estimate a specification where we include height as measure of accumulated health as additional control variable. The past health stock as represented by height-for-age has a positive impact on current weight-for-age. The results pertaining to the shocks are unaffected from the inclusion of height (Appendix, Table A.2, Panel C). In addition, we also account for growth of peanuts in the empirical specification, as groundnuts are a major crop in the villages under study. Peanuts are cultivated in all regions and we find that between 2009 and 2011 the share of children living in households cultivating groundnuts increased from 47% to 89%. Children living in peanut growing households are significantly better off on average. In terms of magnitude the coefficient associated with peanut farming offsets 50% of the impact of the drought shock. Clearly, this crop choice has helped to improve child health in the period considered. However, groundnut production in Senegal has historically led to more droughts. The sustainability of growing peanuts as coping mechanism is questionable given the environmental and non-environmental challenges faced by the farmers (Appendix, Table A.2, Panel D). We further account for the distance to the nearest market as control variable since it reflects to what extent the community is connected to international

[10] We consider the Standardized Precipitation Index, which reflects short and medium term moisture conditions while providing seasonal estimates of precipitation. Related objective shock dummies are positively and significantly correlated with the self-reported drought shocks.

markets. The more remote the households are located, the lower child health. The impact of the various shocks on child health is virtually identical to the main results (Appendix, Table A.2, Panel E).

We conclude the robustness checks with three sub-sample analyses. First, we compare the sub-sample of households whose male breadwinner has farming as main occupation to the sub-sample with male breadwinners having a different main occupation. Children living in households that depend on agriculture as main occupation are more adversely affected by drought shocks as compared to children of households that depend less on farming. Similarly, the price shock only shows up for children in the sub-sample of households whose male breadwinner has farming as main occupation. This finding supports the concept of a poverty-vulnerability channel (Appendix, Table A.3, Panels F and G). Second, the notion that poor people are more vulnerable to shocks is further reinforced when splitting the sample into asset-poor and asset-rich households. It is children from asset-poor households for whom the previously identified shocks and their interdependencies develop their full impact. Children in asset-rich households are not affected (Appendix, Table A.4, Panels H and I). Third, we compare boys and girls. Droughts seem to affect girls more, whereas the differential price and drought shock for the year 2011 develops its negative potential more for boys (Appendix, Table A.5, Panels J and K).

Overall, the robustness checks and sub-sample analyses support our main results: It is the environmental hazard of droughts and the economic shock of price increases that have a pronounced negative impact on child health in the short run whereas interdependencies of the shocks can lead to offsetting effects.

7. Conclusions

The results of our multiple shock analysis for the case of rural Senegal suggest that shocks from the natural, biological, economic and health sphere can considerably reduce the wellbeing of children. Moreover, the impact of adverse events on child health critically depends on the type and concurrence of the shocks. Failing to jointly account for different types of shocks might yield misleading results and ensuing policy conclusions.

We show that child health is negatively affected if households experienced non-concomitant higher purchase prices or a drought. However, if the household experienced both shocks concomitantly, the net effect on child health was not significant. We infer that income effects dominate concomitant drought and price shocks for poor subsistence farmers. The sub-sample analysis highlights that households that depend on agriculture as primary income source and asset-poor households are the most adversely hit by the shocks. Thus, the analysis is yet another demonstration for the dependence of the poor on the resource land and the proceeds from it, which are considerably prone to environmental as well as (international) economic shocks. Management of agricultural land in the light of shocks from the natural, biological, health and economic sphere is a bottleneck for ensuring proper consumption of millions of children and concomitantly sustainable development.

To conclude, children are the most vulnerable constituents of society while at the same time they are the gateways for future household and community welfare. As shown by our analysis growing up in poor shock-prone environments does not necessarily preclude child opportunities to develop. At the same time, leaving shock effects unmanaged could result in a variety of positive and negative effects. Indeed, although the analysis highlighted positive income effects from concomitant price and drought shocks for children in rural households, nothing can be said about the effects of these shocks in urban areas, where mainly net consumers reside. Ultimately the effects on urban children and households are expected to be very different. Hence, from the perspective of the policy maker the various channels for shocks and their (negative) effects have to be considered in short-term intervention decisions and long-term programs aiming at structural change. This will minimize the vulnerability of households and individuals already before shocks occur, while maximizing resilience *ex-post* and ensuring sustainable livelihoods consonant with the natural environment.

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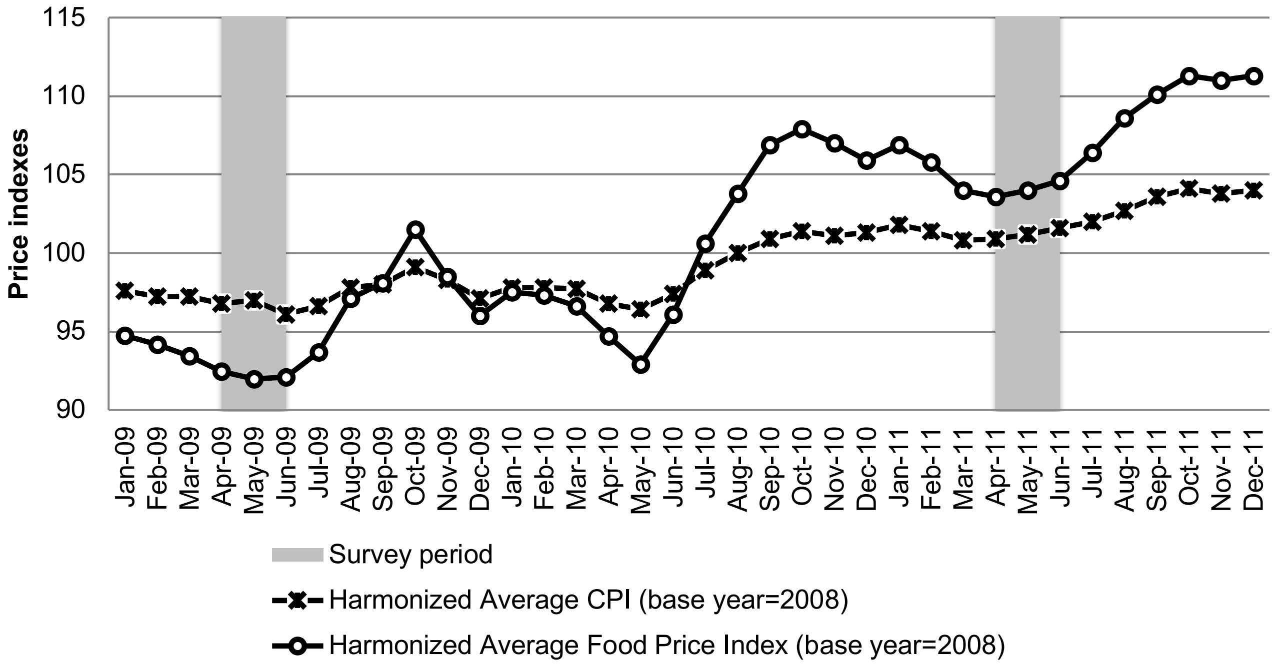
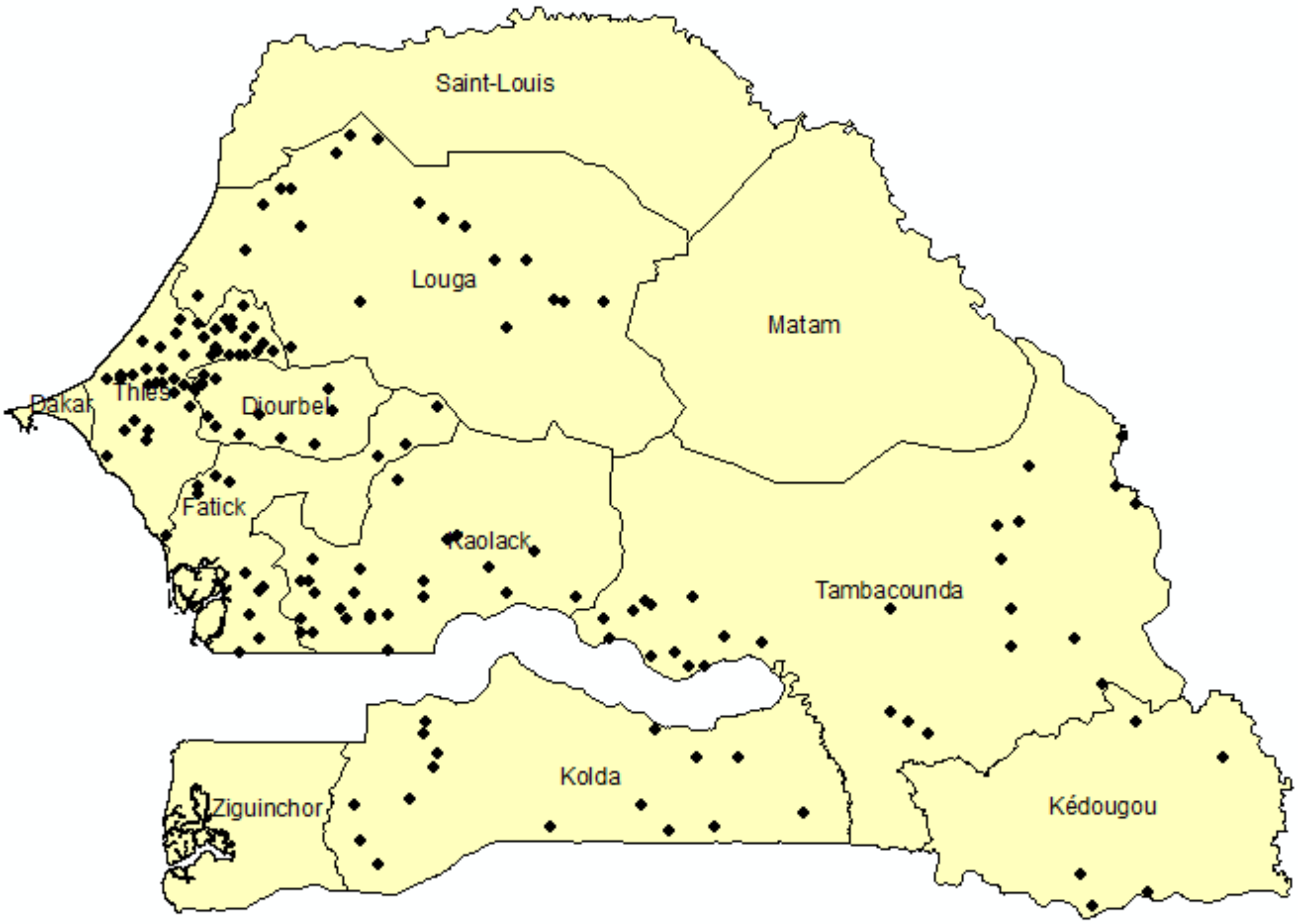
Figure 1 Monthly Harmonized Average CPI and Food Price Index in Senegal for the period 2009-2011.



Source: Agence Nationale de Statistique et de la Démographie (AGNSD, 2013) and authors' elaborations.

Figure 2: Map of Senegal with surveyed villages.



Note: The sample consists of 165 villages in 8 regions according to the 2009 regional subdivision, as defined in the 2009 survey. • indicates the location of a survey village.

Table 1 Descriptive statistics of outcome and control variables for rural households in Senegal.

	2009		2011		
Variable	Mean	St. Dev	Mean	St. Dev	Difference
Weight-for-age (WAZ)[a]	-1.447	(1.805)	-0.576	(1.937)	-0.871***
Height-for-age (HAZ)[a, b]	-1.196	(2.234)	-0.936	(1.919)	-0.260***
WAZ for children experiencing a drought	-1.511	(1.957)	-1.407	(1.541)	-0.104
WAZ for children not experiencing a drought	-1.445	(1.808)	-0.526	(1.948)	-0.919***
WAZ for children experiencing a price increase	-1.367	(1.729)	-0.632	(1.973)	-0.735***
WAZ for children not experiencing a price increase	-1.503	(1.866)	-0.402	(1.813)	-1.101***
Sex	0.453	(0.498)	0.495	(0.500)	-0.042***
Age (months)	30	(12.873)	34	(14.816)	-4.089***
Missing date of birth (=1)	0.787	(0.409)	0.798	(0.402)	0.011
Age HH[c] head	52	(14.602)	54	(15.280)	-1.467***
Sex HH[c] head (Female=1)	0.023	(0.150)	0.024	(0.153)	-0.001
Mother is out of the household (=1)	0.053	(0.223)	0.035	(0.185)	0.018***
Age Mother	29	(7.536)	30	(7.381)	-0.747***
Mother can read and write (=1)	0.148	(0.355)	0.176	(0.381)	-0.028**
Mother is head of household (=1)	0.005	(0.073)	0.004	(0.065)	0.001
Mother is wife of the HH[c] head (=1)	0.523	(0.500)	0.478	(0.500)	0.045***
Mother is daughter of HH[c] head (=1)	0.035	(0.185)	0.042	(0.201)	-0.007
Mother is not a relative	0.025	(0.155)	0.015	(0.122)	0.010**
Household size	14	(6.345)	15	(7.139)	-1.524***
Share of children <5 in household	0.253	(0.105)	0.241	(0.100)	0.012***
Poultry	0.570	(0.495)	0.675	(0.469)	-0.105***
Livestock	0.943	(0.231)	0.953	(0.212)	-0.010
Water					
(1) own tap	0.209	(0.407)	0.234	(0.423)	-0.025*
(2) public tap	0.275	(0.447)	0.247	(0.431)	0.028*
(3) protected well	0.088	(0.283)	0.040	(0.195)	0.048***
(4) neighbor tap	0.012	(0.108)	0.012	(0.110)	-0.000
(5) non-protected well	0.299	(0.458)	0.330	(0.470)	-0.031**
(6) hole	0.073	(0.260)	0.121	(0.327)	-0.048***
(7) other	0.045	(0.207)	0.015	(0.122)	0.030***
Toilet					
(1) none or external	0.207	(0.405)	0.164	(0.370)	0.043***
(2) water sewer	0.010	(0.100)	0.003	(0.057)	0.007***
(3) septic tank	0.032	(0.175)	0.089	(0.285)	-0.057***
(4) covered latrine	0.381	(0.486)	0.292	(0.455)	0.089***
(5) uncovered latrine	0.284	(0.451)	0.243	(0.429)	0.041**
(6) other	0.087	(0.283)	0.208	(0.406)	-0.121***
Own Mobile (=1)	0.668	(0.470)	0.882	(0.322)	-0.214***
Own radio (=1)	0.739	(0.439)	0.820	(0.384)	-0.081***
Number of parcels cultivated	3.032	(1.667)	3.068	(1.462)	-0.036
Size of land cultivated (Ha)	6.729	(6.001)	5.723	(4.807)	1.006***
Farmer (=1 if main occupation of male breadwinner is farming)	0.608	(0.488)	0.586	(0.493)	0.022
Peanuts (=1 if HH cultivates peanuts)	0.344	(0.475)	0.781	(0.413)	-0.438***
Migrants (=1 if the HH has migrants)	0.406	(0.491)	0.276	(0.447)	0.130***
Number of observations	1,694		2,116		

Source: Authors' elaborations.

Note: [a]The pooled standard deviation for child weight-for-age and height-for-age is 1.931 and 2.062 respectively. [b]For HAZ the number of observations is 1,503 and 2,022 in 2009 and 2011, respectively. [c]HH is used as abbreviation for household. */**/*** stands for p-value < 0.10/< 0.05/< 0.01, respectively.

Table 2 Shocks in the survey area in the periods 2009 and 2011.

	2009		2011		
Shocks	***Mean***	***St.Dev***	***Mean***	***St.Dev.***	**Difference**
Economic shocks					
Increase in purchase prices	0.41	0.49	0.76	0.43	**-0.34*****
Decrease in sales prices	0.09	0.28	0.00	0.00	0.09
Loss of key income source	0.01	0.10	0.07	0.25	**-0.06*****
Natural hazard					
Drought	0.03	0.16	0.06	0.23	**-0.03*****
Cold wave	0.04	0.20	0.01	0.09	0.03
Biological hazard					
Crop pest/insects invasion	0.04	0.20	0.04	0.20	0.00
Health shocks					
Death of a member	0.04	0.20	0.05	0.23	**-0.01*****
Number of observations	*1,694*		*2,116*		

Source: Authors' elaborations.

Note: The difference in shock incidence is in bold when it is significantly higher in 2011. *** stands for p-value <0.01.

Table 3 Correlation between the different shocks for the 2009 survey period.

Shock type			(1)	(2)	(3)	(4)	(5)	(6)	(7)
Natural	(1)	Drought	1						
	(2)	Extreme cold	0.040	1					
Biological	(3)	Crop pest	0.131*	0.102*	1				
Health	(4)	Death of a member	-0.015	0.180*	0.016	1			
Economic	(5)	Loss of key income source	0.095*	0.038	-0.021	0.009	1		
	(6)	Decrease in sales prices	0.068*	-0.023	0.060*	-0.064*	0.095*	1	
	(7)	Increase in purchase prices	0.157*	0.142*	0.114*	0.088*	0.072*	0.295*	1

Source: Authors' elaborations.

Note: * stands for level of significance greater or equal to 0.05.

Table 4 Correlation between the different shocks for the 2011 survey period.

Shock type			(1)	(2)	(3)	(4)	(5)	(6)	(7)
Natural	(1)	Drought	1						
	(2)	Extreme cold	0.115*	1					
Biological	(3)	Crop pest	0.168*	0.104*	1				
Health	(4)	Death of a member	0.076*	0.181*	0.053*	1			
Economic	(5)	Loss of key income source	0.240*	0.350*	0.355*	0.182*	1		
	(6)	Decrease in sales prices	.	.	.	.	.	.	
	(7)	Increase in purchase prices	0.011	0.058*	0.082*	0.005	0.127*	.	1

Source: Authors' elaborations.

Note: * stands for level of significance greater or equal to 0.05.

Table 5 Empirical results of the multi-shock analysis of child weight-for-age.

	Dependent variable: Child Weight-for-Age										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Drought	-0.574***							-0.538***	-0.567***	0.104	-0.333
	(0.196)							(0.192)	(0.195)	(0.349)	(0.401)
Extreme cold		0.331						0.353	0.299	0.347	0.287
		(0.265)						(0.257)	(0.259)	(0.262)	(0.264)
Crop pest			0.005					0.082	0.071	0.069	0.033
			(0.169)					(0.175)	(0.173)	(0.169)	(0.165)
Increase in purchase prices				0.039				0.040	0.284**	0.030	0.268**
				(0.088)				(0.091)	(0.126)	(0.091)	(0.126)
Decrease in sales prices					-0.019			-0.006	-0.116	-0.025	-0.139
					(0.185)			(0.195)	(0.192)	(0.193)	(0.191)
Loss of key income source						-0.468*		-0.452*	-0.436	-0.425	-0.403
						(0.277)		(0.271)	(0.275)	(0.269)	(0.265)
Death of HH[a] member							0.230*	0.254**	0.238*	0.261**	0.249*
							(0.127)	(0.128)	(0.130)	(0.129)	(0.131)
Year 2011 * Increased Prices									-0.466**		-0.496**
									(0.199)		(0.201)
Year 2011 * Drought										-0.833**	-1.062*
										(0.380)	(0.544)
Increased Prices * Drought											0.392
											(0.558)
Year 2011 * Increased Prices * Drought											0.446
											(0.688)
R-squared	0.213	0.211	0.211	0.211	0.211	0.212	0.211	0.216	0.218	0.217	0.220
P-value F-test joint sign. Price coeff.									0.047		0.000
P-value F-test joint sign. Drought coeff.										0.001	0.059

Source: Authors' elaborations.

Note: Village-year fixed effects estimations with standard errors clustered at the village level. The number of villages is 165. The total number of observations is 3,810. All shock variables are dummy variables. Additional control variables included are age and gender of the child, head of the household and mother's age and gender, if the mother resides in the household, mother's literacy, if the mother is related to the head of the household, number and size of parcels of land cultivated, ownership of poultry, livestock, radio and mobile phone, dummy variables for water, toilet facilities and migrant members. [a]HH is used as abbreviation for household. */ **/ *** stands for significance at 10/5/1%, respectively.

Tables for the Online Appendix

Table A.1 Robustness checks including shock intensity measures and geo-referenced rainfall data.

	A				B			
	Intensity	Intensity	Intensity	Intensity	HH.SPI3	HH.SPI3	HH.SPI3	HH.SPI3
	(8)	(9)	(10)	(11)	(8)	(9)	(10)	(11)
Drought (SPI3 < –1)					0.099	0.086	0.008	0.123
					(0.090)	(0.084)	(0.139)	(0.120)
Drought	-0.079***	-0.083***	-0.058	-0.096**				
	(0.024)	(0.024)	(0.036)	(0.041)				
Extreme cold	0.031	0.021	0.032	0.017	0.294	0.263	0.320	0.308*
	(0.032)	(0.033)	(0.032)	(0.033)	(0.220)	(0.178)	(0.218)	(0.146)
Crop pest	0.001	-0.001	0.002	-0.003	-0.082	-0.091	-0.081	-0.081
	(0.035)	(0.035)	(0.035)	(0.035)	(0.135)	(0.133)	(0.137)	(0.143)
Increase in purchase prices	0.002	0.033**	0.002	0.030**	0.041	0.197	0.042	0.283
	(0.009)	(0.013)	(0.010)	(0.013)	(0.177)	(0.174)	(0.179)	(0.182)
Decrease in sales prices	-0.065*	-0.071*	-0.065*	-0.068*	-0.114	-0.190	-0.110	-0.162
	(0.037)	(0.037)	(0.037)	(0.037)	(0.250)	(0.195)	(0.248)	(0.196)
Loss of key income source	0.022*	0.027**	0.022*	0.028**	-0.415*	-0.402*	-0.444**	-0.562**
	(0.013)	(0.013)	(0.013)	(0.013)	(0.200)	(0.206)	(0.186)	(0.191)
Death of HH[a] member	0.026**	0.024*	0.026**	0.025**	0.294**	0.284**	0.292**	0.252**
	(0.012)	(0.013)	(0.012)	(0.013)	(0.087)	(0.086)	(0.086)	(0.092)
Year 2011 * Increased Prices		-0.058**		-0.059**		-0.301		-0.690**
		(0.023)		(0.023)		(0.477)		(0.243)
Year 2011 * Drought			-0.034	-0.058			0.181	-1.244**
			(0.045)	(0.056)			(0.246)	(0.405)
Increased Prices * Drought				0.009				-0.371
				(0.007)				(0.267)
Year 2011 * Increased Prices * Drought				0.002				1.997***
				(0.009)				(0.434)
Fixed effects	Village-year	Village-year	Village-year	Village-year	Region	Region	Region	Region
Clusters (number)	Village-year	Village-year	Village-year	Village-year	Region	Region	Region	Region
Observations	3,810	3,810	3,809	3,809	3,808	3,808	3,808	3,808
R-squared	0.217	0.220	0.217	0.221	0.157	0.158	0.157	0.170
P-value F-test joint sign. Drought coeff.			0.003	0.000			0.500	0.000

Source: Authors' elaborations.

Note: Fixed effects estimations with clustered standard errors. In Panel A, the shock variables are expressed in terms of perceived intensity on a Likert scale from 1 to 10. In Panel B, the drought index is based on geo-referenced climatic information from the African Drought and Flood Monitor (AFDM, 2014). Additional control variables included are age and gender of the child, head of the household and mother's age and gender, if the mother resides in the household, mother's literacy, if the mother is related to the head of the household, number and size of parcels of land cultivated, ownership of poultry, livestock, radio and mobile phone, dummy variables for water, toilet facilities and migrant members. [a]HH is used as abbreviation for household. */ **/ *** stands for significance at 10/5/1%, respectively.

Table A.2 Robustness checks controlling for height-for-age (HAZ), peanut farming and distance to the regional capital.

	C				D				E			
	HAZ	HAZ	HAZ	HAZ	Peanuts	Peanuts	Peanuts	Peanuts	Distance	Distance	Distance	Distance
	(8)	(9)	(10)	(11)	(8)	(9)	(10)	(11)	(8)	(9)	(10)	(11)
Height-for-Age	0.312***	0.313***	0.311***	0.311***								
	(0.018)	(0.018)	(0.018)	(0.018)								
Household cultivates peanuts					0.220**	0.216**	0.231***	0.227***				
					(0.087)	(0.086)	(0.088)	(0.086)				
Distance to regional capital									-7.503**	-7.115*	-7.138*	-6.633*
									(3.685)	(3.702)	(3.673)	(3.686)
Drought	-0.411**	-0.444**	0.047	-0.485	-0.533**	-0.553**	0.123	-0.326	-0.505***	-0.534***	0.084	-0.296
	(0.184)	(0.186)	(0.318)	(0.380)	(0.216)	(0.218)	(0.330)	(0.420)	(0.187)	(0.190)	(0.348)	(0.393)
Extreme cold	0.349	0.290	0.350	0.283	0.374	0.336	0.372	0.333	0.303	0.253	0.299	0.245
	(0.240)	(0.235)	(0.242)	(0.238)	(0.276)	(0.277)	(0.281)	(0.282)	(0.256)	(0.258)	(0.261)	(0.262)
Crop pest	0.129	0.134	0.127	0.102	0.200	0.193	0.189	0.171	0.087	0.075	0.074	0.040
	(0.159)	(0.158)	(0.157)	(0.156)	(0.179)	(0.177)	(0.173)	(0.169)	(0.177)	(0.175)	(0.171)	(0.167)
Increase in purchase prices	-0.118	0.153	-0.124	0.144	0.076	0.254**	0.068	0.235*	0.031	0.266**	0.022	0.252**
	(0.082)	(0.120)	(0.082)	(0.120)	(0.097)	(0.126)	(0.097)	(0.126)	(0.090)	(0.124)	(0.090)	(0.125)
Decrease in sales prices	0.192	0.072	0.174	0.048	-0.069	-0.145	-0.091	-0.166	-0.021	-0.126	-0.038	-0.146
	(0.181)	(0.182)	(0.180)	(0.182)	(0.212)	(0.208)	(0.210)	(0.207)	(0.194)	(0.192)	(0.192)	(0.191)
Loss of key income source	-0.708***	-0.693**	-0.695**	-0.672**	-0.287	-0.267	-0.269	-0.257	-0.447	-0.431	-0.422	-0.401
	(0.271)	(0.274)	(0.270)	(0.268)	(0.255)	(0.255)	(0.255)	(0.257)	(0.272)	(0.276)	(0.271)	(0.267)
Death of HH[a] member	0.274**	0.256**	0.279**	0.267**	0.215	0.203	0.227	0.219	0.236*	0.222	0.244*	0.233*
	(0.120)	(0.122)	(0.121)	(0.122)	(0.146)	(0.147)	(0.147)	(0.149)	(0.132)	(0.134)	(0.133)	(0.135)
Year 2011 * Increased Prices		-0.510***		-0.545***		-0.376*		-0.376*		-0.448**		-0.478**
		(0.189)		(0.191)		(0.212)		(0.217)		(0.197)		(0.199)
Year 2011 * Drought			-0.577*	-0.657			-0.886**	-0.768			-0.767**	-1.031*
			(0.341)	(0.426)			(0.375)	(0.553)			(0.372)	(0.538)
Increased Prices * Drought				0.497				0.437				0.332
				(0.520)				(0.557)				(0.553)
Year 2011 * Increased Prices * Drought				0.270				-0.024				0.475
				(0.588)				(0.674)				(0.682)
Observations	3,525	3,525	3,525	3,525	3,352	3,352	3,352	3,352	3,810	3,810	3,810	3,810
R-squared	0.316	0.319	0.316	0.320	0.223	0.225	0.225	0.226	0.218	0.220	0.218	0.221

Source: Authors' elaborations.

Note: Village-year fixed effects estimations with standard errors clustered at the village level. All shock variables are dummy variables. Additional control variables included are age and gender of the child, head of the household and mother's age and gender, if the mother resides in the household, mother's literacy, if the mother is related to the head of the household, number and size of parcels of land cultivated, ownership of poultry, livestock, radio and mobile phone, dummy variables for water, toilet facilities and migrant members. [a]HH is used as abbreviation for household. */ **/ *** stands for significance at 10/5/1%, respectively.

Table A.3 Robustness checks splitting the sample into households with the main occupation of the male breadwinner being farming and other households.

	F				G			
	Sub-sample: Main occupation of male breadwinner is farming				Sub-sample: Main occupation of male breadwinner is not farming			
	(8)	(9)	(10)	(11)	(8)	(9)	(10)	(11)
Household cultivates peanuts								
Drought	-0.721**	-0.742**	-0.225	-0.340	-0.565**	-0.580**	0.028	-1.386***
	(0.308)	(0.314)	(0.601)	(0.591)	(0.272)	(0.278)	(0.430)	(0.454)
Extreme cold	-0.127	-0.213	-0.140	-0.222	0.651*	0.637*	0.655*	0.626*
	(0.378)	(0.382)	(0.393)	(0.394)	(0.343)	(0.343)	(0.343)	(0.338)
Crop pest	0.111	0.103	0.105	0.085	0.003	0.002	-0.008	-0.068
	(0.277)	(0.272)	(0.270)	(0.262)	(0.212)	(0.212)	(0.206)	(0.207)
Increase in purchase prices	-0.107	0.251	-0.117	0.234	0.162	0.272	0.159	0.247
	(0.137)	(0.190)	(0.137)	(0.189)	(0.139)	(0.182)	(0.139)	(0.185)
Decrease in sales prices	0.125	-0.035	0.109	-0.047	0.177	0.141	0.151	0.077
	(0.254)	(0.245)	(0.256)	(0.246)	(0.334)	(0.334)	(0.328)	(0.329)
Loss of key income source	-0.488	-0.480	-0.452	-0.445	-0.236	-0.223	-0.240	-0.202
	(0.345)	(0.341)	(0.347)	(0.344)	(0.439)	(0.447)	(0.432)	(0.403)
Death of HH member	0.333**	0.313*	0.343**	0.316*	-0.066	-0.074	-0.062	-0.044
	(0.165)	(0.170)	(0.166)	(0.170)	(0.261)	(0.262)	(0.261)	(0.263)
Year 2011 * Increased Prices		-0.634**		-0.634**		-0.220		-0.309
		(0.276)		(0.277)		(0.266)		(0.273)
Year 2011 * Drought			-0.687	-1.013			-0.723	-0.188
			(0.680)	(0.847)			(0.491)	(0.748)
Increased Prices * Drought				-				1.954***
								(0.635)
Year 2011 * Increased Prices * Drought				0.525				-0.724
				(0.491)				(0.837)
Observations	2,271	2,271	2,271	2,271	1,539	1,539	1,539	1,539
R-squared	0.277	0.280	0.278	0.281	0.283	0.284	0.284	0.289
P-value F-test joint sign. Drought coefficients			0.026	0.016			0.065	0.000

Source: Authors' elaborations.

Note: Village-year fixed effects estimations with standard errors clustered at the village level. All shock variables are dummy variables. Additional control variables included are age and gender of the child, head of the household and mother's age and gender, if the mother resides in the household, mother's literacy, if the mother is related to the head of the household, number and size of parcels of land cultivated, ownership of poultry, livestock, radio and mobile phone, dummy variables for water, toilet facilities and migrant members. [a]HH is used as abbreviation for household. */ **/ *** stands for significance at 10/5/1%, respectively.

Table A.4 Robustness checks for the subsamples of asset-poor versus asset-rich households.

	H				I			
	Asset-poor households				Asset-rich households			
	(8)	(9)	(10)	(11)	(8)	(9)	(10)	(11)
Drought	-0.569**	-0.590**	0.269	0.274	-0.207	-0.231	-0.138	-1.122**
	(0.256)	(0.258)	(0.362)	(0.508)	(0.269)	(0.269)	(0.437)	(0.462)
Extreme cold	0.416	0.365	0.385	0.335	0.449	0.423	0.451	0.392
	(0.305)	(0.307)	(0.315)	(0.315)	(0.347)	(0.344)	(0.348)	(0.348)
Crop pest	0.294	0.285	0.281	0.271	-0.664*	-0.663*	-0.667*	-0.734**
	(0.182)	(0.177)	(0.171)	(0.166)	(0.359)	(0.360)	(0.357)	(0.353)
Increase in purchase prices	0.071	0.292**	0.061	0.276*	0.051	0.209	0.049	0.221
	(0.106)	(0.142)	(0.107)	(0.143)	(0.154)	(0.236)	(0.155)	(0.242)
Decrease in sales prices	-0.005	-0.093	-0.019	-0.100	0.383	0.292	0.379	0.259
	(0.233)	(0.230)	(0.227)	(0.227)	(0.322)	(0.325)	(0.322)	(0.331)
Loss of key income source	-0.608**	-0.564*	-0.577*	-0.539*	-0.490	-0.496	-0.488	-0.474
	(0.291)	(0.290)	(0.296)	(0.295)	(0.396)	(0.396)	(0.396)	(0.381)
Death of HH member	0.240	0.215	0.263	0.243	0.282	0.277	0.282	0.264
	(0.160)	(0.159)	(0.159)	(0.159)	(0.251)	(0.252)	(0.251)	(0.250)
Year 2011 * Increased Prices		-0.497*		-0.498*		-0.248		-0.335
		(0.257)		(0.267)		(0.302)		(0.308)
Year 2011 * Drought			-1.146***	-1.504*			-0.087	
			(0.428)	(0.792)			(0.474)	
Increased Prices * Drought				-0.087				0.906
				(0.675)				(0.615)
Year 2011* Increased Prices *Drought				0.506				0.344
				(0.909)				(0.479)
Observations	2,204	2,204	2,204	2,204	1,606	1,606	1,606	1,606
R-squared	0.261	0.263	0.263	0.265	0.290	0.290	0.290	0.292
P-value F-test Drought coefficients			0.004	0.014			0.740	0.096

Source: Authors' elaborations.

Note: Village-year fixed effects estimations with standard errors clustered at the village level. All shock variables are dummy variables. Additional control variables included are age and gender of the child, head of the household and mother's age and gender, if the mother resides in the household, mother's literacy, if the mother is related to the head of the household, number and size of parcels of land cultivated, ownership of poultry, livestock, radio and mobile phone, dummy variables for water, toilet facilities and migrant members. [a]HH is used as abbreviation for household. */ **/ *** stands for significance at 10/5/1%, respectively.

Table A.5 Robustness checks for the subsamples of boys versus girls.

	J				K			
	Sub-sample: Boys				Sub-sample: Girls			
	(8)	(9)	(10)	(11)	(8)	(9)	(10)	(11)
Drought	-0.356	-0.405	0.313	-0.249	-0.700***	-0.708***	0.070	0.585
	(0.292)	(0.295)	(0.394)	(0.739)	(0.251)	(0.253)	(0.872)	(0.385)
Extreme cold	0.813**	0.704**	0.824**	0.711**	0.055	0.040	0.039	0.022
	(0.326)	(0.333)	(0.334)	(0.340)	(0.344)	(0.344)	(0.350)	(0.352)
Crop pest	0.195	0.183	0.188	0.159	-0.114	-0.125	-0.145	-0.181
	(0.201)	(0.200)	(0.200)	(0.199)	(0.304)	(0.303)	(0.284)	(0.281)
Increase in purchase prices	0.058	0.384**	0.042	0.358**	-0.040	0.104	-0.047	0.097
	(0.121)	(0.174)	(0.121)	(0.174)	(0.121)	(0.179)	(0.122)	(0.180)
Decrease in sales prices	-0.170	-0.323	-0.198	-0.357	0.048	-0.016	0.038	-0.029
	(0.280)	(0.274)	(0.279)	(0.274)	(0.236)	(0.240)	(0.237)	(0.241)
Loss of key income source	-0.676*	-0.665*	-0.635*	-0.625*	-0.205	-0.194	-0.176	-0.157
	(0.343)	(0.345)	(0.340)	(0.342)	(0.449)	(0.451)	(0.446)	(0.430)
Death of HH member	0.206	0.184	0.217	0.199	0.232	0.219	0.240	0.226
	(0.245)	(0.250)	(0.245)	(0.250)	(0.173)	(0.176)	(0.172)	(0.175)
Year 2011 * Increased Prices		-0.630**		-0.633**		-0.268		-0.337
		(0.267)		(0.269)		(0.246)		(0.250)
Year 2011 * Drought			-0.968**	-0.803			-0.901	-2.326***
			(0.456)	(0.970)			(0.907)	(0.690)
Increased Prices * Drought				0.530				-0.597
				(0.900)				(0.976)
Year 2011*Increased Prices*Drought				-0.036				1.733
				(1.098)				(1.206)
Observations	1,994	1,994	1,994	1,994	1,816	1,816	1,816	1,816
R-squared	0.257	0.260	0.258	0.262	0.253	0.254	0.254	0.256
P-value F-test Drought coefficients			0.044	0.141			0.005	0.002

Source: Authors' elaborations.

Note: Village-year fixed effects estimations with standard errors clustered at the village level. All shock variables are dummy variables. Additional control variables included are age and gender of the child, head of the household and mother's age and gender, if the mother resides in the household, mother's literacy, if the mother is related to the head of the household, number and size of parcels of land cultivated, ownership of poultry, livestock, radio and mobile phone, dummy variables for water, toilet facilities and migrant members. [a]HH is used as abbreviation for household. */ **/ *** stands for significance at 10/5/1%, respectively.