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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 relationship of these self-reported shocks with 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 farming household panel dataset containing information on children living in poor, rural households in eight regions of Senegal in 2009 and 2011 and account for structural changes occurring between survey periods due to the large scale, national Nutrition Enhancement Program. By zooming in to the micro level we demonstrate that Senegal as a Sahelian country, mainly reliant on subsistence agriculture, is very vulnerable to climate variability and international price developments: According to our conservative estimates, the occurrence of a drought explains 25% of the pooled weight-for-age standard deviation, income losses 31%. Our multi-shock analysis reveals that the shocks are perceived as more severe in 2011 with droughts explaining up to 44% of the standard deviation of child health, increased prices up to 21%. Yet, the concomitance of droughts and increased prices after the structural change, i.e. the Nutrition Enhancement Program, indicates that the health of children experiencing both shocks in 2011 has improved. 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.

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 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

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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 panel 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 household panel 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 are most negatively associated with child weight-for-age. Crop pests or periods of extreme cold weather are not identified as having a significant relationship with child health. According to our conservative estimates, the occurrence of a drought explains 25% of the pooled weight-for-age standard deviation, income losses 31%, whereas an increase in purchasing prices is negatively but insignificantly related to child weight-for-age. Moreover, in 2011 we observe important structural improvements in child anthropometrics due to nation-wide food and agricultural programs that were implemented with the stated target to counteract the negative impact of the macro-economic shocks. These programs reached more than 50% coverage across Senegal in 2011 and contributed to the reduction of underweight, putting Senegal on track for reaching the Millennium Development Goal (MDG) for nutrition (Natalicchio, 2011). Including interaction terms between the year dummy and the two most pronounced shocks in 2011, namely increasing purchase prices and droughts, we find that in 2011 these shocks explain up to 21% and 44% of the pooled standard deviation of child health, respectively. But concomitance of the drought and the price shock in 2011 suggests competing price and income effects for poor farming households, as the triple interaction term is positive and significantly related to child weight-for-age. 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. In addition, we show that the death of a productive household member has a negative, albeit insignificant effect. The death of an unproductive household member has a positive effect, which is similarly imprecisely measured. As the exogeneity of shocks is likely to be mitigated due to recall bias and differences in perceptions, we conduct several robustness checks. Employing perceived shock intensities in place of shock dummies, including village-level measures of covariate shocks, and including geo-referenced precipitation data in the analysis, we similarly find that multiple shocks have to be carefully dealt with because of their interdependencies. Further, we show that our results are not driven by changes in household composition. Moreover, it is the asset-poor that are most hit by both drought and price shocks. The positive impact of the combined shocks is not just an artifact but identified by children in the 40% WAZ quantile and above. Results for weight-for-height (WHZ) suggest that the short-term dynamics reflected in weight-for-age dominate in this particular sample as the results for WHZ and WAZ are by and large identical. The dynamics for height-for-age (HAZ) differ in line with the long-term nature of this indicator.

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

[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.

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). Extreme events may also relate to individual mortality, with no clear effects on remaining household members' wellbeing. For the case of Tanzania, Beegle et al. (2008) find a negative short-term but no long-term impact of prime-age adult mortality on consumption whereas for the case of Ethiopia, a study by Dercon and Krishnan (2000) find no significant effect of adult mortality on the nutrition status of the survivors. On the other hand, mortality may sometime result in positive effects through resource redistribution within the household. The death of an unproductive member may allow resources previously allocated to that member to be redistributed to the remaining members. Depending on 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). Overall the existing evidence is inconclusive but points to differences between the death of a productive and an unproductive household member.[2]

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). NEP has been more than a simple nutrition project. NEP institutionalized nutrition as a cross-sectoral effort to foster prevention, education and behavioral changes. According to Alderman et al. (2008) and Natalicchio (2011) NEP is “undoubtedly” responsible for the recent radical improvements in child health. Moreover, 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. The nutritional and agricultural programs constitute large, national coping strategies and are considered as structural changes in the context of this analysis.

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). Fig. 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, 2010a). 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 Fig. 1 the Harmonized Average Food Price Index is below the Harmonized Average Consumer Price Index (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.

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, in the period under study we expect households to be most adversely affected by price and drought shocks.

[2] As mortality shocks are not the main theme of the paper, we do not elaborate on them further. A more comprehensive literature review is presented by Grimm (2010).

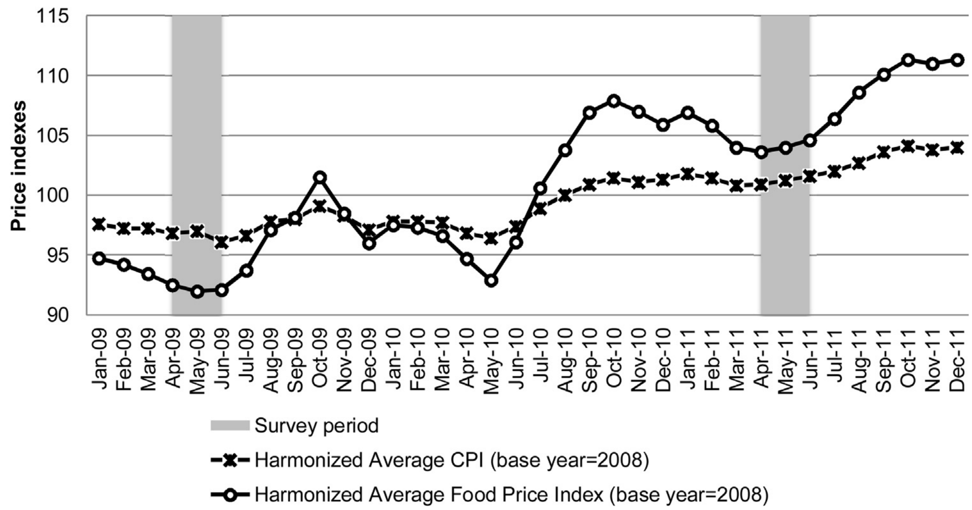

Fig. 1. Monthly Harmonized Average CPI and Food Price Index in Senegal for the period 2009–2011.
Source: Agence Nationale de Statistique et de la Démographie (ANSD, 2013) and authors' elaborations.

3.2. Survey indicators and descriptive statistics

Child health information is provided by a household panel survey carried out in eight regions of Senegal.[3] Two rounds of data were collected to form the panel of households: 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. All the households in the sample are farming households. In both survey rounds all the households reported cultivating at least one crop. Notably, since both the surveys were conducted during the same agricultural season, seasonal effects are minimized. 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 Fig. 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 1694 and 2116 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]

Table 1 presents the descriptive statistics of the children in the dataset for whom anthropometric data are available. The sample is fairly gender balanced. In 2009, the children are 30 months old on average. To measure child nutritional status we rely on the 2006 growth standards expressed in terms of Z-scores. As the metric for Z-scores is standard deviations, they can be easily interpreted. A child with a Z-score of zero has no deviation of its health status with respect to the reference population. Weight-for-Height (WHZ) mostly relates to recent and severe weight loss, often associated with acute starvation and/or disease, or a chronic unfavorable condition. Height-for-Age (HAZ) is an indicator of long-term nutritional status resulting from prolonged suboptimal health and/or nutrition. Weight-for-Age (WAZ) reflects body mass relative to chronological age (WHO and UNICEF, 2009). It is influenced by both the height of the child (height-for-age) and his or her weight (weight-for-height). The composite nature of WAZ means that it combines short- and long-term dynamics. In our sample, child WHZ is close to the international reference population (−0.56). Yet, with an average WAZ (HAZ) of −1.45 (−1.20) the children in the sample are moderately underweight (stunted). Exploiting WHZ data in our case implies a considerable reduction in the number of observations: 13% and 6% of the children drop out in 2009 and 2011, respectively. Similarly, exploiting HAZ data reduces the sample by 11% and 4% in 2009 and 2011, respectively. Although the shocks considered in the analysis occurred in the short-term (within 3–6 months before the child was measured), we argue that the recorded improvements in anthropometrics between survey rounds are grounded in large scale nutritional and agricultural programs that started some years before the first survey took place. Since WAZ reflects both the long-term and short-term nutritional status of children (WHO, 1997) we consider this indicator most appropriate for our analysis.[5] Importantly we observe that WAZ highly improves between rounds. The increase in the weight-for-age Z-score amounts to 48% of the standard deviation of the indicator in 2009. This sharp improvement comes along with a significant improvement in other key determinants of child health such as mother's presence in the household, mother's education, and access to improved water and sanitation.[6] Maternal presence is likely to increase attention towards the health needs of the child while maternal

[3] The regions are Diourbel, Fatick, Kaolack, Kedougou, Kolda, Louga, Tambacounda, and Thies according to the 2009 regional subdivision. Data collection was undertaken in the context of a program providing off-grid village electrification to poor villages that were not connected to the national grid. Since this program did not cover the region of Saint-Louis, no data collection was done there. Similarly, Casamance, the area with highest rainfall, is only represented by one of the two regions, namely Kolda. Potential program villages were selected randomly from the pool of eligible villages. Control villages were selected using multivariate matching based on observable characteristics. It was ensured that control villages are located in the same regions as the program villages (CERDI et al., 2009).

[4] Children without anthropometric data and/or anthropometric data out of range are 1515 in 2009 and 1179 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.

[5] We report in the Appendix A also results using as dependent variable WHZ and HAZ. Appendix A Table A4 shows that the short-term dynamics reflected in weight-for-age dominate in this particular sample as the results for WHZ and WAZ are largely identical. The dynamics for HAZ differ in line with the long-term nature of this indicator.

[6] Other determinants of child health such as age of the child, the mother and the head of the household significantly changed between survey rounds but we do not discuss these changes since they result mainly from the time elapsed between the two rounds.

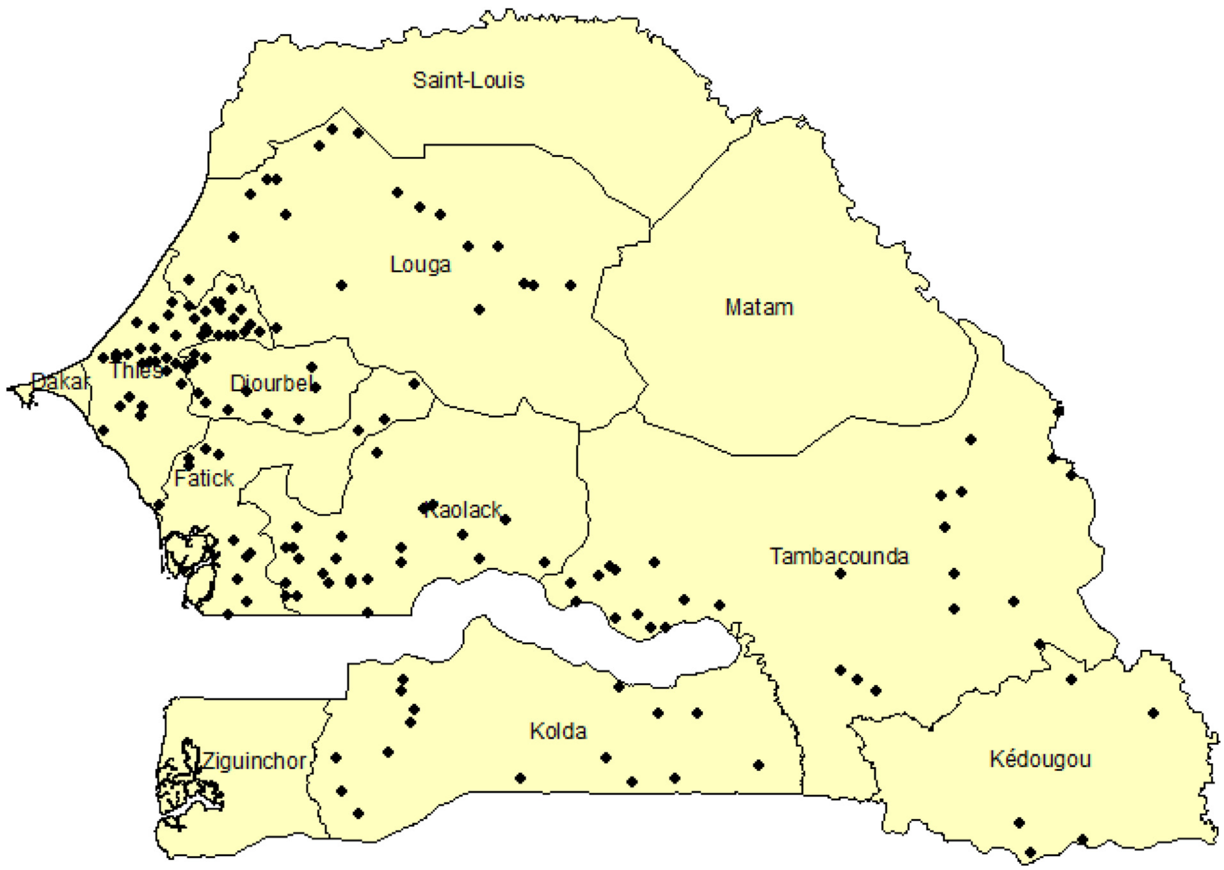

Fig. 2. Map of Senegal with surveyed villages.
Note: The sample consists of 165 villages in 8 regions according to the 2009 regional subdivision, as defined in the 2009 survey. A small black diamond symbol (◆) indicates the location of a survey village.

literacy and education are associated with the improved ability to process health and nutrition information (Christiaensen and Alderman, 2004; Glewwe, 1999). In 2011 the share of children living in households without their mothers decreased from 5.3% to 3.5%. Maternal literacy has increased by about 3 percentage points.

Access to improved water such as tap water and reduction in open defecation further enhance child health by reducing child morbidity. Access to tap water increased by 12% and open defecation was reduced by 21%. Moreover, household connectedness and the economic conditions also changed substantially. Mobile phone and radio ownership increased by 32% and 11%, respectively. The combined effect of increasing maternal education and connectedness may have induced 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.

Poultry ownership grew by 18% while the share of households farming peanuts increased by 127% between 2009 and 2011. All these changes in socio-economic outcomes in such short time span can result only from large combined interventions in the health, communication and agricultural sectors that we attribute to the nation-wide multi-sectoral nutrition and agricultural programs scaled up between 2006 and 2011 in response to the widespread malnutrition and the international economic crisis. These interventions put Senegal on good track for reaching the MDGs, especially in the health sector (République du Sénégal, 2010b), and achieving the target on extreme poverty reduction (UNECA, 2015).

Following Lépine and Strobl (2013) who also study the determinants of child health in Senegal, we control for additional explanatory variables that have been shown to be important demographic controls in the context of Senegal. The relative rank of a child among the siblings was found to affect child health by determining the relative resource allocation among siblings (Gupta, 1990). Thus, we calculated the relative rank of the child by dividing the birth order by the average birth order as in Booth and Kee (2009). In addition, we control for the number of brothers and sisters to account for gender effects in parental preferences. We also control for the number of other individuals in the household to account for total household size.

According to Lépine and Strobl (2013), ethnicity of the mother is very important in terms of her bargaining power within the household. Moreover, it is not ethnicity *per se* but rather maternal ethnicity in relation to the ethnicity of the community in which she lives. In particular, historically Wolof women rely on a matrilineal system while Tukulor (also known as Fula, Pular) women rely on a patrilineal system. Consequently, Wolof women have more of a say compared to Tukulor women. Following this argument, we classify the ethnicities present in our dataset into patrilineal and matrilineal ethnic groups (Murdock, 1967). Similar to Lépine and Strobl (2013) we compute a control variable that is referred to as "*Relative ethnicity*". This variable takes the value of 1 if the mother is of a patrilineal ethnicity and lives in a village where matrilineal ethnicities prevail (pooling the data, 3.31% of the children are in this category), of 2 if the mother is of matrilineal ethnicity and lives in a largely matrilineal village (56.69%), and of 3

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

Variable	2009 Mean	St. Dev	2011 Mean	St. Dev	Difference (uncond)	Difference (vill. FE)
Weight-for-age (WAZ)[a]	−1.447	(1.805)	−0.576	(1.937)	−0.871***	−0.834***
Weight-for-Height (WHZ)[a,b]	−0.556	(1.996)	0.017	(2.228)	−0.573***	−0.547***
Height-for-age (HAZ)[a,b]	−1.196	(2.234)	−0.936	(1.919)	−0.260***	−0.228***
Sex	0.453	(0.498)	0.495	(0.500)	−0.042***	−0.039**
Age (months)	30	(12.873)	34	(14.816)	−4.089***	−4.054***
Missing date of birth (=1)	0.787	(0.409)	0.798	(0.402)	0.011	0.027**
Age HH[c] head	52	(14.602)	54	(15.280)	−1.467***	−0.002
Sex HH[c] head (Female = 1)	0.023	(0.150)	0.024	(0.153)	−0.001	−1.614***
Mother is out of the household (=1)	0.053	(0.223)	0.035	(0.185)	0.018***	0.017**
Age Mother	29	(7.536)	30	(7.381)	−0.747***	−0.749***
Mother can read and write (=1)	0.148	(0.355)	0.176	(0.381)	−0.028**	−0.036***
Mother is head of household (=1)	0.005	(0.073)	0.004	(0.065)	0.001	0.002
Mother is wife of the HH[c] head (=1)	0.523	(0.500)	0.478	(0.500)	0.045***	0.054***
Mother is daughter of HH[c] head (=1)	0.035	(0.185)	0.042	(0.201)	−0.007	−0.006
Mother is not a relative	0.025	(0.155)	0.015	(0.122)	0.010**	0.008*
Marital status: Rank of mother						
Other (=−1)	0.191	(0.393)	0.147	(0.354)	0.044***	0.045***
Monogamous (=0)	0.455	(0.498)	0.526	(0.499)	−0.070***	−0.069***
Polygamous – 1 st wife (=1)	0.147	(0.354)	0.129	(0.335)	0.018*	0.019*
Polygamous – 2nd to last wife (=2)	0.207	(0.405)	0.199	(0.399)	0.008	0.006
Mother relative ethnicity (vs. village ethnicity)						
Patrilineal vs. matrilineal (=1)	0.030	(0.169)	0.036	(0.186)	−0.006	−0.005
Matrilineal vs. matrilineal (=2)	0.573	(0.495)	0.562	(0.496)	0.011	0.002
Patrilineal vs. patrilineal/missing (=3)	0.397	(0.489)	0.402	(0.490)	−0.005	0.003
Relative child rank	1.105	(0.345)	1.073	(0.369)	0.032***	0.028**
Number of sisters	0.997	(1.087)	1.070	(1.153)	−0.103***	−0.087**
Number of brothers	1.139	(1.185)	1.189	(1.248)	−0.050	−0.048**
Number of other individuals in HH	10.851	(5.382)	12.211	(6.063)	−1.360***	−1.380***
Poultry	0.570	(0.495)	0.675	(0.469)	−0.105***	−0.096***
Livestock	0.943	(0.231)	0.953	(0.212)	−0.010	−0.005
Water: own tap	0.209	(0.407)	0.234	(0.423)	−0.025*	−0.024**
Water: public tap	0.275	(0.447)	0.247	(0.431)	0.028*	0.026**
Water: protected well	0.088	(0.283)	0.040	(0.195)	0.048***	0.048***
Water: neighbor tap	0.012	(0.108)	0.012	(0.110)	−0.000	−0.003
Water: non-protected well	0.299	(0.458)	0.330	(0.470)	−0.031**	−0.026***
Water: hole	0.073	(0.260)	0.121	(0.327)	−0.048***	−0.044***
Water: other	0.045	(0.207)	0.015	(0.122)	0.030***	0.023***
Toilet: none or external	0.207	(0.405)	0.164	(0.370)	0.043***	0.043***
Toilet: water sewer	0.010	(0.100)	0.003	(0.057)	0.007***	0.007***
Toilet: septic tank	0.032	(0.175)	0.089	(0.285)	−0.057***	−0.056***
Toilet: covered latrine	0.381	(0.486)	0.292	(0.455)	0.089***	0.078***
Toilet: uncovered latrine	0.284	(0.451)	0.243	(0.429)	0.041**	0.054***
Toilet: other	0.087	(0.283)	0.208	(0.406)	−0.121***	−0.126***
Own Mobile (=1)	0.668	(0.470)	0.882	(0.322)	−0.214***	−0.221***
Own radio (=1)	0.739	(0.439)	0.820	(0.384)	−0.081***	−0.076***
Number of parcels cultivated	3.032	(1.667)	3.068	(1.462)	−0.036	−0.016
Size of land cultivated (Ha)	6.729	(6.001)	5.723	(4.807)	1.006***	1.177***
Farmer (=1 if main occup. of male breadw. is farming)	0.608	(0.488)	0.586	(0.493)	0.022	0.028*
Peanuts (=1 if HH cultivates peanuts)	0.344	(0.475)	0.781	(0.413)	−0.438***	−0.407***
Migrants (=1 if the HH has migrants)	0.406	(0.491)	0.276	(0.447)	0.130***	0.146***
Number of ill HH members in the last month	0.726	(0.957)	0.933	(1.428)	−0.207***	−0.205***
Number of ill HH children in the last month	0.176	(0.486)	0.244	(0.618)	−0.068***	−0.059***
Number of observations	1694		2116			

Note: [a]The pooled standard deviation for WAZ, HAZ and WHZ is 1.931, 2.062 and 2.152, respectively. [b]For HAZ (WHZ) the number of observations is 1503 (1476) and 2022 (1982) in 2009 and 2011, respectively. [c]HH stands for household. ***/**/* stands for p-value <0.01/<0.05/<0.10, respectively.

if the mother is of a patrilineal ethnicity and lives in a patrilineal ethnicities village (31.21%). The 2.36% children of matrilineal women who live in a patrilineal neighborhood and the 6.43% children of mothers with missing data on ethnicity or uncategorized ethnicity are included in the last category since akin to Lépine and Strobl (2013) we assume that the ethnicity of the community has more effect on a woman's relative status than the ethnicity of the woman.

Moreover, polygamy is widespread in Senegal and the rank of the wife is an important determinant of her social status. Depending on a wife's rank different household chores are assigned to her (Lépine and Strobl: 21). In our sample more than 30% of the mothers are in a polygamous marriage. We control for the rank of the mother coding this variable 0 for children whose mother is in a monogamous union (reference category), 1 for children whose mother entered a monogamous marriage but became a first wife, and 2 for children whose mother is

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

Shocks	2009		2011		Difference	Difference
	Mean	*St.Dev*	*Mean*	*St.Dev.*	(uncond.)	(village FE)
Economic shocks						
Increase in purchase prices	0.41	0.49	0.76	0.43	**−0.34*****	**−0.35*****
Decrease in sales prices	0.09	0.28	0.00	0.00	0.09	0.08***
Loss of key income source	0.01	0.10	0.07	0.25	**−0.06*****	**−0.06*****
Natural hazard						
Drought	0.03	0.16	0.06	0.23	**−0.03*****	**−0.04*****
Cold wave	0.04	0.20	0.01	0.09	0.03	0.03***
Biological hazard						
Crop pest/insects invasion	0.04	0.20	0.04	0.20	0.00	0.00
Health shocks						
Death productive member	0.01	0.11	0.01	0.11	**−0.00**	**−0.00**
Death unproductive member	0.03	0.17	0.04	0.20	**−0.01***	**−0.01***
Number of observations	1694		2116			

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

polygamously married and of lower rank.[7] Finally, as most of the households in the sample consist of large, extended families, we also control for the relationship between the mother and the head of the household through a set of dummy variables. These are: mother is the head, mother is the wife of the head, mother is the daughter of the head, mother is the wife of the son, mother is not a relative.

Next we turn to the shock module. In each survey round respondents were *asked* whether the household had experienced a shock within a list of possible adverse events. Inter alia, 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?

We set up a dummy variable that takes the value 1 if the household experienced the shock in a given survey year, 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. We have to rely on self-reported shocks making the reporting of adverse events susceptible to recall and preference bias. Importantly, household level, self-reported shocks also incorporate the personality of the respondent and cannot be considered as fully exogenous. 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 Sénégal, 2010a). Second, we exploit alternative measures of shock occurrence: intensity-related shock measures, village-level shock measures for covariate events (shocks that are more likely to involve the entire community), and household level climate indices from externally supplied weather data.[8] Third, we employ sub-sample and quantile regression 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 Sénégal, 2010a).[9] 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 3–6% 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.

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 pairwise 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.

[7] About 8% of the children in each round cannot enter in any of the previous categories either because the mother is a single parent or because there is missing information on the rank of the wife. For such children the variable rank of the wife will be coded −1 (compare Lépine and Strobl, 2013).

[8] Unfortunately, we do not have information about prices at the village level.

[9] 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. Yet, 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. 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.

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

Shock type			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Natural	(1)	Drought	1							
	(2)	Extreme cold	0.0399	1						
Biological	(3)	Crop pest	0.1312*	0.1020*	1					
Health	(4)	Death productive member	−0.0178	0.0317	−0.0230	1				
	(5)	Death unproductive member	−0.0060	0.1924*	0.0335	−0.0189	1			
Economic	(6)	Loss of key income source	0.0953*	0.0381	−0.0212	−0.0110	0.0180	1		
	(7)	Decrease in sales prices	0.0683*	−0.0226	0.0598*	−0.0337	−0.0532*	0.0952*	1	
	(8)	Increase in purchase prices	0.1569*	0.1416*	0.1144*	0.0304	0.0841*	0.0719*	0.2949*	1

Note: * stands for level of significance greater or equal to 0.05.Source: Authors' elaborations.

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

Shock type			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Natural	(1)	Drought	1							
	(2)	Extreme cold	0.1152*	1						
Biological	(3)	Crop pest	0.1679*	0.1036*	1					
Health	(4)	Death productive member	0.0605*	−0.0119*	−0.0007	1				
	(5)	Death unproductive member	0.0515*	0.2134*	0.0605*	−0.0240	1			
Economic	(6)	Loss of key income source	0.2400*	0.3503*	0.3547*	0.0699*	0.1670*	1		
	(7)	Decrease in sales prices	–	–	–	–	–	–	–	
	(8)	Increase in purchase prices	0.0114	0.0581*	0.0816*	0.0463*	−0.0215*	0.1273*	–	1

Note: * stands for level of significance greater or equal to 0.05.Source: Authors' elaborations.

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. The main effect we are interested in is that of drought and price shocks in concomitance with other types of shocks from the natural, biological, economic and health sphere. We assume that child weight-for-age directly responds to shocks occurring in the year of the survey (i.e. in the months from January up to the month of interview −either April, May or June). 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:

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

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} is the vector of natural hazards experienced by the household in the survey year, BIO_{hvt} represents biological hazards, economic shocks are collected in ECN_{hvt} and health-related shocks in HLT_{hvt}. 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 Sénégal, 2010a) and implement various robustness checks to assess the relationship between the shocks with respect to observable child, household and community characteristics.

4.3. 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:

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

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 $PriceIncrease_{2011}$.

4.4. 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:

$$Health_{ihvt} = \alpha + \beta\, CC_{ihvt} + \gamma\, HH_{hvt} + \delta_1\, NAT_{hvt-} + \delta_2\, BIO_{hvt} + \delta_3\, ECN_{hvt} + \delta_4\, HLT_{hvt} \quad (3)$$

where $PriceXDrought_{hvt}$ 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

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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Drought	−0.473***								−0.386**	−0.395**	0.306	0.927***
	(0.180)								(0.172)	(0.175)	(0.367)	(0.268)
Extreme cold		0.247							0.299	0.280	0.302	0.280
		(0.228)							(0.228)	(0.226)	(0.235)	(0.231)
Crop pest			−0.106						−0.001	−0.013	−0.015	−0.036
			(0.189)						(0.188)	(0.188)	(0.186)	(0.183)
Increase in purchase prices				−0.128					−0.106	0.117	−0.112	0.107
				(0.101)					(0.104)	(0.141)	(0.104)	(0.141)
Decrease in sales prices					−0.409**				−0.318	−0.405**	−0.325*	−0.400**
					(0.190)				(0.199)	(0.203)	(0.196)	(0.201)
Loss of key income source						−0.601**			−0.547*	−0.544*	−0.518*	−0.511*
						(0.282)			(0.284)	(0.287)	(0.281)	(0.276)
Death of a productive HH[a] member							−0.098		−0.033	−0.013	−0.021	0.018
							(0.297)		(0.304)	(0.303)	(0.305)	(0.306)
Death of an unproductive HH[a] member								0.170	0.184	0.158	0.192	0.163
								(0.121)	(0.129)	(0.130)	(0.131)	(0.132)
Year 2011 × Increased Prices										−0.403*		−0.429**
										(0.212)		(0.217)
Year 2011 × Drought											−0.854**	−1.960***
											(0.370)	(0.515)
Increased Prices × Drought												−0.760
												(0.497)
Year 2011 × Increased Prices × Drought												1.361**
												(0.675)
Observations	3810	3810	3810	3810	3810	3810	3810	3810	3810	3810	3810	3810
R-squared	0.280	0.278	0.278	0.279	0.279	0.280	0.278	0.278	0.283	0.284	0.283	0.285
Combined price coefficient[b]										−0.286		0.279
Combined drought coefficient[b]											−0.548***	−0.432***

Note: Village-year fixed effects estimations with standard errors clustered at the village level. The number of villages is 165. All shock variables are dummy variables. Additional control variables included are age and gender of the child, dummy variable accounting for children with incomplete date of birth information, relative rank of the child among siblings, number of brothers, sisters and other individuals in the household, age of the mother, whether the mother resides in the household, maternal literacy, dummy variables accounting for the relationship between the mother and the head of the household (head/wife/daughter/wife of the son/not a relative), rank of the mother with respect to other wives, relative ethnicity of the mother in the village, age and sex of 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 access, access to toilet facilities and migrant members. [a]HH is used as abbreviation for household. [b]Level of significance of the combined price (drought) coefficient in the specifications with interaction terms is determined by the F-test for the joint significance of the terms. ***/**/* stands for significance at 1/5/10%, respectively.

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 8 we include the shocks one by one; 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 is negatively associated with child health. In column 9 we include the shocks jointly (Eq. (1)), in column 10 (11) we explore the relationship between the 2011 price increase (droughts) and child health (Eq. (2)), and in column 12 we investigate the role of concomitance of price increase and drought shocks (Eq. (3)). Concerning other control variables, we account for age and gender of the child, a dummy variable accounting for children with incomplete date of birth information, the relative rank of the child among siblings, number of brothers, sisters and other individuals in the household, age of the mother, whether the mother resides in the household, maternal literacy, dummy variables accounting for the relationship between the mother and the head of the household, rank of the mother with respect to co-wives, relative ethnicity of the mother in the village, age and sex of the head of the household, number and size of parcels of land cultivated, ownership of poultry and livestock, dummy variables for water access and access to toilet facilities. Indicator variables for the ownership of a radio and/or mobile phone in the household are included as proxies 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.[10] We expect households located in the same areas to have similar characteristics, risk and food 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 specific shock in the same village environment. We

[10] Migration of entire households did not occur. In the second survey round we successfully found the households back in the villages. But we cannot 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 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 the effects of adverse events. In line with our expectations, having migrant household members significantly improves child weight-for-age. Detailed coefficient estimates are provided upon request.

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.

Results show that droughts have a substantial negative association with child health explaining $(0.473 \times 100/1.931 =)$ 24.5% of the pooled variation in weight-for-age according to the stand-alone specification (Table 5, Column 1) and $((0.306 - 0.854) \times 100/1.931 =)$ 28.4% when all shocks are jointly included (Table 5, Column 9).[11] The hazards extreme cold and crop pests do not have a significant relationship with child health. The economic shocks that are coherently associated with a reduction in child health are a decrease in sales prices (prices at which the farming household sells her products) and the loss of a key income source. The loss of a key income source reduces child health explaining between $(0.601 \times 100/1.931=)$ 31 and $(0.547 \times 100/1.931=)$ 28.3% of the pooled variation in weight-for-age (Table 5, Columns 6 and 9). The increase in purchase prices has a negative coefficient but is not significantly associated with child health (Table 5, Columns 4 and 9). The health shock we account for is the death of a household member with a split of the variable into two categories: "death of an unproductive member" and "death of a productive member". Albeit insignificant, the death of a productive household member has a negative coefficient whereas the death of an unproductive household member has a positive coefficient (Table 5, Columns 7–9). This is in line with Grimm (2010), who shows that the death of unproductive household members may be compensated by the increase in available resources in the household. In our sample 73% 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 association with child health, we further exploit the drought and price dynamics in light of the structural change occurring between the two survey rounds due to the large scale nutrition and agricultural programs. Specifications (10) and (11) of Table 5 present the multi shock estimates accounting for the macro-economic shock of 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 relationship of both increased prices and droughts with child weight despite the considerable overall improvements in 2011 explaining up to $(0.403 \times 100/1.931=)$ 21% and $(0.854 \times 100/1.931 =)$ 44% of the pooled variation in weight-for-age, respectively. Note that the combined drought coefficient (column 11, last row) amounts to $(0.548 \times 100/1.931=)$ 28% of the pooled variation in weight-for-age, significant at 1%. The combined price shock coefficient is negative, but statistically insignificant. These findings highlight the need to implement measures to protect child health from certain adverse events even during periods of overall prosperity 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 by interacting drought and price occurrence with the year dummy. We find that concomitance has a positive and significant relationship with child weight-for-age (Table 5, Column 12, triple interaction term is +1.361, significant at 5%). This is an interesting finding given the improvements in child health observed in 2011 but the higher incidence of shocks during the same period. The coefficient 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. 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. If we calculate the total effect of the price shock, the coefficient is positive but not significant, whereas droughts show a negative and significant total effect amounting to $(0.432 \times 100/1.931=)$ 22.4% of the pooled standard deviation in child WAZ (Table 5, column 12, last row).

6. Robustness checks

In this section we present the results of robustness checks for the previous analysis. To this end we replicate specifications 9–12 of Table 5 for (i) redefined shock measures, (ii) sub-samples, (iii) additional time interactions with slow moving control variables, (iv) redefined dependent variables, and (v) a quantile regression model. 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 the robustness checks by replacing the shock dummy with the reported shock intensity on a 1 to 10 Likert scale (Appendix A Table A1—Panel A). Drought shocks display a direct negative association with child health. The negative link of the price shock with child health is not statistically significant supporting the baseline result that combined shocks may not necessarily be detrimental for child health. The triple interaction is negative but statistically insignificant. As expected the coefficient estimates are smaller implying that the more severe a shock is, the worse is the anthropometric outcome.

In addition, droughts, extreme cold events, crop pests, and price variations are likely to be covariate shocks.[12] Therefore, we run a specification that aims at capturing the village level effects of these shocks. To this end we take the average level of each covariate shock at the village level in 2009 and 2011. We then classify a village as having experienced a particular covariate shock, say a drought shock, if the average of the self-reported shocks is above 50%. Otherwise, the village is classified as not having experienced the shock. We estimate specifications (9) to (12) including village level covariate shocks alongside the household level shocks with region fixed effects since village fixed effects cannot be implemented. We present the results in Appendix A Table A1—Panel B. Including village level covariate shocks alongside the household level shocks yields similar conclusions about the combined drought and price effect. The triple interaction term is positive

[11] For ease of interpretation of the results, we report the pooled standard deviations of the child anthropometric measures below Table 1.

[12] In our sample the intra-village correlation of droughts, extreme cold events, crop pests, increasing purchase prices and decreasing sales prices is 52% (21%), 18% (28%), 16% (11%), 34%(19%) and 31% in 2009 (2011), respectively. Idiosyncratic shocks such as the loss of a key income source and the death of a member show low intra-village correlation in both years.

but insignificant. Thus, our results are robust to the inclusion of village level averages that are likely to be less noisy.

Next we complement our main results with objective drought measures.[13] We collected household level precipitation data based on geo-referenced climatic information from the African Drought and Flood Monitor (AFDM, 2014).[14] 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. 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 min: Given that we do not have GPS information about plots, we cannot rule out variation in precipitation intensity related to the land cultivated (Appendix A, Table A1, Panel C).

Furthermore, poor people tend to be more vulnerable to shocks. We assess this common notion by splitting the sample into asset-poor and asset-rich households. It is children from asset-poor households for whom droughts develop their full impact. Children in asset-rich households are less affected (Appendix A Table A2, Panels D and E). Note that even the asset-rich households might struggle to sell assets in times of shocks, but we cannot control for this channel. In order to provide more convincing evidence regarding the role of coping strategies on household resilience we looked at food consumption data. We replicated the analysis in Table 5 using as dependent variable the average number of food items consumed and the share of food items that are own produced and purchased (results not reported). We do not find any association between shocks and average consumption levels but we find that consumption of own produced goods increases for households experiencing both a drought and a price increase in 2011. This is contrasted by a reduction in purchased goods suggesting that shock-stricken households rely more on their own resources and less on the market.

Next we show that our main results are not driven by changes in household composition. For this we include year interactions with selected socio-demographic characteristics to allow the effect of covariates to vary by survey round. We focus on slow moving, pre-determined covariates that typically do not change in the short run: the sex of the head of household, the relationship of the mother to the head of household (head/wife/daughter/unrelated), the relative ethnicity of the mother, the rank of the mother among other wives, the relative rank of the child, and the number of brothers, sisters and other individuals. As can be seen in Appendix A Table A3—panel F our main results hold.

Furthermore, when including village and year fixed effects separately (Appendix A Table A3—Panel G) we observe a positive and significant coefficient estimate associated with the year dummy supporting the occurrence of a structural change between the survey rounds. The shock effects estimated with village fixed effect are in line with estimates in Table 5, the triple interaction term is positive albeit insignificant suggesting that identification of the effect of the combined shocks in 2011 comes from the within village-year variation.

As further robustness check we report in Appendix A Table A4 results using WHZ and HAZ as outcome indicators. Sign, magnitude and level of significance of the relevant interaction terms in specifications (10)–(12) are in line with the argument that WAZ incorporates the evolution of long- and short-term nutritional conditions. The short-term dynamics reflected in weight-for-age dominate in this particular sample as the results for WHZ and WAZ are by and large identical. The dynamics for HAZ differ in line with the long-term nature of this indicator.

In Appendix A Table A5 we check the effect of the shocks on child health using binary outcomes. A child is considered malnourished if the Z-score is below −2 standard deviations from the international reference population. In our sample prevalence of underweight, wasting and stunting is 34, 19 and 36% in 2009, and 21, 18 and 27% in 2011, respectively. We estimate a linear probability model with village-year fixed effects. We find a positive association of both the price and the drought shock with all three binary measures indicating that the share of underweight, wasted and stunted children increases in response to these shocks. As in the main specification, the price effect is particularly strong in 2011 and mainly displays for the short-term child health measures WAZ and WHZ. In addition, the triple interaction term supports our notion that shock concomitance can have offsetting effects. The coefficient estimate is negative albeit statistically insignificant for WAZ and WHZ pointing at possible reductions in the share of underweight and wasted children when increased prices and drought shocks occur jointly. Thus, the findings associated with the binary indicators further support the results from our main specification.

Finally, in Fig. 3 we plot quantile regression estimates measuring the estimated shock effect along the distribution of child WAZ. We depict the estimated triple interaction coefficient and the associated 95% confidence bands. The quantile regressions highlight that the positive impact of the combined shocks is jointly identified by all children in the 40% WAZ quantile and above. The quantile coefficients for these children fluctuate closely around the OLS coefficient. Thus, our results are not driven by one quantile but represent a general phenomenon.

Overall, the robustness checks and sub-sample analyses support our baseline results. The first main consistent finding is that drought shocks are negatively associated with child health. The evidence for the negative relationship between increase in purchase prices is less pronounced. While the coefficient estimates tends to be negative it is statistically insignificant in most specifications. Yet, the combined occurrence of drought and increasing prices in 2011 (triple interaction term) shows a positive or insignificant association with child health in the short run suggesting that interdependencies of the shocks can lead to offsetting effects trough the agriculture pathway.[15]

[13] We consider the Standardized Precipitation Index (SPI), 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. The correlation between the objective drought measure using SPI and the self-reported drought is 7.94% in 2009 and 13.46% in 2011, both significant at 1%. The moderate positive correlation indicates that the self-reported drought measure is relevant but contains more than just the pure drought information.

[14] We have access to the households' GPS coordinates and use the grid location of the households to construct climatic measures at the household level. We employ grid level weather data from AFDM (2014) using the ArcGIS software. Household level climate data are highly correlated within villages. Therefore, we estimate the specifications with the objective drought measure and region fixed effects in place of village-year fixed effects to allow for more variability in the drought measure.

[15] To rule out the disease pathway for villages affected by a weather shock, we looked into the correlation between reported illness and weather shocks. We have household level information on the number of ill members in the month preceding the interview and construct two variables: (i) a count of all ill members and (ii) a count of all ill children below 5 years of age. We correlate these variables with a village level drought variable in order to test whether the disease environment changed in villages affected by a drought shock. There is no statistical difference in the disease patterns between villages where the majority of the household reports having experienced a drought and villages where the majority of the household reports not having experienced a drought.

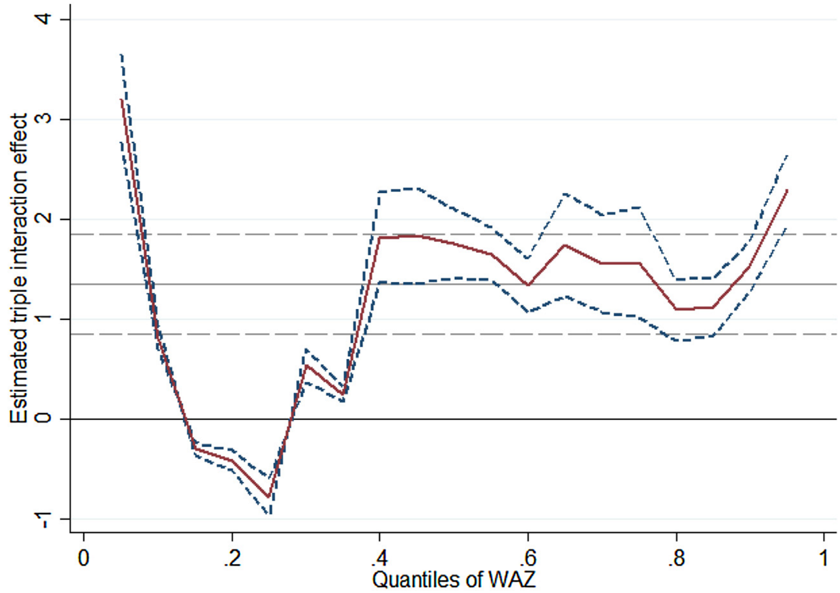

Fig. 3. Quantile regression estimates of the triple interaction term.
Note: The solid horizontal line indicates the OLS coefficient.
Source: Authors' elaborations.

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 associated with the non-concomitant experience of a drought or higher purchase prices. However, if the household experienced both shocks concomitantly, the net effect on child health is positive. We infer that income effects dominate concomitant drought and price shocks for poor subsistence farmers. The sub-sample analysis highlights that asset-poor households are the most adversely hit by the shocks. Thus, the study at hand 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 suggests positive income effects from concomitant price and drought shocks for children in rural households, nothing can be said about the role of these shocks in urban areas, where mainly net consumers reside. Hence, from the perspective of the policy maker the various channels for shocks and their (negative) repercussions 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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Appendix A.

See Tables A1–A5 .

Table A1
Robustness checks including shock intensity measures, average village level perceived shocks, and geo-referenced rainfall data.

	A				B				C			
	(9)	(10)	(11)	(12)	(9)	(10)	(11)	(12)	(9)	(10)	(11)	(12)
Year = 2011					0.951**	1.112*	0.980**	1.160*	1.007***	1.170**	0.969**	1.401***
					(0.313)	(0.532)	(0.309)	(0.529)	(0.241)	(0.436)	(0.299)	(0.368)
Drought (SPI3 < −1)									0.090	0.077	−0.000	0.101
									(0.090)	(0.083)	(0.139)	(0.118)
Drought	−0.058***	−0.060***	−0.055	−0.083**	−0.539***	−0.549***	−0.009	0.138				
	(0.021)	(0.021)	(0.035)	(0.042)	(0.141)	(0.132)	(0.204)	(0.219)				
Drought (village-level)					0.511	0.467	0.406	0.428				
					(0.479)	(0.466)	(0.457)	(0.371)				
Extreme cold	0.031	0.025	0.031	0.022	0.272	0.246	0.272	0.242	0.301	0.272	0.327	0.320*
	(0.029)	(0.030)	(0.029)	(0.031)	(0.214)	(0.180)	(0.220)	(0.185)	(0.210)	(0.172)	(0.210)	(0.143)
Extreme cold (village-level)					−1.342***	−1.314***	−1.345***	−1.319***				
					(0.178)	(0.134)	(0.179)	(0.132)				
Crop pest	−0.025	−0.026	−0.021	−0.027	−0.051	−0.056	−0.058	−0.080	−0.082	−0.090	−0.081	−0.083
	(0.037)	(0.037)	(0.037)	(0.037)	(0.148)	(0.148)	(0.153)	(0.156)	(0.139)	(0.137)	(0.141)	(0.147)
Crop pest (village-level)					–	–	–	–				
Increase in purchase prices	−0.014	0.009	−0.014	0.006	0.006	0.157	−0.003	0.142	0.047	0.201	0.048	0.281
	(0.011)	(0.015)	(0.011)	(0.015)	(0.159)	(0.244)	(0.156)	(0.249)	(0.177)	(0.168)	(0.179)	(0.181)
Increase in purchase prices (village-level)					0.154	0.140	0.142	0.129				
					(0.257)	(0.283)	(0.255)	(0.279)				
Decrease in sales prices	−0.080**	−0.084**	−0.082**	−0.084**	−0.239	−0.309	−0.242	−0.312	−0.123	−0.197	−0.119	−0.172
	(0.037)	(0.036)	(0.037)	(0.036)	(0.238)	(0.169)	(0.234)	(0.165)	(0.256)	(0.201)	(0.254)	(0.204)
Decrease in sales prices (village-level)					0.674	0.682	0.656	0.666				
					(0.413)	(0.423)	(0.446)	(0.458)				
Loss of key income source	0.035**	0.038***	0.035**	0.039***	−0.296	−0.280	−0.268	−0.247	−0.399*	−0.385	−0.428*	−0.549**
	(0.014)	(0.015)	(0.014)	(0.015)	(0.205)	(0.213)	(0.202)	(0.216)	(0.204)	(0.209)	(0.191)	(0.194)
Death of a productive HH[a] member	−0.002	0.000	−0.002	0.003	0.331	0.336	0.348	0.373	0.294	0.300	0.286	0.274
	(0.030)	(0.030)	(0.030)	(0.030)	(0.287)	(0.282)	(0.288)	(0.286)	(0.254)	(0.250)	(0.243)	(0.227)
Death of an unproductive HH[a] member	0.018	0.015	0.017	0.017	0.312**	0.297**	0.315**	0.297**	0.299*	0.284**	0.299*	0.252*
	(0.012)	(0.013)	(0.012)	(0.012)	(0.124)	(0.106)	(0.121)	(0.102)	(0.132)	(0.111)	(0.132)	(0.116)
Year 2011 × Increased Prices		−0.039		−0.040		−0.282		−0.308		−0.297		−0.682**
		(0.024)		(0.025)		(0.473)		(0.484)		(0.470)		(0.240)
Year 2011 × Drought			−0.003	−0.026			−0.705**	−1.470**			0.179	−1.240**
			(0.044)	(0.065)			(0.205)	(0.494)			(0.243)	(0.398)
Increased Prices × Drought				0.012**				−0.241				−0.343
				(0.005)				(0.257)				(0.265)
Year 2011 × Increased Prices × Drought				−0.003				1.031				1.979***
				(0.008)				(0.544)				(0.422)
Replacing shock dummies with intensities	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No	No
Adding village-level covariate shocks	No	No	No	No	Yes	Yes	Yes	Yes	No	No	No	No
Fixed effects	Vill-year	Vill-year	Vill-year	Vill-year	Region	Region	Region	Region	Region	Region	Region	Region
Clusters (number)	165	165	165	165	8	8	8	8	8	8	8	8
Observations	3810	3810	3809	3809	3810	3810	3810	3810	3808	3808	3808	3808
R-squared	0.284	0.285	0.284	0.286	0.164	0.165	0.165	0.166	0.159	0.160	0.159	0.171
Combined price coefficient (HH level)[ab]		−0.030		−0.025*		−0.125		0.624		−0.096		1.235***
Combined drought coefficient (HH level)[ab]			−0.058**	−0.100***			−0.714***	−0.542***			0.179	0.497***

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 covariate shock variables (drought, extreme cold, crop pest, increase in purchase prices and decrease in sales prices) take value 1 if more than 50% of the household in the village experienced the shock. In Panel C, 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, dummy variable accounting for children with incomplete date of birth information, relative rank of the child among siblings, number of brothers, sisters and other individuals in the household, age of the mother, whether the mother resides in the household, maternal literacy, dummy variables accounting for the relationship between the mother and the head of the household (head/wife/daughter/wife of the son/not a relative), rank of the mother with respect to other wives, relative ethnicity of the mother in the village, age and sex of 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 access, access to toilet facilities and migrant members. [a]HH is used as abbreviation for household. [b]Level of significance of the combined price (drought) coefficient in the specifications with interaction terms is determined by the *F*-test for the joint significance of the terms. ***/**/* stands for significance at 1/5/10%, respectively.

Table A2
Robustness checks for the subsamples of asset-poor versus asset-rich households.

	D				E			
	(9)	(10)	(11)	(12)	(9)	(10)	(11)	(12)
Drought	−0.369	−0.374	0.285	0.297	−0.113	−0.121	0.385	−1.143*
	(0.263)	(0.266)	(0.431)	(0.446)	(0.313)	(0.311)	(0.715)	(0.609)
Extreme cold	0.550**	0.521*	0.537*	0.510*	0.279	0.265	0.286	0.237
	(0.276)	(0.265)	(0.276)	(0.265)	(0.360)	(0.359)	(0.363)	(0.364)
Crop pest	0.231	0.225	0.216	0.208	−0.660	−0.661	−0.680	−0.750*
	(0.214)	(0.213)	(0.212)	(0.211)	(0.456)	(0.455)	(0.449)	(0.440)
Increase in purchase prices	−0.000	0.223	−0.004	0.215	−0.139	0.021	−0.147	0.004
	(0.134)	(0.175)	(0.134)	(0.176)	(0.183)	(0.320)	(0.184)	(0.322)
Decrease in sales prices	−0.315	−0.395	−0.315	−0.392	−0.281	−0.333	−0.313	−0.354
	(0.263)	(0.270)	(0.260)	(0.269)	(0.370)	(0.371)	(0.357)	(0.358)
Loss of key income source	−0.737**	−0.731**	−0.706**	−0.705**	−0.433	−0.437	−0.409	−0.377
	(0.354)	(0.352)	(0.356)	(0.353)	(0.434)	(0.434)	(0.432)	(0.416)
Death of a productive HH[a] member	0.201	0.190	0.223	0.235	−0.025	−0.012	−0.032	0.012
	(0.315)	(0.316)	(0.316)	(0.320)	(0.852)	(0.849)	(0.850)	(0.835)
Death of an unproductive HH[a] member	0.023	−0.008	0.039	0.009	0.231	0.225	0.227	0.199
	(0.221)	(0.220)	(0.219)	(0.219)	(0.301)	(0.301)	(0.303)	(0.304)
Year 2011 × Increased Prices		−0.495		−0.509		−0.220		−0.275
		(0.299)		(0.311)		(0.394)		(0.393)
Year 2011 × Drought			−0.917*	−1.308**			−0.586	–
			(0.519)	(0.661)			(0.786)	
Increased Prices × Drought				−0.063				1.485
				(0.677)				(0.954)
Year 2011 × Increased Prices × Drought				0.531				−0.189
				(0.848)				(0.767)
Sub-samples: Asset poor vs. Asset rich	Poor	Poor	Poor	Poor	Rich	Rich	Rich	Rich
Observations	2204	2204	2204	2204	1606	1606	1606	1606
R-squared	0.341	0.343	0.342	0.344	0.365	0.365	0.365	0.367
Combined price coefficient[b]		−0.272		0.174		−0.199		1.025
Combined drought coefficient[b]			−0.632*	−0.543			−0.201	0.153

Note: Village-year fixed effects estimations with standard errors clustered at the village level. In Panel D, the sub-sample of the asset-poor is considered and in Panel E the subsample of the asset-rich. All shock variables are dummy variables. Additional control variables included are age and gender of the child, dummy variable accounting for children with incomplete date of birth information, relative rank of the child among siblings, number of brothers, sisters and other individuals in the household, age of the mother, whether the mother resides in the household, maternal literacy, dummy variables accounting for the relationship between the mother and the head of the household (head/wife/daughter/wife of the son/not a relative), rank of the mother with respect to other wives, relative ethnicity of the mother in the village, age and sex of 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 access, access to toilet facilities and migrant members. [a]HH is used as abbreviation for household. [b]Level of significance of the combined price (drought) coefficient in the specifications with interaction terms is determined by the F-test for the joint significance of the terms. ***/**/* stands for significance at 1/5/10%, respectively.

Table A3
Robustness checks including interacted socio-demographic variables, and village and year fixed effects.

	F				G			
	(9)	(10)	(11)	(12)	(9)	(10)	(11)	(12)
Year = 2011					1.010***	1.262***	1.033***	1.308***
					(0.095)	(0.150)	(0.095)	(0.152)
Drought	−0.381**	−0.389**	0.331	0.838***	−0.545***	−0.573***	0.082	−0.380
	(0.173)	(0.176)	(0.363)	(0.278)	(0.189)	(0.192)	(0.338)	(0.412)
Extreme cold	0.260	0.241	0.264	0.241	0.362	0.310	0.355	0.300
	(0.227)	(0.225)	(0.233)	(0.229)	(0.264)	(0.266)	(0.269)	(0.271)
Crop pest	−0.030	−0.043	−0.045	−0.069	0.091	0.080	0.078	0.042
	(0.184)	(0.185)	(0.183)	(0.180)	(0.178)	(0.176)	(0.172)	(0.168)
Increase in purchase prices	−0.104	0.118	−0.110	0.109	0.045	0.285**	0.035	0.268**
	(0.102)	(0.141)	(0.102)	(0.141)	(0.090)	(0.126)	(0.091)	(0.126)
Decrease in sales prices	−0.271	−0.358*	−0.278	−0.353*	−0.010	−0.119	−0.027	−0.141
	(0.195)	(0.199)	(0.192)	(0.196)	(0.193)	(0.190)	(0.191)	(0.190)
Loss of key income source	−0.484*	−0.482*	−0.455	−0.448	−0.430	−0.414	−0.404	−0.383
	(0.283)	(0.286)	(0.280)	(0.274)	(0.270)	(0.274)	(0.268)	(0.265)
Death of a productive HH[a] member	0.008	0.026	0.021	0.059	0.175	0.184	0.187	0.217
	(0.246)	(0.248)	(0.248)	(0.252)	(0.277)	(0.280)	(0.280)	(0.284)
Death of an unproductive HH[a] member	0.181	0.157	0.190	0.161	0.281**	0.257*	0.286**	0.260*
	(0.127)	(0.128)	(0.128)	(0.129)	(0.135)	(0.137)	(0.136)	(0.138)
Year 2011 × Increased Prices		−0.401*		−0.429**		−0.459**		−0.489**
		(0.209)		(0.213)		(0.198)		(0.200)
Year 2011 × Drought			−0.878**	−1.884***			−0.813**	−1.015*
			(0.366)	(0.505)			(0.370)	(0.551)
Increased Prices × Drought				−0.622				0.419
				(0.491)				(0.557)
Year 2011 × Increased Prices × Drought				1.240*				0.415
				(0.658)				(0.680)
Include demographic controls × Year2011	Yes	Yes	Yes	Yes	No	No	No	No

Table A3 (*Continued*)

	F				G			
	(9)	(10)	(11)	(12)	(9)	(10)	(11)	(12)
Fixed effects	Vill-year	Vill-year	Vill-year	Vill-year	Village	Village	Village	Village
Clusters (number)	165	165	165	165	165	165	165	165
Observations	3810	3810	3810	3810	3810	3810	3810	3810
R-squared	0.297	0.298	0.298	0.299	0.218	0.220	0.219	0.222
Combined price coefficient[b]		−0.283		0.298		−0.174**		0.613*
Combined drought coefficient[b]			−0.547***	−0.428***			−0.731***	−0.561***

Note: Fixed effects estimations with clustered standard errors. In Panel F, we control for year interactions with selected socio-demographic characteristics (sex of the head of household, relationship of the mother to the head of household (head/wife/daughter/unrelated), relative ethnicity of the mother, rank of the mother among other wives, relative rank of the child, number of brothers, sisters and other individuals). In Panel G we include village fixed effects in place of village-year fixed effects. Additional control variables common to both panels are: age and gender of the child, dummy variable accounting for children with incomplete date of birth information, relative rank of the child among siblings, number of brothers, sisters and other individuals in the household, age of the mother, whether the mother resides in the household, maternal literacy, dummy variables accounting for the relationship between the mother and the head of the household (head/wife/daughter/wife of the son/not a relative), rank of the mother with respect to other wives, relative ethnicity of the mother in the village, age and sex of 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 access, access to toilet facilities and migrant members. [a]HH is used as abbreviation for household. [b]Level of significance of the combined price (drought) coefficient in the specifications with interaction terms is determined by the *F*-test for the joint significance of the terms. ***/**/* stands for significance at 1/5/10%, respectively.

Table A4
Empirical results of the multi-shock analysis of child weight-for-height and child height-for-age.

Dependent variable:	WHZ				HAZ			
	(9)	(10)	(11)	(12)	(9)	(10)	(11)	(12)
Drought	−0.496**	−0.512**	−0.625*	−0.868	−0.180	−0.174	1.062**	1.625**
	(0.217)	(0.222)	(0.370)	(1.072)	(0.216)	(0.215)	(0.519)	(0.796)
Extreme cold	0.627**	0.599*	0.626**	0.592*	−0.798***	−0.786***	−0.777***	−0.767***
	(0.310)	(0.310)	(0.310)	(0.309)	(0.296)	(0.296)	(0.292)	(0.293)
Crop pest	0.289	0.280	0.289	0.264	−0.182	−0.179	−0.189	−0.191
	(0.225)	(0.227)	(0.225)	(0.225)	(0.241)	(0.242)	(0.233)	(0.233)
Increase in purchase prices	−0.370***	0.024	−0.369***	0.027	0.302***	0.158	0.290***	0.139
	(0.127)	(0.167)	(0.127)	(0.167)	(0.099)	(0.166)	(0.099)	(0.167)
Decrease in sales prices	−0.026	−0.174	−0.023	−0.177	−0.711**	−0.657**	−0.732**	−0.662**
	(0.257)	(0.267)	(0.259)	(0.272)	(0.299)	(0.307)	(0.303)	(0.318)
Loss of key income source	−0.925***	−0.918***	−0.929***	−0.915***	0.386	0.384	0.429*	0.431*
	(0.325)	(0.330)	(0.323)	(0.320)	(0.246)	(0.245)	(0.240)	(0.236)
Death of a productive HH[a] member	−0.243	−0.218	−0.244	−0.195	0.457	0.446	0.477	0.478
	(0.459)	(0.459)	(0.459)	(0.458)	(0.432)	(0.435)	(0.435)	(0.440)
Death of an unproductive HH[a] member	0.362**	0.323*	0.360**	0.316*	0.037	0.052	0.058	0.072
	(0.169)	(0.176)	(0.171)	(0.179)	(0.156)	(0.157)	(0.156)	(0.157)
Year 2011 × Increased Prices		−0.692***		−0.731***		0.256		0.252
		(0.257)		(0.264)		(0.202)		(0.201)
Year 2011 × Drought			0.154	−0.104			−1.527***	−2.330**
			(0.438)	(1.161)			(0.570)	(0.936)
Increased Prices × Drought				0.210				−0.650
				(1.149)				(1.032)
Year 2011 × Increased Prices × Drought				0.409				0.955
				(1.262)				(1.144)
Observations	3458	3458	3458	3458	3603	3603	3603	3603
R-squared	0.268	0.272	0.268	0.272	0.215	0.216	0.217	0.218
Combined price coefficient[b]		−0.668***		−0.085**		0.414***		0.696**
Combined drought coefficient[b]			−0.471**	−0.353*			−0.465**	−0.400**

Note: Village-year fixed effects estimations with standard errors clustered at the village level. The number of villages is 165. All shock variables are dummy variables. Additional control variables included are age and gender of the child, dummy variable accounting for children with incomplete date of birth information, relative rank of the child among siblings, number of brothers, sisters and other individuals in the household, age of the mother, whether the mother resides in the household, maternal literacy, dummy variables accounting for the relationship between the mother and the head of the household (head/wife/daughter/wife of the son/not a relative), rank of the mother with respect to other wives, relative ethnicity of the mother in the village, age and sex of 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 access, access to toilet facilities and migrant members. [a]HH is used as abbreviation for household. [b]Level of significance of the combined price (drought) coefficient in the specifications with interaction terms is determined by the *F*-test for the joint significance of the terms. ***/**/* stands for significance at 1/5/10%, respectively.

Table A5
Robustness checks with binary malnutrition indicators.

Dependent variable:	Child is underweight (WAZ < −2)				Child is wasted (WHZ < −2)				Child is stunted (HAZ < −2)			
	(9)	(10)	(11)	(12)	(9)	(10)	(11)	(12)	(9)	(10)	(11)	(12)
Drought	0.108**	0.111**	−0.002	−0.209	0.109**	0.113**	0.123	0.021	0.033	0.032	−0.226**	−0.002
	(0.046)	(0.047)	(0.107)	(0.199)	(0.049)	(0.049)	(0.142)	(0.079)	(0.052)	(0.052)	(0.102)	(0.210)
Extreme cold	−0.000	0.006	−0.001	0.006	−0.009	−0.002	−0.009	−0.002	0.138**	0.136**	0.134**	0.132**
	(0.050)	(0.049)	(0.051)	(0.049)	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)	(0.056)
Crop pest	−0.006	−0.002	−0.003	0.002	−0.065	−0.064	−0.065	−0.064	0.014	0.014	0.016	0.020
	(0.044)	(0.044)	(0.043)	(0.043)	(0.043)	(0.044)	(0.043)	(0.044)	(0.057)	(0.057)	(0.055)	(0.055)
Increase in purchase prices	0.017	−0.050	0.018	−0.049	0.060***	−0.027	0.059***	−0.028	−0.052**	−0.029	−0.049**	−0.025

Table A5 (*Continued*)

Dependent variable:	Child is underweight (WAZ < −2)				Child is wasted (WHZ < −2)				Child is stunted (HAZ < −2)			
	(9)	(10)	(11)	(12)	(9)	(10)	(11)	(12)	(9)	(10)	(11)	(12)
	(0.023)	(0.039)	(0.023)	(0.039)	(0.021)	(0.035)	(0.021)	(0.035)	(0.023)	(0.036)	(0.023)	(0.036)
Decrease in sales prices	0.145**	0.171***	0.146**	0.168***	−0.021	0.012	−0.021	0.009	0.150**	0.141**	0.154**	0.152**
	(0.057)	(0.060)	(0.056)	(0.060)	(0.053)	(0.055)	(0.053)	(0.057)	(0.066)	(0.067)	(0.067)	(0.069)
Loss of key income source	0.030	0.029	0.025	0.024	0.054	0.053	0.055	0.053	−0.098*	−0.097*	−0.106**	−0.108**
	(0.062)	(0.063)	(0.062)	(0.061)	(0.052)	(0.053)	(0.051)	(0.051)	(0.054)	(0.053)	(0.053)	(0.052)
Death of a productive HH[a] member	−0.022	−0.028	−0.024	−0.034	0.074	0.068	0.074	0.069	−0.036	−0.034	−0.040	−0.044
	(0.072)	(0.071)	(0.072)	(0.072)	(0.088)	(0.086)	(0.088)	(0.087)	(0.089)	(0.090)	(0.089)	(0.092)
Death of an unproductive HH[a] member	−0.045	−0.037	−0.046	−0.037	−0.052*	−0.043	−0.051	−0.042	−0.012	−0.014	−0.016	−0.019
	(0.033)	(0.033)	(0.034)	(0.033)	(0.031)	(0.032)	(0.031)	(0.032)	(0.041)	(0.042)	(0.041)	(0.041)
Year 2011 × Increased Prices		0.121**		0.127**		0.153***		0.153***		−0.040		−0.035
		(0.050)		(0.050)		(0.046)		(0.047)		(0.047)		(0.047)
Year 2011 × Drought			0.135	0.447**			−0.016	0.084			0.319***	0.209
			(0.112)	(0.222)			(0.150)	(0.133)			(0.116)	(0.235)
Increased Prices × Drought				0.253				0.131				−0.276
				(0.235)				(0.190)				(0.237)
Year 2011 × Increased Prices × Drought				−0.382				−0.127				0.132
				(0.263)				(0.224)				(0.250)
Observations	3810	3810	3810	3810	3458	3458	3458	3458	3603	3603	3603	3603
R-squared	0.190	0.192	0.190	0.193	0.192	0.198	0.192	0.198	0.193	0.193	0.194	0.195
Combined price coefficient[b]		0.071**		−0.051**		0.126***		0.129***		−0.069*		−0.204**
Combined drought coefficient[b]			0.133**	0.109**			0.107*	0.109			0.093**	0.063**

Note: Linear probability model with village-year fixed effects and clustered standard errors at the village level. Prevalence of underweight, wasting and stunting is 34%, 19% and 36% in 2009, and 21%, 18% and 27% in 2011, respectively. Additional control variables included are age and gender of the child, dummy variable accounting for children with incomplete date of birth information, relative rank of the child among siblings, number of brothers, sisters and other individuals in the household, age of the mother, whether the mother resides in the household, maternal literacy, dummy variables accounting for the relationship between the mother and the head of the household (head/wife/daughter/wife of the son/not a relative), rank of the mother with respect to other wives, relative ethnicity of the mother in the village, age and sex of 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 access, access to toilet facilities and migrant members. [a]HH is used as abbreviation for household. [b]Level of significance of the combined price (drought) coefficient in the specifications with interaction terms is determined by the F-test for the joint significance of the terms. ***/**/* stands for significance at 1/5/10%, respectively.

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