YOUNG LIVES STUDENT PAPER

The Impact of Climatic Shocks on Child Nutrition in Peru

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The data used in this paper comes from Young Lives, a longitudinal study investigating the changing nature of childhood poverty in Ethiopia, India (Andhra Pradesh), Peru and Vietnam over 15 years. For further details, visit: www.younglives.org.uk.

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Young Lives
An International Study of Childhood Poverty

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Abstract

This paper examines the impact of climatic shocks on young children's nutritional indicators, using the Peruvian Young Lives project data set. Special attention is given to child nutrition and climatic shocks, since malnutrition in young children may have long-term negative effects, and the covariate nature of climatic shocks may make them more difficult to cope with than other shocks. This paper finds that climatic shocks led to a significant increase in child stunting, reducing the height-for-age z-score of five-year-old children by 10%. This evidence suggests that climatic shocks may have a permanent effect on health, affecting children's ability to acquire cognitive and non-cognitive skills. This paper also contributes to the literature by finding that the negative impact of climatic shocks on child nutrition can be offset by executing risk-coping strategies. Yet, Government aid seems irrelevant in offsetting such negative effects. These findings suggest that it might be pertinent to change the focus of government policies, from direct actions, to the improvement of household risk-coping capacities and abilities.

1. Introduction

In recent years, special attention has been given to the consequences of climate change[1]. The evidence suggests that climate change is expected to increase the severity and frequency of climatic shocks and natural disasters (Intergovernmental Panel on Climate Change, 2007; Institute for European Environmental Policy, 2006). This paper is motivated by this threat, and seeks to examine how child nutrition in rural areas might be affected by climatic shocks and natural disasters. Then, we might be able to anticipate the potential impact of more severe and frequent climatic shocks on child nutrition in rural areas.

The importance of measuring the impact of climatic shocks on young children's nutrition is obvious from two key facts: a) malnutrition occurring from the prenatal period to age three may have permanent effects on health (Carter and Maluccio, 2003; Martorell et al. 1994; Commission on Growth and Development, 2008); and b) children under five years of age are more vulnerable to malnutrition because of their high nutritional requirements[2], high growth rates (higher than at any other time), less developed immune systems, and limited ability to manifest their needs (Osmani, 1992; Martorell, 1999). The permanent negative effects of young children's malnutrition is supported by the empirical evidence of Alderman et al. (2006), who reports that low pre-school nutritional status is associated with delayed school enrolment, fewer years of schooling completed, and low height as a young adult. In addition, Martorell (1999) finds that children experiencing malnutrition might suffer functional disadvantages as adults, including diminished intellectual performance, low work capacity, and increased risk of delivery complications during childbirth. Finally, Hoddinott and Kinsey (2001) also find that children experiencing slow height growth perform less well in school, score poorly on cognitive function tests, and have poorer psychomotor development and fine motor skills.

[1] See for example: http://www.worldbank.org/environment; http://www.ifad.org/climate/index.htm; http://www.unep.org/themes/climatechange/publication/index.asp; and http://www.unisdr.org/eng/risk-reduction/climate-change/climate-change.html

[2] From about six months, for optimal growth and development, a child needs to be fed frequently with energy-rich, nutrient-dense foods. The failure to make such investments at the right time can never be remedied (UNICEF, 1998).

The economic literature establishes that household economic decisions are affected by shocks in two ways: ex-post, through the household experience of a shock, and ex-ante, through its perception of the distribution of shocks (Elbers et al. 2007). Therefore, households will select risk-management and risk-coping strategies to reduce the impact of shocks. As Dercon (2002) explains, risk-management strategies (also called income smoothing) are implemented to reduce the variability/uncertainty of income ex-ante, for example through the diversification of income sources. On the other hand, risk-coping strategies (also called consumption smoothing) are implemented to deal with the consequences of a shock, for example by buying insurance or borrowing[3]. Both strategies are implemented with the objective of reducing the impact of shocks on income and consumption; even though, they probably only succeed in partial protection, especially if markets are imperfect (Dercon, 2004; Morduch, 1995). In addition, these strategies are usually unequally costly among poor and rich households, which can lead to long-lasting negative effects on efficiency, inequality and poverty (Elbers et al. 2007; Rosenzweig and Binswanger, 1993; Morduch, 1999).

Two types of shocks are distinguished in the literature: idiosyncratic and covariate shocks. Idiosyncratic or individual shocks affect only a particular individual or household, for example the illness of household members. Conversely, covariate or common shocks affect all members of a community or region, for example climatic shocks. The available evidence suggests that risk-coping strategies can offset the impact of idiosyncratic shocks. However, covariate shocks are more difficult to offset and commonly affect household consumption, requiring the assistance of public or external agents to avoid their negative effects (Trivelli et al., 2006; Carter and Maluccio, 2003; Townsend, 1994; Porter, 2006).

Despite the fact that climatic shocks are more difficult to offset, little is known about the impact of climatic shocks on individual consumption and nutrition (Dercon and Krishnan, 2000), especially on child nutrition. To date, very few studies have analysed the impact of climate-related shocks on child nutrition. Hoddinott and Kinsey (2001) find that children aged twelve to twenty-four months lost 1.5-2 cm of growth in the

[3] Yet, risk-coping strategies will also involve ex-ante actions such as forming networks or building up savings or liquid assets.

aftermath of a drought in Zimbabwe and that catch-up in growth was limited for four years after the drought. Yamano et al. (2005) find that crop damage (although not exclusively caused by a climatic shock)[4] reduced child growth substantially among children aged six to twenty-four months in Ethiopia[5].

Analysing the impact of climatic shocks on child nutrition is not a simple task since it requires information on shocks and child nutritional indicators for the same group of households. In this regard, the data used for this paper is unique because it gathers self-reported information on climatic shocks and anthropometric indicators for children. Thus, the objective of this paper is to contribute with the existing literature on climatic shocks by analysing the impact of self-reported climatic shocks on five-year-old children's anthropometric indicators in Peruvian rural areas[6]. The advantage of using household self-reported information, compared to climate data, is that we are able to find enough variation within a community to differentiate the effect of a shock from other community characteristics. On the other hand, self-report shocks may be less reliable than climate data due to possible different perceptions about climatic shocks. Nevertheless, this disadvantage will be offset in this paper by matching the household level information with community level information on climatic shocks.

This paper is different from previous work, since it also attempts to analyse whether the impact of climatic shocks can be reduced by government aid and risk-coping strategies[7]. Particular attention is given to the role of government, since there is a high reliance on public safety nets to cope with covariate shocks (Dercon, 2002)[8]. Finally, this paper is the first of its kind in Latin America.

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[4] Two other causes accredited for crop damage are: insect attacks and crop diseases.

[5] Other related researchers are: Foster (1995), who used child weight to study inter-temporal resource allocation and credit access variations in Bangladesh (after the severe flood of 1988) and found that children in landless households were especially vulnerable to the conditions created by the flood. Alderman et al. (2006), who analysed indirectly the effect of Zimbabwean's droughts of 1982-1984 on child height-for-age in 1987 (using the droughts as instruments of initial height), found a negative relation between the droughts and the height-for-age of children in 1987.

[6] It has been decided to focus on Peruvian rural areas because malnutrition problems are worst in these areas (Escobal et al., 2003).

[7] Both public interventions and risk-coping strategies can reduce the impact of shocks on consumption and child nutrition. If they are not taken into consideration in the analysis, however, the coefficient estimate of climatic shocks can be biased toward zero.

[8] Yamano et al. (2005) tried to analyse whether food aid can offset the negative impact of crop damage. Nevertheless, it seems that food aid was not correlated with crop damage (only 46% households affected

The next section will outline and briefly discuss the theoretical model that will be used throughout the paper. Section 3 describes the data and presents the main variables of analysis with some descriptive statistics. Section 4 presents the empirical model to be estimated, and Section 5 discusses the results. Section 6 analyses further potential estimation problems. Finally, section 7 summarizes and presents some concluding remarks.

2. The Theoretical Model

This section outlines a model that links shocks and child nutrition. This model draws on the works of Behrman and Deolikar (1988), Hoddinott and Kinsey (2001) and Dercon and Hoddinott (2004). I start by assuming that the household maximises a joint inter-temporal utility function subject to a set of constraints[9]. As in Hoddinott and Kinsey (2001) preferences are assumed to be inter-temporal additive, individual utilities are assumed to be increasing and quasi-concave, and the future utility discount factor is assumed to be constant[10].

$$U = f(U_1, U_2, \ldots, U_T) \qquad \text{for time periods t= 1 to T} \qquad (1)$$

Household utility in each period (U_t) is a function of the health of household members (H^i), the consumption of household members (C^i), the consumption of public goods (C^p) and the leisure time of household members (L^i)[11]. It is presumed that all these variables have a positive impact on utility. Furthermore, a relation between them is also expected; for example, good health can make consumption and leisure more enjoyable. Finally, the utility function is also conditional on household's norms and tastes (Z).

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by crop damage received food aid), which does not allow us to consider food aid as a risk-coping strategy.

9 As explained by Behrman and Deolikar (1988), assuming a collective household model will not affect the empirical specification since the reduced form will be the same and only the interpretation of some variables will change.

10 Relaxing this assumption will make mathematics more difficult but will not add any value to the final results.

11 The variable of number of surviving children is included in other specifications but it has been omitted in this case, since the effect of mortality can be understood as H_i taking the value of zero.

$$U_t = U(H_t^i, C_t^i, C_t^p, L_t^i; Z_t) \qquad \text{for household members i= 1 to N} \tag{2}$$

The household faces two inter-temporal constraints[12]: a health production function and an income constraint[13]. I start by defining the first constraint as the one that produces health, giving special attention to children's nutritional inputs. Following Martorell (1999) and UNICEF (1998), there are three causes that affect child nutrition: a) food consumption; b) health services (within the household and the community); and c) child care practices. Taking this into account, the health of the a household member *i* in period *t* will be determined by: the initial health stock (H_{t-1}); the consumption of private goods (C^i); the consumption of public goods (C^p), especially health public goods such as access to clean water; his/her education (E^i); the education of the household member in charge of health-related decisions (E^c); the leisure time (L^i); the time devoted to health practices (TH^i); the surrounding environment (Ω); and the individual endowments (e^i). All of them are conditional on the initial health stock, for example, the same intake of nutrients will differently affect an undernourished child and a well-nourished one.

$$H_t^i = H_{t-1}^i + h(C_t^i, C_t^p, E_t^i, E_t^c, L_t^i, TH_t^i, \Omega_t, e^i; H_{t-1}^i) \tag{3}$$

The initial health stock of the household member will reflect his/her past experiences. Moreover, if partial catch-up[14] exists, it will also determine his/her future health status (Hoddinott and Kinsey, 2001). The consumption of goods, with emphasis on the intake of nutrients and health related goods (medicines), are expected to have a positive impact on health; though, too much consumption may also negatively affect health[15]. The individual education, and the education of the household member in charge of health-related decisions, may affect health through better information and better use of health-

[12] For simplicity, the constraints are presented in a two-period context, although it is not difficult to expand them to a wider horizon of analysis.
[13] Dercon and Hoddinott (2004) and Hoddinott and Kinsey (2001) consider an additional constraint: the present value of the child income contribution. This constraint can be implicitly introduced through the relative importance of the child's health in the household utility, not affecting the empirical specification.
[14] Catch-up refers to the ability of an undernourished child to grow faster than a healthy child and "catch-up" their original growth curve.
[15] Obesity is emerging as a potential public health problem in Peru. (Escobal et al., 2003).

related inputs and practices[16]. Leisure time of individuals is strictly related to health since any activity is energy consuming. In the same way as consumption, too much or too little leisure (conditioned by age), can have negative impacts on nutrition. Next, the time devoted to health and care practices have strong health effects (in the case of children, this time should be understood as the time the caregiver devotes to them). The surrounding environment is related to any input outside the household that may have an effect on health, for example, the availability of health infrastructure. Finally, the individual endowments such as age, sex or genetic characteristics will also affect health, for example, women and men can have different growth speeds at different ages.

The second constraint is the household income or budget constraint. The household capital stock (K_t) is a function of the net return to the initial capital stock (nK_{t-1}), the net transfers or aid received (Aid_t), household income in period t (Y_t), household consumption of private and public goods (C_t+C_t^p) and a vector of prices (P_t and P_t^p).

$$K_t = nK_{t-1} + Aid_t + Y_t - P_t C_t - P_t^p C_t^p \tag{4}$$

The net return of initial capital stock (nK_{t-1}) is also a function of the initial capital stock (K_{t-1}), the rate of return of capital (r_t), the depreciation rate (d_t), and any shock that could have affected the stock of capital (KS_t)[17]. On the other hand, household income is a function of technology (tec_t), the stock of capital (K_t), wages (w_t), working time (WT_t), leisure time (L_t), time devoted to health (TH_t), a vector of output and input prices (P_t) and any shock that could have affected income (IS_t).

$$nK_{t-1} = f(K_{t-1}, r_t, d_t, KS_t) \tag{5}$$

$$Y_t = f(tec_t, K_t, w_t, WT_t, L_t, TH_t, P_t, IS_t) \tag{6}$$

Maximising (1) subject to (2)-(6) would lead us to a set of reduced form demand functions, which will depend only on exogenous factors. Neither K_t nor Y_t have been

[16] In the case of children, their education may not play a central role in defining their health status as opposed to the caregiver's education.

[17] I am assuming that the distribution of shocks is known by the household; therefore, just the ex-post effect of risk is analysed. Elbers et al. (2007) analyse the difference between ex-post and ex-ante effects.

included in the reduced demand equation, since doing so would produce biased estimates (Behrman and Deolikar, 1988). Among these demand functions, the reduced form of the health demand function is the one which will be analysed in this paper; where health will be represented by the nutritional status of the child.

$$H_t^i = f(H_{t-1}^i, E_t^i, E_t^c, \Omega_t, e^i, Aid_t, K_{t-1}, r_t, d_t, KS_t, tec_t, w_t, IS_t, P_t, P_t^p, Z_t) \qquad (7)$$

We can see from this model that risk-management strategies will be reflected in the effect of IS_t and KS_t on Y_t and nK_{t-1} respectively (equations 6 and 5); while risk-coping strategies will be reflected in the effect of Y_t and K_t (conditional on IS_t and KS_t) on nutrition (H_t). However, since only the reduced form equation of the health demand function will be estimated, the coefficient of IS_t and KS_t will combine the effect of both strategies. Therefore, current health and nutrition will be affected by income or capital shocks only if effective risk-management and risk-coping strategies are not applied[18,19].

3. The Data

The Survey

The survey which is going to be used for the purposes of this paper was implemented by the Young Lives research project. The approach of the project is unique and has the objective of tracking the development of 12,000 children in Ethiopia, India (Andhra Pradesh), Peru and Vietnam over a fifteen-year period[20]. To date, two rounds of surveys have been executed by the project in Peru, one between August and December 2002 and the second between October 2006 and August 2007.

[18] In addition, it is also possible that the shocks could have an impact on health through the change of the surrounding environment (Ω); for example, damaging the community infrastructure. However, this effect is expected to be common to all the households (or individuals), making it impossible to distinguish from the effect of other community characteristics.

[19] Only when risk-coping is perfect, current consumption will not depend on current income or capital but on its permanent value. Thus, consumption changes will exclusively reflect changes in the interest rates and the rate at which future consumption is discounted (Morduch, 1995).

[20] Two cohorts of children were surveyed in 2002, one-year-old children and eight-year-old children. For the purposes of this research I will only use information from the younger cohort since children under five years of age are more vulnerable to malnutrition (Osmani, 1992; Martorell, 1999).

Peru is divided into twenty-five "departments"; each department is subdivided into provinces and the provinces into districts. The methodology followed by the Young Lives project consisted of a general multi-stage sampling protocol. The initial sampling frame was at the district level, where twenty sentinel sites were selected by systematic sampling. Once the sentinel sites were selected, an initial community, city or sector in each district was chosen at random according to the population size. This was the initial point where surveys started, identifying and interviewing households with a one-year-old child[21]. A total of 807 rural households in sixty-one communities[22] were interviewed in the first round and 779 of them were re-interviewed in the second round. As we can see, the sample attrition is very small (3%); still, it will be analysed in Section 6.

Despite the low attrition among surveys, the sample size had to be restricted further because 119 rural households moved from their initial community in between the surveys. The reasons for this exclusion are twofold: first, it is not possible to impute a unique set of the community characteristics for these households[23]; and second, the inclusion of these households in the analysis can bias the results. This bias surges from the specific reasons of migration which are unknown and might be correlated with other variables of the model (for example migration could be a response to climatic shocks or a response to undernutrition)[24]. Nevertheless, dropping these households means that the results are relevant for a population of non-migrants, affecting to some extent the external validity of the results. Yet, the analysis of migration was beyond the scope of this paper.

In addition to the household surveys, information about the communities in which the children live was collected in a Community Questionnaire. Answered by key informants, such as local authorities and representatives of the education, health, and agricultural sectors, this questionnaire collected information about the shocks that affected the community and the community characteristics. This questionnaire will complement the information collected in the Household Questionnaire.

[21] For additional information about the methodology please review Escobal et al. (2003).
[22] In a rural area, a community is a group of villages or a small town.
[23] Furthermore, since the date of migration is not known this task is impossible.
[24] Just focusing on observable characteristics, we can see that these households are significantly different from the rest of households (Table 2).

Nutritional Variables

The nutritional literature, (see for example Waterlow et al., 1977; WHO Working Group, 1986; Osmani, 1992), defines three possible anthropometric indicators to measure the health status of children: height-for-age, weight-for-height, and weight-for-age.

- *Height-for-age* is an indicator of past nutrition or stunting (also called chronic malnutrition). This indicator is associated with poor overall economic conditions, chronic or repeated infections, and/or constant inadequate nutrient intake (WHO Working Group, 1986).
- *Weight-for-height* is an indicator of wasting and is associated with the failure of gaining weight or actual weight loss (also called acute malnutrition). Wasting might be precipitated by infections or household crisis and will usually occur when the family food supply is limited and the food intake of children is low. Wasting can develop very rapidly; however, it will also be restored rapidly under favourable conditions (WHO Working Group, 1986).
- *Weight-for-age* is an indicator that sums up the information given by the previous two indicators[25]. This indicator is used to measure underweight children and is useful for giving an overview of nutritional problems in a country (WHO Working Group, 1986).

These indicators are usually presented in a standardised manner with respect to a reference population[26], called the z-score of an indicator. This standardization allows us to compare children, (regardless of age or sex), in terms of their deviation from their reference median. Thus, a stunted, wasted, and underweight child should be understood as a child whose z-score is two deviations below the median for the respective indicator.

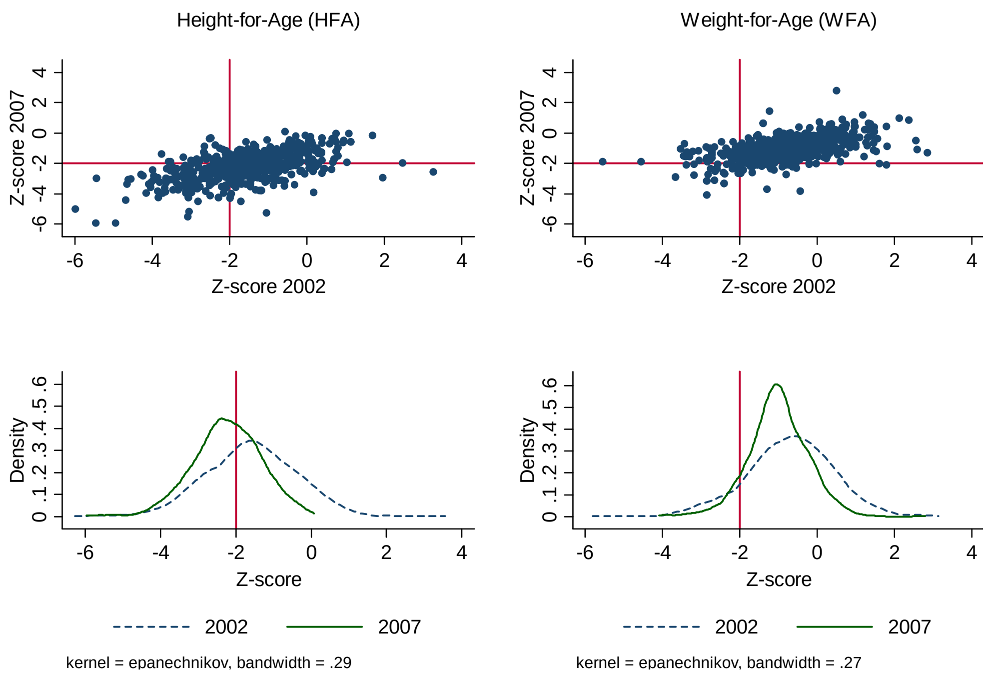
From the surveys, these three z-scores can easily be obtained since the height and weight of children have been recorded in both rounds. Nevertheless, this paper will

[25] It has been found that weight-for-height and height-for-age account for more than 95% of the variance in weight-for-age (Keller, 1983).

[26] WHO reference population (World Health Organization, 2006).

focus its analysis on stunting, for three reasons. First, stunting is the main undernutrition problem in Peru, while wasting is relatively uncommon (Escobal et al., 2003). Second, the analysis of height-for-age indicators allows us to identify possible permanent effects (Hoddinott and Kinsey, 2001). Third, five years of panel data are useful for analysing long run changes in nutrition, which are measured in terms of height-for-age. Conversely, it would be less accurate to analyse weight-for-height or weight-for-age given that they are sensitive to short run negative events. Hence, it would be imprecise to assume that shocks occurring in the last five years have had an effect on weight-for-height and weight-for-age[27].

Figure 1: Nutritional Indicators in Peruvian Rural Areas



Source: Young Lives data

Figure 1 presents some descriptive graphs of the height-for-age and weight-for-age indicators of the sample. We observe, as expected, a positive relation between the first round and second round indicators (a good nutritional status in 2002 seems to determine

[27] Furthermore, weight-for-height is more likely to be affected by measurement error, since, measurement error can be present both in the denominator and numerator, producing spurious results. Moreover, because weight-for-height is nearly independent of age (Waterlow et al., 1977) and catching up in weight deficits is dictated by attained height (Payne, 1992), it is less likely to find enough variation in the weight-for-height indicator to consolidate robust estimations.

a good nutritional status in 2007). We also observe that stunting is more prevalent than underweight, especially in the second round. Nevertheless, the higher predominance of stunting in the second round does not necessarily mean higher malnutrition between 2002 and 2007. It could just be that the retardation process started before 2002, but was only perceived after 2002. Several studies in Peru have clearly indicated that stunting is a consequence of the poor diet of children aged between six and eighteen months (Escobal et al., 2003). Finally, it is interesting to see that a group of initially stunted children were no longer stunted by 2007 (dots above -2 in the y-axis but below -2 in the x-axis of the first-row graphs), implying that reversibility is to some extent possible between one and five years of age.

The shocks

Following Dercon et al. (2005), we start by defining a shock as "an adverse event that leads to a loss of household income, a reduction in consumption, and/or a loss of productive assets" (p. 5). Having said this, a climatic shock should be understood as a natural or environment related hazard or disaster that affects a household in the same way as expressed by Dercon et al. (2005). The second round survey included a household module on the economic changes and recent life history of the household. In this module, households were requested to consider a list of adverse events, and indicate whether the household was affected by them. For each shock, information was collected about the scope of influence (whether it was confined to the household or widespread), and the risk-coping strategies applied by the household to offset its impact. In addition, the Community Questionnaire included a set of questions about natural disasters: the type of disaster, the date of the disaster, and the type of aid received. Table 1 details the set of shocks reported by the households which are going to be analysed in this paper[28]. Table 1 presents the shocks reported by the surveyed rural households. The climatic shocks of Table 1 represent the frosts, droughts and floods reported by both the rural households and the community key informants. Between the reported shocks, climatic

[28] From the survey, it is also possible to obtain information about economic and crime shocks. However, these shocks are not analysed in this paper since they are more likely to be endogenous. Economic shock can be associated with unobservables such as business capacity and ability, while crime shocks can be associated with the riskiness of the neighbourhood, the relative wealth of the household in relation to their neighbours, and negligence.

shocks seem to be the most frequent type shock. This is probably associated with the fact that rural households depend on the climate to perform their economic activities, (96% of rural households perform an agricultural activity), or the fact that rural households are physically more vulnerable, (due to lack of protection and infrastructure). Other frequent shocks are pests and diseases in crops and livestock, and the birth of a new household member.

Table 1: Reported Shocks

Shocks	% of HHs Affected	ANOVA R^2	Self-reported Idiosyncratic	Self-reported Covariate
Death of a parent	1%	0.10	100%	0%
Illness of a parent	8%	0.15	100%	0%
Divorce/separation/abandonment	2%	0.15	99%	1%
Birth/new household member	15%	0.10	98%	2%
Pest/disease in crop/livestock	16%	0.15	28%	72%
Earthquake	2%	0.32	12%	88%
Climatic shocks (frost, droughts and floods)	31%	0.44	10%	91%
Agricultural loss (crops failed /livestock died)	8%	0.17	40%	60%

Source: Young Lives data

Regarding the classification of shocks, two approaches were followed to determine whether the shock was idiosyncratic or covariate. First, a variance decomposition analysis (Analysis of Variance - ANOVA) was executed to explore the variance structure of the shocks and see the extent to which the total variance is generated by the community-level variance (the higher the R-squared, the more covariate the shock). Second, it was analysed the self-reported information about the scope of influence of the shocks. A shock was defined as idiosyncratic if the household answered that it was the only household affected by the shock, while, if more than one household was affected by the shock it was considered as covariate. Both approaches gave similar results, determining that climatic shocks and earthquakes are the most covariate shock, and therefore probably the more difficult to cope with. Other covariate shocks are agricultural losses, and pests and disease in crops and livestock.

In addition, households were asked to rank the shocks in order of importance (not reported). It was found that higher importance was given to idiosyncratic shocks as opposed to covariate shocks. Yet, climatic shocks and earthquakes were also considered in the ranking. After ranking them, households were requested to define if these “most important" shocks affected the child (not reported). The results show that idiosyncratic shocks tend to affect children more[29]; still, agricultural losses were also considered to have a negative impact on children. It appears from this point of view that one would expect to find a greater negative impact from idiosyncratic shocks than covariate shocks.

Finally, information from the Peruvian National System of Civil Defence ("Sistema Nacional de Defensa Civil" – SINADECI) was collected to determine whether the area affected by the climatic shocks received public aid. The SINADECI is the Peruvian public institution responsible of protecting the Peruvian population from natural or technological disasters, preventing damages and/or providing aid after a disaster (Instituto Nacional de Defensa Civil, 2006b). Each of the SINADECI's actions is recorded in an annual statistical compendium, detailing (at the district level) information about the type of natural disaster, the date of the disaster, and the number of people, dwellings, and agricultural area affected. This information will be used to determine whether the Peruvian Government aid offset the impact of climatic shocks[30].

Descriptive Statistics

Table 2 displays the statistics of the main variables of analysis, distinguishing between the households that were affected by a climatic shock and those that were not. We observe that the households affected by climatic shocks had, on average in 2002, fewer nourished children, older children, older and less educated caregivers, more household members, higher access to credit, and were more used to perform agricultural tasks. This suggests that omitting these variables from the analysis could bias the coefficient estimate of climatic shocks. The same applies to the shock variables of "birth/new household member" and "divorce/separation/abandonment". Table 2 also shows that areas in which climatic shocks were reported received more government aid than others, as expected. Finally, we also observe that children affected by climatic shocks are on

[29] Here "affect" should be understood in a broader sense and should not be related exclusively to health.
[30] It was tested (not reported) whether the government aid was driven by other characteristics such as poverty or political parties (whether the local authority was a member of the president's party). No significant correlation was found. Yet, Section 5 results show that government aid is probably associated to the intensity of the shocks (only most severe climatic shocks receive aid).

average more stunted in 2006/2007 than other children. Yet, it is still not possible to distinguish whether this effect is generated by the initial stunting (first round), the climatic shocks or other factors.

Table 2: Means and Correlations

Variable	Without Climatic Shocks	With Climatic Shocks	Diff.[1/]		Corr.[2/]	
Birth weight (grams)	3,149	2,979	-170.12	***	-0.16	***
Height-for-age z-score (1st round)	-1.44	-1.89	-0.45	***	-0.17	***
Height-for-age z-score (2nd round)	-2.16	-2.41	-0.25	***	-0.12	***
Age of child (months) (1st round)	11.32	11.90	0.58	*	+0.07	*
Age of child (months) (2nd round)	60.98	61.00	0.02		+0.00	
Male	0.47	0.43	-0.04		-0.04	
Age of caregiver (1st round)	27.58	28.80	1.22	*	+0.07	*
Education years of caregiver (1st round)	4.96	2.93	-2.03	***	-0.26	***
Mother's height (1st round)	148.44	148.46	0.02		+0.00	
Number of household members (1st round)	5.86	6.28	0.42	**	+0.09	**
Only one child in the household (1st round)	0.27	0.27	0.00		-0.00	
Log of annual income (1st round - Lima prices)	7.81	7.82	0.01		+0.00	
The household performs agricultural tasks (1st round)	0.96	1.00	0.03	**	+0.10	**
Assets index (1st round)	0.26	0.27	0.01		+0.03	
Access to credit (1st round)	0.33	0.25	-0.08	*	-0.08	*
Death of a parent	0.01	0.01	0.00		-0.01	
Illness of a parent	0.08	0.10	0.02		+0.03	
Divorce/separation/abandonment	0.03	0.00	-0.03	**	-0.08	**
Birth/new household member	0.13	0.19	0.05	*	+0.07	*
Pest/disease in crop/livestock	0.15	0.17	0.02		+0.03	
Earthquake	0.02	0.02	0.00		+0.01	
Agricultural loss (crops failed /livestock died)	0.07	0.10	0.03		+0.05	
The district received government aid for a climatic shock	0.66	0.95	0.29	***	+0.31	***

Source: Young Lives data
Notes:
1) T-test on the equality of means (Ho: means are equal)
2) Pairwise correlation coefficients between the Variable and Climatic Shock (Ho: correlation equal to zero)
3) *** p<0.01, ** p<0.05, * p<0.1

4. Model Specification

Following the theoretical model presented in Section 2, a dynamic model is presented in this section, assuming a linear relationship between the dependent and independent variables. As explained in the previous section, height-for-age z-score will be the dependent variable (H_t)[31]. Following the theoretical model, the independent variables of analysis will be: the initial z-score of the child (H_{t-1}), the shocks (S_t), the aid received

[31] A complementary analysis was executed during this research to find the impact of shocks on weight-for-age indicators. The findings indicate that weight-for-age indicators are not affected by shocks, suggesting that weight can be restored more easily as opposed to height.

(Aid_t), and the child, caregiver, household, and community characteristics that explain child nutrition (X_{t-1}). Therefore, the empirical model to be estimated is[32]:

$$H_{it} = \beta_0 + \beta_1 H_{i(t-1)} + \beta_2 S_t + \beta_3 S_t * Aid_t + \beta_4 X_{i(t-1)} + \varepsilon_{it} \quad (8)$$

The inclusion of a lag dependent variable (H_{t-1}) in the right-hand side of the equation is not a simple task. To include this variable in the model allow us to control by the health heterogeneity of children (past nutritional status may affect the current nutritional status; Hoddinott and Kinsey, 2001). Yet, the inclusion of a lag dependent variable creates endogeneity problems in the specification. It is likely that actual and past nutritional indicators will depend on a similar set of nutrition-specific unobservables (ε_i), which are likely to be correlated [$corr(\varepsilon_{i(t=2)},\varepsilon_{i(t=1)})\neq 0$][33]. Thus, as theory stipulates, the endogenous variables (H_{t-1}) will exhibit a biased coefficient estimate. Moreover, if the rest of the explanatory variables (*EV*) are correlated with the initial health stock [$corr(H_{i(t-1)},EV_{it})\neq 0$], their coefficients will also be biased (Wooldridge, 2006)[34]. Therefore, to deal with the endogeneity, the birth weight of the child will be used as an instrument for the lag dependent variable.

The birth weight is no more than the initial stock of health ($H_{i(t=0)}$)[35], which has not been affected by current nutrition-specific unobservables ($\varepsilon_{i(t=2)}$). However, it could have been affected by unobserved actions of the mother and the household during pregnancy ($\varepsilon_{i(t=0)}$). Therefore, to define it as a valid instrument it is necessary to assume that the "pregnancy unobservables" are uncorrelated with current nutrition-specific unobservables [$corr(\varepsilon_{i(t=2)},\varepsilon_{i(t=0)})=0$]. Two arguments support this assumption. First,

[32] It is easy to expand this model to a nutrition growth model: $\Delta H_i = \beta_0 + (\beta_1 - 1)H_{i(t-1)} + \beta_2 S_t + \beta_3 S_t * Aid_t + \beta_4 X_{i(t-1)} + \varepsilon_{it}$; where the coefficient of the lag dependent variable is equal to (β_1-1), and the rest of the parameters are exactly the same. We observe that the lower the β_1, the higher the catch-up, since less healthy children will grow faster.

[33] For example, how much the caregiver cares about child nutrition.

[34] If we assume that $corr(H_{i(t-1)},EV_{it})=0$, then we can give up efficiency by using an endogenous variable in the model, but obtain consistency in the coefficient estimates of shocks (since H_{t-1} will pick up the time-invariant nutrition-specific unobservables). This may be applicable to climatic shocks if the impact of the shock is uncorrelated with the nutrition-specific unobservables (how much the family cares about child nutrition). This assumption will be revised further in Section 5.

[35] Birth weight, compared to birth height, is the most important determinant of child mortality (WHO Working Group, 1986).

child stunting at age five in Peru is mainly caused by observed and unobserved actions after birth (Escobal et al., 2003), implying that observed and unobserved actions during pregnancy are unrelated with child stunting at age five. Second, there is evidence that all pregnancies in the sample were similarly driven (prenatal care and tetanus immunisation was high, and mother and infant mortality was low)[36] suggesting that all mothers had a similar knowledge about pregnancy practices or cared similarly about their child. Moreover, birth weight can be considered as an informative instrument since it represents the initial stock of health ($H_{i(t=0)}$) and its effect on current nutritional status ($H_{i(t=2)}$) is perceived through the initial nutritional status ($H_{i(t=1)}$) and not directly. These characteristics suggest that birth weight fulfils the conditions of a good instrument since: a) it explains a substantial proportion of the endogenous variable (informative condition); and b) it is not correlated with the residuals (validity condition)[37]. Then, by using birth weight as an instrument we would be able to control for individual heterogeneity and find more consistent estimates for the impact of climatic shocks.

The empirical model will also exploit the availability of panel data by including lagged explanatory variables (first round variables), avoiding possible simultaneity biases. When two variables are determined at the same moment it is impossible to determine the causality between them (also called reverse causality)[38]. However, it is assumed that four-year-lagged variables are not likely to be simultaneously determined by the current child nutritional status. The lagged explanatory variables ($X_{i(t-1)}$) are: the age and sex of the child, the education and age of the caregiver, the height of the mother, the household size, whether the child is the only one in the household, the household income, the household assets, whether the household performs agricultural tasks, whether the household has access to credit, and community fixed-effects; all these variables are obtained from the first round survey. In addition, the age of the child in the second round is also included, since the number of months between the two surveys is not the

[36] 86% of mothers received prenatal care and tetanus immunisation, only two mothers died before the first round, and by construction, all the children in our sample lived to one year.
[37] Following Alderman et al. (2006) approach it was also tested whether rainfall patterns between 2001 and 2002 can be used as instrument of initial height-for-age z-scores. Yet, it was not statistically significant.
[38] For example, between income and child nutrition, current working time may be affected by current child nutrition if having an undernourished child would make the family either work more to gain more income, or to work less in order to attend to the child.

same for all households (the coefficient of this variable will pick up these time differences). Despite the fact that the theoretical model recommends replacing income by its exogenous determinants, (see equation 6 and 7), it was not possible to find this information. Moreover, it is likely that this information would be collinear with the community fixed-effects. Hence, I assume that a four-year-lagged value of income would be sufficiently independent to avoid simultaneity biases. The same problem occurred when including output and input prices in the model; nevertheless, it is expected that the community fixed-effects will pick up the price effects.

Subsequently, the shock variables (*S*) represent all the shocks of Table 1, while the aid variable (*Aid*) represents the SINADECI interventions described in Section 3. Equation (8) has omitted the term $\beta_5 Aid_t$ on purpose, since the *Aid* variable is collinear with the community fixed-effects (bearing in mind that the SINADECI information is aggregated at the district level). Therefore, it is not possible to distinguish the impact of *Aid* independently from the community characteristics. Yet, an interaction term is included, (fourth term of equation 8), and will represent the impact of a climatic shock in a district where SINADECI aid was received. This aid, by definition, only occurs after or before a climatic shock, therefore it is possible to consider it as the government strategy to offset the impact of the climatic shock.

5. Results

Table 3 reports the results of estimating the impact of climatic shocks on child nutrition, using height-for-age z-score (HAZ) as the dependent variable. Both the OLS and the first and second stage of the instrumental variable estimation (IV) are reported in the table[39].

From a starting point, we notice a high R-squared in all three regressions, which implies that a high percent of the variation in HAZ is explained by the empirical model. Furthermore, the instrument is statistically significant at the one percent level, which suggests that the informative condition is satisfied. Moreover, an under-identification

[39] The final number of observations (470) is less than the second round sample because not all the households answered all questions. This sample attrition is analysed in Section 6.

Table 3: HAZ Analysis

	OLS	1st Stage IV (OLS)	2nd Stage IV
Dependent Variable:	HAZ 2nd round	HAZ 1st round	HAZ 2nd round
Birth weight (grams)		0.0003***	
		[0.000]	
Height-for-age z-score (1st round)	0.4422***		0.2488
	[0.034]		[0.221]
Age of child (months) (1st round)	0.0019	-0.0335	-0.0047
	[0.049]	[0.072]	[0.047]
Age of child (months) (2nd round)	0.0516	-0.0742	0.0374
	[0.048]	[0.072]	[0.049]
Male	0.1194*	-0.4472***	0.0365
	[0.069]	[0.100]	[0.114]
Age of caregiver (1st round)	0.0255	0.1179**	0.0522
	[0.038]	[0.057]	[0.047]
Age of caregiver squared (1st round)	-0.0001	-0.0022**	-0.0005
	[0.001]	[0.001]	[0.001]
Education years of caregiver (1st round)	0.0242*	-0.0103	0.0223*
	[0.013]	[0.019]	[0.012]
Mother's height (1st round)	0.0244***	0.0598***	0.0364**
	[0.008]	[0.011]	[0.015]
Number of household members (1st round)	-0.0399**	-0.0468*	-0.0492**
	[0.018]	[0.026]	[0.020]
Only one child in the household (1st round)	0.1550	0.0710	0.1615*
	[0.099]	[0.149]	[0.095]
Log of annual income (1st round - Lima prices)	0.0473	-0.0131	0.0455
	[0.038]	[0.057]	[0.036]
The household performs agricultural tasks (1st round)	0.0055	0.5939**	0.1175
	[0.196]	[0.290]	[0.225]
Assets index (1st round)	0.2974	0.7548	0.4610
	[0.353]	[0.525]	[0.383]
Access to credit (1st round)	0.1829**	0.1308	0.1996***
	[0.078]	[0.117]	[0.076]
Death of a parent	-1.4333**	-1.1829	-1.7186***
	[0.568]	[0.848]	[0.628]
Illness of a parent	-0.0191	-0.2064	-0.0685
	[0.125]	[0.187]	[0.132]
Divorce/separation/abandonment	0.2409	-0.0814	0.2307
	[0.223]	[0.333]	[0.212]
Birth/new household member	-0.0493	-0.0405	-0.0624
	[0.100]	[0.149]	[0.096]
Pest/disease in crop/livestock	0.0398	-0.1693	0.0088
	[0.097]	[0.144]	[0.099]
Earthquake	-0.4284	-0.6984	-0.5868
	[0.343]	[0.511]	[0.372]
Climatic shock	-0.1578*	0.0118	-0.1579*
	[0.094]	[0.140]	[0.089]
Agricultural loss (crops failed /livestock died)	-0.2331	-0.2368	-0.2809*
	[0.142]	[0.211]	[0.145]
Constant	-9.1282***	-8.9980**	-10.8051***
	[2.722]	[4.031]	[3.206]
Observations	470	470	470
R-squared	0.564	0.484	0.527
Weak identification test (Wald F statistic)			8.344
Under identification test (Chi2 P-value)			0.0017

Source: Young Lives data

Note: The homoskedasticty of the standard errors was tested using Breusch-Pagan / Cook-Weisberg Test (obtaining p-values of Prob > Chi2 = 0.4 and 0.6 for the OLS and IV models respectively); Thus, we fail to reject the null hypothesis that the standard errors are homoskedastic. (Standard errors in brackets)

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

test[40] rejects the null hypothesis that the model is under-identified, indicating that the instrument is relevant and correlated with the endogenous regressor.

However, the weak identification test[41] provides a statistic of 8.3 which is relatively lower than the Staiger and Stock (1997) rule of thumb[42] of 10, suggesting that we may have a relatively weak instrument and we should interpreted the estimates carefully[43]. Nevertheless, we find in Table 3 evidence that climatic shocks have a negative impact on child nutrition, whether we estimate the model by OLS or IV, which gives robustness to the results. Children affected by a climatic shock have approximately a 0.16 lower HAZ than the rest of children at age five in the sample, controlling for other variables. This result suggests that the impact of climatic shocks might be uncorrelated with the nutrition-specific unobservables, implying that climatic shocks may have the same impact on children no matter how much the household cares about child nutrition.

We also observe from Table 3 other significant determinants of HAZ in both the OLS and IV models, such as the number of years of education of the caregiver (positive effect), the mother's height (positive effect), the number of household members (negative effect), the access to credit (positive effect)[44], and the death of parents (negative effect). Furthermore, a test for joint significance of the community fixed-effects suggests that the community characteristics are also important for defining the nutrition of children in both models[45].

In addition, we observe that there are two variables that are significant in the OLS but not in the IV: the HAZ of the child in the first round and the sex of the child. These two variables do not seem to be significantly different from zero in the IV model, and both the coefficient estimates and the standard error seem to change. Therefore, it is not

[40] LM test of the Anderson (1951) canonical correlations test.
[41] F-version of the Cragg-Donald (1993) Wald statistic.
[42] This rule of thumb indicates that the maximum Two Stage Least Squares size distortion is no more than 10% (Stock and Yogo 2002).
[43] The Sargan-Hansen test of overidentifying restrictions (Ho: the instruments are uncorrelated with the error term) was not possible to estimate because we only have one instrument.
[44] The positive impact of access to credit may reflect later returns to investments. These returns might not be reflected in the income of 2002 since they could have been received between the first and second round, increasing the household income after 2002 and having a positive impact on child nutrition.
[45] A p-value of Prob>F = 0.002 and Prob>Chi2 = 0.000 was obtained in the OLS and IV model respectively (not reported).

possible to know whether these variables are significant in the OLS due to unobservable reasons or nutrition related issues[46]. Between these variables, special attention has to be given to the initial HAZ, since it will determine whether catch-up is possible. The OLS model suggests that only partial catch-up is possible [$(\beta_1\text{-}1)$ = -0.56][47]; while the IV model suggests that complete catch-up is possible and that actual nutritional status is independent from past nutritional status (the coefficient is not significantly different from zero). Yet the coefficient of the IV model is still greater than zero and could be inefficient since IV estimators are less efficient than OLS when the endogenous variable is exogenous (Wooldridge, 2006). A Durbin-Wu-Hausman test was done to test whether the coefficient estimate of the endogenous variable differs significantly between the OLS and IV model. A Chi-square value of 0.85 was obtained (p-value = 0.36), failing to reject the null hypothesis, that the coefficient of initial HAZ is significantly different between the two models. Therefore, it is possible to conclude that the coefficient of initial HAZ would tend to be different from zero, suggesting that only partial catch-up is possible.

Regarding the variables identified as significant in the IV model but insignificant in the OLS, ("only one child in the household" and "agricultural losses"), it is possible that these IV estimates might be relatively biased. Yet, IV estimates would be preferred to the OLS estimates if the correlation between the endogenous variable and the error term is higher than the correlation between the instruments and the error term divided by the correlation between the instruments and the endogenous variable (Wooldridge, 2006)[48]. The high correlation between birth weight and initial HAZ, plus the relative high value of the Cragg-Donald statistic, suggest that the IV estimates should be preferred. Furthermore, their relative high t-statistic[49] in the OLS model reinforces the fact that the IV significance should be considered. Therefore, it is concluded that being the only child of the household has a positive impact on nutrition, while agricultural shocks have a negative impact.

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[46] For example, whether past health status determines current health status.
[47] See footnote 32.
[48] IV estimates are preferred to OLS, on asymptotic bias grounds, when Corr(z,u)/Corr(z,x)< Corr(x,u); where z is the instrument, x is the endogenous variable and u is the error term (Wooldridge, 2006).
[49] The t-statistic is 1.57 for the "only one child in the household" variable and 1.64 for the "agricultural loss" variable.

Reviewing Table 1, it seems that the most significant shocks are the death of a parent, climatic shocks and agricultural losses. The first of these reduces the HAZ of the child by approximately 1.7, probably because the household lost an important source of income and/or the time devoted to child care was reduced. The climatic shock reduces the HAZ of the child by approximately 0.16, which might be the result of inadequate risk-management and/or risk-coping strategies. Finally, the agricultural losses reduce the HAZ of the child by 0.28 probably due the same reasons. It is worth mentioning that the significance of the covariate shocks displayed in Table 3 can be even higher, since their standard errors might be affected by multicollinearity. The multicollinearity problem will be analysed in Section 6.

The next step of the analysis is to estimate whether the impact of climatic shocks can be offset by government aid. Table 4 shows the result of estimating equation 8. The first thing we observe is that the coefficient estimates of climatic shocks and government aid (interacted variable)[50] are negative, but not significantly different from zero. The negative coefficient of the interacted variables suggests that households which received aid appear to be worse off than the rest of households. This might be explained by the fact that aid was probably allocated only to more severe shocks. Moreover, the fact that none of the coefficients are significantly different from zero may imply that including government aid in the model generates inefficiency (we see that the variance of climatic shocks is increased[51]). Therefore, it is probably irrelevant to distinguish between households which received aid for climatic shocks, and households which did not. Then, we can affirm that even though government aid was granted after the climatic shocks there is no evidence, in this sample, of a positive impact. This null impact of government aid can be the result of poor targeting, insufficient resources, or a crowding out effect with other household strategies.

[50] The interacted variable (climatic shock & government aid) should be interpreted as the additional impact of climatic shocks on the households that received aid. We observe that by adding up the coefficients of "climatic shocks" and "climatic shock & government aid" we obtain a similar coefficient (-0.17) as on Table 3.

[51] The higher the correlation (in absolute value) between the relevant and irrelevant variable, the higher is the variance of the coefficient (Maddala, 2001). Since 80% of the households affected by a climatic shock received government aid, correlation is relatively high.

Table 4: Government Aid

	OLS	1st Stage IV (OLS)	2nd Stage IV
Dependent Variable:	HAZ 2nd round	HAZ 1st round	HAZ 2nd round
Birth weight (grams)		0.0003***	
		[0.000]	
Height-for-age z-score (1st round)	0.4428***		0.2538
	[0.034]		[0.223]
Age of child (months) (1st round)	0.0034	-0.0354	-0.0035
	[0.049]	[0.073]	[0.047]
Age of child (months) (2nd round)	0.0502	-0.0724	0.0368
	[0.048]	[0.072]	[0.048]
Male	0.1202*	-0.4477***	0.0390
	[0.069]	[0.100]	[0.115]
Age of caregiver (1st round)	0.0239	0.1200**	0.0504
	[0.038]	[0.057]	[0.048]
Age of caregiver squared (1st round)	0.0000	-0.0022**	-0.0005
	[0.001]	[0.001]	[0.001]
Education years of caregiver (1st round)	0.0247*	-0.0110	0.0227*
	[0.013]	[0.019]	[0.012]
Mother's height (1st round)	0.0244***	0.0598***	0.0361**
	[0.008]	[0.011]	[0.015]
Number of household members (1st round)	-0.0400**	-0.0467*	-0.0490**
	[0.018]	[0.026]	[0.020]
Only one child in the household (1st round)	0.1470	0.0804	0.1559
	[0.101]	[0.150]	[0.096]
Log of annual income (1st round - Lima prices)	0.0476	-0.0135	0.0458
	[0.038]	[0.057]	[0.036]
The household performs agricultural tasks (1st round)	0.0035	0.5957**	0.1135
	[0.196]	[0.290]	[0.225]
Assets index (1st round)	0.3002	0.7515	0.4591
	[0.353]	[0.525]	[0.383]
Access to credit (1st round)	0.1817**	0.1319	0.1984***
	[0.078]	[0.117]	[0.076]
Death of a parent	-1.4310**	-1.1873	-1.7102***
	[0.568]	[0.849]	[0.629]
Illness of a parent	-0.0157	-0.2108	-0.0650
	[0.126]	[0.188]	[0.132]
Divorce/separation/abandonment	0.2470	-0.0885	0.2352
	[0.224]	[0.333]	[0.212]
Birth/new household member	-0.0552	-0.0336	-0.0662
	[0.101]	[0.150]	[0.096]
Pest/disease in crop/livestock	0.0397	-0.1690	0.0095
	[0.097]	[0.145]	[0.099]
Earthquake	-0.4329	-0.6935	-0.5860
	[0.343]	[0.511]	[0.371]
Climatic shock	-0.0647	-0.1022	-0.0938
	[0.192]	[0.286]	[0.185]
The district received gov. aid for climatic shocks	-0.1200	0.1467	-0.0826
	[0.215]	[0.321]	[0.209]
Agricultural loss (crops failed /livestock died)	-0.2323	-0.2377	-0.2792*
	[0.142]	[0.211]	[0.145]
Constant	-9.0256***	-9.1143**	-10.6946***
	[2.731]	[4.043]	[3.237]
Observations	470	470	470
R-squared	0.564	0.484	0.529
Weak identification test (Wald F statistic)			8.154
Under identification test (Chi2 P-value)			0.0019

Source: Young Lives data

Note: The homoskedasticty of the standard errors was tested using Breusch-Pagan / Cook-Weisberg Test (obtaining p-values of Prob > Chi2 = 0.4 and 0.6 for the OLS and IV models respectively); Thus, we fail to reject the null hypothesis that the standard errors are homoskedastic. (Standard errors in brackets)

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

Table 5: Risk-Coping Strategies

Dependent Variable:	OLS HAZ 2nd round	1st Stage IV (OLS) HAZ 1st round	2nd Stage IV HAZ 2nd round
Birth weight (grams)		0.0003***	
		[0.000]	
Height-for-age z-score (1st round)	0.4459***		0.3388
	[0.034]		[0.217]
Male	0.1224*	-0.4629***	0.0747
	[0.070]	[0.100]	[0.115]
Age of caregiver (1st round)	0.0210	0.1301**	0.0372
	[0.039]	[0.057]	[0.048]
Age of caregiver squared (2002)	0.0000	-0.0024***	-0.0003
	[0.001]	[0.001]	[0.001]
Education years of caregiver (1st round)	0.0281**	-0.0149	0.0264**
	[0.013]	[0.019]	[0.012]
Mother's height (1st round)	0.0250***	0.0587***	0.0315**
	[0.008]	[0.011]	[0.015]
Number of household members (1st round)	-0.0395**	-0.0436*	-0.0443**
	[0.018]	[0.026]	[0.019]
The household performs agricultural tasks (1st round)	0.0149	0.5867**	0.0759
	[0.197]	[0.287]	[0.218]
Assets index (1st round)	0.1715	1.0070*	0.2930
	[0.361]	[0.529]	[0.411]
Access to credit (1st round)	0.1663**	0.1236	0.1755**
	[0.079]	[0.117]	[0.075]
Death of a parent	-1.4816**	-1.1721	-1.6368***
	[0.574]	[0.844]	[0.611]
Climatic Shock & no response	-0.2496**	0.0493	-0.2420**
	[0.118]	[0.173]	[0.109]
Climatic Shock & consumption response	-0.1104	-0.1026	-0.1196
	[0.169]	[0.248]	[0.156]
Climatic Shock & received aid	0.0401	0.1583	0.0485
	[0.181]	[0.267]	[0.166]
Climatic Shock & work response	0.1283	-0.1309	0.1024
	[0.196]	[0.290]	[0.187]
Climatic Shock & sold assets response	0.0209	1.0697***	0.1268
	[0.259]	[0.377]	[0.318]
Climatic Shock & credit/savings response	0.2336	-0.5258	0.1674
	[0.357]	[0.523]	[0.353]
Climatic Shock & other response	0.0002	-0.5289*	-0.0623
	[0.190]	[0.279]	[0.215]
Agricultural loss (crops failed /livestock died)	-0.2389*	-0.1707	-0.2582*
	[0.143]	[0.209]	[0.137]
Constant	-9.465***	-9.099**	-10.392***
	[2.737]	[3.996]	[3.123]
Observations	470	470	470
R-squared	0.568	0.503	0.557
Weak identification test (Wald F statistic)			8.255
Under identification test (Chi2 P-value)			0.0017

Source: Young Lives data

Notes:

1) The model specification includes the same explanatory variables than Table 3; yet, the climatic shock variable has been replaced by the climatic shock's responses. The variables with parameter estimates not significantly different from zero are not displayed because of lack of space.

2) The homoskedasticty of the standard errors was tested using Breusch-Pagan / Cook-Weisberg Test (obtaining p-values of Prob > Chi2 = 0.4 and 0.8 for the OLS and IV models respectively); Thus, we fail to reject the null hypothesis that the standard errors are homoskedastic. (Standard errors in brackets)

3) *** p<0.01, ** p<0.05, * p<0.1

The last part of the analysis consists of identifying possible household strategies and characteristics which offset the negative impacts of climatic shocks. The model used in Table 3 is re-estimated replacing the climatic shock variable by the household risk-coping strategies. The coefficient of each strategy reflects the impact of the climatic shocks in the sub-set of households that applied a specific risk-coping strategy[52]. Table 5 displays the results. These results have to be carefully understood and should be considered as informative rather than conclusive since they might be representing not the result of a strategy, but unobservables such as how much a household care about coping with risks (for example only the households that care more about child nutrition might apply these risk-coping strategies). Still, Table 5 results highlight the importance of applying risk-coping strategies to cope with climatic shocks.

We observe that households which did not apply a risk-coping strategy were significantly affected by climatic shocks while households that managed to apply any risk-coping strategy reduced the impact of climatic shocks. The climatic shocks diminished the HAZ of children at age five by 0.24 of households that did not apply a risk-coping strategy (observing that 37% of the households did not apply a risk-coping strategy may justify the significant impact of climatic shocks in Table 3). Conversely, the impact of climatic shocks on the HAZ of children at age five of households that applied any risk-coping strategy is not significantly different from zero. Between the risk-coping strategies applied, we observe that the most successful were using credit and savings, selling assets, working and receiving aid. On the other hand, the consumption strategy (whether the household decided, or was forced, to cut consumption) seems to reduce the impact of climatic shocks but not offset it totally. The statistics suggest that none of the coefficients of the risk-coping strategies are significantly different from zero implying that total offsetting is possible whatever strategy is chosen.

[52] The households affected by climatic shocks were requested to report in the Household Questionnaire the response they took to protect themselves from the shock. The responses considered for each strategy were: consumption strategies - to eat or buy less; aid strategies - to receive help from community/leaders, relative/friends or government/NGO; work strategies - to work more, start working or start looking for a job; sold assets strategies - to sell possessions, animals or properties; credit/savings strategies - to use saving, credit or mortgages.

Finally, the positive sign of the aid strategy complements the results of Table 4, in the sense that, it seems possible to offset the impact of climatic shocks by receiving aid from external agents. Yet, it is not possible to distinguish whether this aid came from the government or private source.

6. Potential Estimation Problems

There are five potential estimation problems that need to be considered after interpreting the results. The first and major problem involves the existence of child, caregiver, and household[53] time-invariant unobservables (α_i) that may determine child nutrition and might not be controlled by the variables included in equation (8)[54]. These unobservables may bias the results if they are correlated with our estimators (if $cov(X_{it},\alpha_i)\neq 0$ then $cov(X_{it},\varepsilon_i+\alpha_i)\neq 0$). To avoid (and test) this problem one should include child fixed-effects in the model and compare the results with the OLS estimates. However, this is not possible because in doing so the model would lose all the degrees of freedom. Therefore, the results presented in Section 5 should be interpreted taking into account possible biases due to household, caregiver and child unobservables[55].

The second potential problem is multicollinearity. Multicollinearity arises when the correlation between two or more independent variables is high, increasing the variance of the coefficient estimates[56]. We should be aware of this problem when analysing the results since multicollinearity can lead us to conclude that one or more of the independent variables does not matter, although they actually do. This problem is more likely to affect the coefficient estimates of the covariate shocks since they seem to be

[53] The community time-invariant characteristics are collected with the community fixed effects.

[54] Between these time-invariant unobservables the one which is probably controlled better is the child unobservable genetic capacities, which should be represented in the mother height variable.

[55] Two possible estimation strategies can be applied to control for the unobservables in future analysis: a) look for siblings in the second cohort of the survey and apply household fixed-effects to remove part of the unobservables (access to this information was not possible); and b) after the third round of the survey is executed, a dynamic panel model can be estimated, with interacted time dummies to differentiate the impact of climatic shocks between one and five years of age and five and nine years of age.

[56] Recall that $Var(\beta_j)=\sigma^2/\sum(x_{ij}-\overline{x_j})R_j^2$; where R^2_j is the R-squared of regressing x_j on all other independent variables. The higher the R^2_j the higher is the correlation between x_j and all the independent variables, and the higher is the variance of its coefficient.

correlated with the community fixed-effects[57]. For example, given the high correlation of earthquakes and community fixed-effects, it is probable that its coefficient estimate is being affected by multicollinearity. On the other hand, the fact that we have found a significant impact of climatic shocks and agricultural losses on HAZ (despite multicollinearity) suggests that their impact could be even more significant[58].

The third potential problem is sample bias by attrition. There are two sources of attrition in our model: a) 4% of the surveyed households in 2002 were not surveyed in 2007[59]; b) the final number of observations (470) is less than the 2007 sample because not all the households answered all questions and some household migrated from the initial community. Table A.1 of the appendix analyses the sample attrition on observable variables[60]. We observe that the first source of attrition is relatively small and is only represented in the age of the caregiver and access to credit, qualifying the second round sample as slightly more vulnerable. With respect to the second source of attrition, we observe that the final sample is relatively wealthier than the non-migrant's household sample (column D), and has relatively more assets than the initial sample, (despite the fact that the initial sample includes migrant households which seem to be wealthier than non-migrant households). This analysis suggests that the sample attrition due to observables is minimal, (when comparing the initial and final sample), and that this attrition would tend to underestimate rather than overestimate the negative effects of climatic shocks.

The fourth potential problem is omitted variables, such as the intensity of the shocks and the amount of aid received by the households. These omitted variables may bias our

[57] Table 1 shows us that the variances of covariate shocks are likely to be explained by the community-level variances. Furthermore, the possibility that the covariate shocks can be correlated between them increases the probability of facing multicollinearity problems; for example, agricultural losses could have been generated by climatic shocks or pests. Yet, Table 2 does not show any correlation between the climatic shocks and the rest of the covariate shocks.

[58] It is possible that agricultural losses do not have a significant impact on HAZ in the OLS model because of multicollinearity. Despite this, its t-statistic is relatively high ($|t| = 1.64$).

[59] A group of households emigrated from Peru, while another group was affected by the death of the child. The former reason can overestimate or underestimated our estimates, depending on the reasons of migration, whereas the latter will underestimated the coefficients since our sample will be relatively healthier.

[60] However, if attrition is driven by unobservables and, these affect child nutrition, then the sample bias would not be identified.

climatic shock and government aid coefficients. In this regard, information on rainfall, temperatures and public expenditure may be useful. However, since the survey followed a multi-stage sampling protocol, all information would be collinear with the community fixed-effects unless it is obtained in a household basis. It was not possible to obtain information of this kind for this paper[61]. Thus, the coefficient estimates of climatic shocks and government aid should be interpreted in the model as the impact of an average shock and average amount of aid.

Finally, the last problem is measurement error in our dependent variable. Since child nutrition is not directly observed, we are representing it by the latent variable of height-for-age z-score. Although height-for-age z-score is an indicator of child nutrition, it is not possible to confirm that it was correctly measured. If height was correctly measured then there is no measurement error, or in any case we can assume it is random[62]. Yet, it is likely to find a non-random measurement error on height correlated with child age, due to the difficulties of measuring young children height especially when the length is measured. However, once controlled by age, it can be assumed that the measurement error is random[63].

7. Concluding Remarks

This paper examined the impact of climatic shocks of 2002-2007 on the nutritional indicators of one-year-old children in Peruvian rural areas. It was found that these

[61] It was not possible to obtain information on temperature and public expenditure; nevertheless, rainfall was used to measure differences in rainfall pattern. The difference between the monthly rainfall average between rounds and a ten year average was constructed using information from the NASA rainfall archives (http://lake.nascom.nasa.gov/tovas), and following the community's latitude and longitude degrees. The results showed a negative impact of changes in rain patterns over child nutrition yet not significantly different from zero. Nevertheless, these results are less reliable than the ones presented in Section 5 since they do not control for community fixed-effects because the rainfall information was obtained at the community level.

[62] Although the randomness can affect the efficiency of the estimator, it will not affect its consistency (Wooldridge, 2006).

[63] Measurement error can also be present with regards to birth weight. However, information on documented birth weight was used to test whether this measurement was random. The T-test on the equality of means cannot reject the hypothesis that the means of the two sub-samples are equal; and the Kolmogorov-Smirnov test cannot reject the null hypothesis of equality of distribution at the 5% confidence level (not reported). These results suggest that undocumented birth weight will probably have more variance, but that its distribution would be relatively similar to the documented birth weight distribution. Therefore, it can be assumed that measurement error in birth weight would affect its efficiency but not its consistency.

shocks had a negative impact on child nutrition: climatic shocks reduced the height-for-age z-score of five-year-old children by 0.16, (equivalent to a 10% of the initial height-for-age z-score). Furthermore, this reduction represents 25% of the total reduction observed in height-for-age z-score between 2002 and 2007 in the sample. The results, in addition to the existing literature on child nutrition, suggest that climatic shocks may have permanent effects on health, affecting the ability of children to acquire both cognitive and non-cognitive skills. Therefore, it is suggested that protecting rural children against climatic shocks may have a positive return in long-term rural poverty and inequality.

The second part of the analysis focused on the effect of government aid and risk-coping strategies to reduce the impact of climatic shocks. The results show that households which had the capacity or ability of applying risk-coping strategies managed to offset the impact of climatic shocks, while households which did not have this capacity were significantly affected. In this sense, risk-coping strategies appear to be successful in offsetting the impact of climatic shocks. Among these strategies, the most successful seem to have been using credit and savings, selling assets, working and receiving aid (public and private). Regarding the impact of government aid, Table 4 showed no evidence of a positive impact of public aid in offsetting the negative effects of climatic shocks on child nutrition in the sample. Moreover, it seems irrelevant to distinguish between households which received aid and households which did not. Therefore, it appears that government aid has not been as successful as other strategies in offsetting the impact of climatic shocks. These findings suggest that it might be relevant to change the focus of government policies, from direct actions to the improvement of household risk-coping capacities and abilities to protect children against climatic shocks.

There are a number of additional findings to note. First, in addition to climatic shocks, other shocks that affect child nutrition are the death of a parent and agricultural losses. Second, only partial catch-up has been found in height-for-age indicators. Third, other significant determinants of child nutrition at age five seem to be: the years of education of the caregiver, the mother’s height, the number of household members, the access to credit, whether the child is the only one in the household, and the community characteristics. Finally, the fact that first round level of income and assets do not affect second round nutrition suggests that some consumption smoothing is occurring.

These estimations appear to be valid and robust to a number of econometric concerns, yet it was not possible to control for child, caregiver and household time-invariant unobservables.

To conclude, it is worth mentioning that this paper is just a first step in estimating the impact of climatic shocks on child nutrition. As explained by Elbers et al. (2007), households are affected by shocks in two ways: ex-post and ex-ante. So far, this paper has found and examined the ex-post effects of climatic shocks. Yet, climatic shocks can also have ex-ante effects on child nutrition. Then, if it is found that households apply risk diminishing strategies to offset the impact of climatic shocks ex-ante, it is possible that the effect of climatic shocks found in this paper will only represent one part of the total "real" effect. For that reason, future research which accounts for both types of effects would certainly be interesting.

8. References

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Appendix

Table A. 1: Test of Means of the Different Samples

	(A) Initial Sample	(B) 2nd Round Sample	Significant Difference[1/] (A)-(B)	(C) Migrant HH	(D) Non-Migrant HH	Significant Difference[1/] (C)-(D)	(E) Final Sample	Significant Difference[1/] (D)-(E)	Significant Difference[1/] (A)-(E)
Birth weight (grams)	-1.558	-1.548	No	-1.377	-1.579	No	-1.580	No	No
Height-for-age z-score in 2002	3112	3112	No	3191	3096	Yes	3101	No	No
Age of child (months) in 2002	11.568	11.566	No	11.924	11.502	No	11.532	No	No
Male	0.465	0.465	No	0.487	0.461	No	0.470	No	No
Age of caregiver in 2002	27.44	27.52	Yes	25.10	27.96	Yes	27.89	No	Yes
Education years of caregiver in 2002	4.558	4.551	No	5.798	4.326	Yes	4.481	Yes	No
Mother's height in 2002	148.4	148.5	No	148.5	148.4	No	148.3	No	No
Number of household members in 2002	5.934	5.937	No	5.639	5.991	No	5.892	Yes	No
Only 1 child in the household in 2002	0.300	0.299	No	0.462	0.270	Yes	0.292	Yes	No
Log of annual income in 2002 (Lima prices)	7.852	7.858	No	8.103	7.816	Yes	7.903	Yes	No
A household member did agricultural tasks in 2002	0.954	0.955	No	0.866	0.971	Yes	0.968	No	Yes
Assets index in 2002	0.264	0.266	No	0.288	0.262	Yes	0.276	Yes	Yes
Access to credit in 2002	0.314	0.308	Yes	0.328	0.305	No	0.317	No	No
Lived in coast in 2002	0.019	0.018	No	0.042	0.014	Yes	0.017	No	No
Lived in mountain in 2002	0.718	0.721	No	0.546	0.753	Yes	0.732	Yes	No
Lived in jungle in 2002	0.264	0.261	No	0.412	0.233	Yes	0.251	Yes	No
Sample size:	807	779		119	660		470		

[1/] Significance estimated using T-test on equality of means (Ho: means are equal). Yes=p<0.1
Source: Young Lives data