THREE ESSAYS ON INVESTMENTS IN CHILDREN'S HUMAN CAPITAL

BY

MONSERRAT BUSTELO

DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Agricultural and Applied Economics
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2011

Urbana, Illinois

Doctoral Committee:

Professor Mary Arends-Kuenning, Chair
Professor Craig Gundersen
Professor Charles Nelson
Professor Elizabeth T. Powers
Professor Walter Sosa-Escudero

ABSTRACT

This dissertation encompasses three chapters that study the extent to which natural disasters and social assistance programs affect children's schooling, child labor, and children's health in developing countries. Below are the individual abstracts for each chapter.

Chapter 1: Bearing the Burden of Natural Disasters: Child Labor and Schooling in the Aftermath of Tropical Storm Stan in Guatemala

This paper exploits an extreme climate event, Tropical Storm Stan, which devastated Guatemala in 2005, to identify the short-term impact of a large-scale disaster on children's schooling and child labor. The empirical strategy exploits time and spatial variation in the intensity of the shock. The paper uses a self-reported measure of shock exposure collected by a nationally representative household survey six to twelve months after the disaster. In addition, the paper uniquely incorporates an external administrative measure of exposure that captures the direct value of damages caused by the storm in each Guatemalan department. Results emphasize that child labor is an important part of family self-insurance strategies and that a great deal of heterogeneity by gender and age exists in terms of how children's time allocation was affected by the storm. The shock led to a significant increase in child labor for children aged 13 to 15 and school participation decreased only for male children. By contrast, findings suggest that children aged 7 to 12 tended to not bear the burden of the disaster. Results are robust to alternative specifications, including an instrumental variable strategy.

Chapter 2: Persistent Impact of Natural Disasters on Child Nutrition and Schooling: Evidence from the 1999 Colombian Earthquake

This paper studies the impact of the 1999 Colombian Earthquake on child nutrition and schooling. The identification strategy combines household survey data with event data on the

timing and location of the earthquake, exploiting the exogenous exposure of children to the shock. The paper uniquely identifies both the short- and medium-term impacts of the earthquake, combining two cross-sectional household surveys collected before the earthquake and two cross-sectional household surveys collected one and six years after the earthquake. Colombia provides a unique setting for our study because the government launched a very successful reconstruction program after the earthquake. Findings report a strong negative impact of the earthquake on child nutrition and schooling in the short-term. Relevantly, amid the aid received by the affected area, the negative consequences of the earthquake persist with a lesser degree in the medium-term, particularly for boys.

Chapter 3: *Who Else Benefits from Conditional Cash Transfer Programs? Indirect Effects on Siblings in Nicaragua*

Conditional Cash Transfer (CCT) welfare programs encourage households to invest in the human capital of their children. They offer eligible families cash in exchange for commitments, such as sending children from targeted populations to school. When this educational requirement can be met via the school attendance of only certain children within a household, other siblings within the same household might be indirectly affected in both positive and negative ways. This paper reports on new evidence from Nicaragua's Red de Proteccion Social CCT program, which targets educational grants only to children aged 7 to 13 who have not completed 4^{th} grade. I analyze the indirect effects within households on the schooling and employment of two groups of non-targeted siblings: those aged 9 to 13 who have already completed 4^{th} grade and those aged 14 to 17, who are too old to be eligible. Results suggest positive schooling effects within the households for older, non-targeted siblings, with higher impacts for boys than girls. Indeed, the enrollment gains for male siblings come hand in hand with a reduction of their labor supply.

To Leo who has shared this unforgettable experience with me and who has made it special

To my family and dearest friends

ACKNOWLEDGEMENTS

I wish to express my gratitude to all the people who gave me their support over the years and helped me in making this research possible. I owe my deepest gratitude to my advisor, Professor Mary Arends-Kuenning, who has been a mentor and has become a friend. It was an honor for me to work with her and she has been a great support and invaluable guidance throughout graduate school. She provided me many insightful suggestions related to my project and patiently read all my work. I am also grateful to the other members of my thesis committee, professors Craig Gundersen, Charles Nelson, Elizabeth Powers, and Walter Sosa-Escudero, for their time, patient, comments, constant support, and valuable advice. I am most thankful to the ACE department at the University of Illinois at Urbana-Champaign for the opportunity to be part of the Ph.D. program, for the financial assistance over the years, and for its friendly and challenging environment. I wish to thank Pam Splittstoesser for her constant help, which made the end of this process a little easier. I am grateful to Amanda Huensch for her help in editing the chapters of this manuscript and Leonardo Lucchetti and Professor Mary Arends-Kuenning for co-authoring chapter 2 of this project. I would like to thank Omar Arias and Walter Sosa-Escudero for always believing in me and encouraging me to continue my Ph.D. studies. I am eternally grateful to Leonardo Lucchetti, who has been with me in all the ups and downs and knows how much this experience meant to me. There are a number of persons who provided also important feedback to strengthen my learning and research, including David Bullock, Philip Garcia, Alex Winter-Nelson, Anna Fruttero, Kinnon Scott, Diane Steele, Alexandra Marini, Javier Baez, Rafael Perez Ribas, Rafael De Matta, Vicenzo Di Maro, Karen Macours, Ferdinando Regalia, Marco Rocha, Breno Sampaio, Gustavo Sampaio, Flor de María Figueroa Larios and Celia de León from the Guatemalan Statistics Bureau (INE), Lorena Alvarez and

Claudio Cesar Castañon Contreras from the Guatemalan Seismology, Volcanology, Meteorology, and Hydrology Bureau (INSIVUMEH), Noureddine Abderrahim from Demographics and Health Surveys (DHS), Helena Sanchez and Ana Elvira Vega from PROFAMILIA in Colombia, and seminar participants at the University of Illinois, the 5th IZA/World Bank Conference on Employment and Development in Cape Town, and the 15th Annual LACEA Meeting in Medellín.

Finally, I wish to convey utmost thanks to several persons who have been and are always there for me, making my life so beautiful: my partner, Leo; my parents Liliana and Jorge; my dearest siblings Manu, Geo, and Ro; my in-laws Leli and Quique; my dearest grand-ma Abu Nelly; and my dearest friends (the old and the new) Dolo, Mari, Mer, Eve, Sole, Juli, Chep, Flor, Geor, Marc, Raf, Magdis, Anna, Anita, Omar, Vani, Caro, Lau, Vick, Vero, Edisa, Diego, and the Brazilian gang (fortunately too many to mention). None one of my experiences over the years would have been the same without their unflagging support and love. I owe them so much.

TABLE OF CONTENTS

CHAPTER 1 BEARING THE BURDEN OF NATURAL DISASTERS: CHILD LABOR AND SCHOOLING IN THE AFTERMATH OF THE TROPICAL STORM STAN IN GUATEMALA 1

CHAPTER 2 PERSISTENT IMPACT OF NATURAL DISASTERS ON CHILD NUTRITION AND SCHOOLING: EVIDENCE FROM THE 1999 COLOMBIAN EARTHQUAKE 38

CHAPTER 3 WHO ELSE BENEFITS FROM CONDITIONAL CASH TRANSFERS PROGRAMS? INDIRECT EFFECTS ON SIBLINGS IN NICARAGUA 75

APPENDIX A 109

APPENDIX B 119

REFERENCES 122

CHAPTER 1
BEARING THE BURDEN OF NATURAL DISASTERS: CHILD LABOR AND SCHOOLING IN THE AFTERMATH OF THE TROPICAL STORM STAN IN GUATEMALA

1. Introduction

The question of whether natural disasters cause a decrease in children's human capital investment is an increasing concern for development economists and policymakers. The concern partly stems from the increasing exposure of lives and property to disasters, with earthquakes and storms causing the most damage (World Bank 2010).[1] Though exposure to natural disasters has risen in the last decades, two key issues have lacked the attention they deserve: (i) how to prevent them, and (ii) how to mitigate them. Understanding how natural disasters affect investment in child human capital is an important first step in recommending sensible interventions to protect children's welfare. However, rigorous evidence that quantifies the consequences of specific large-scale natural disasters in developing countries is still limited. The present paper aims to contribute to such an understanding. This paper exploits an extreme climate event, Tropical Storm Stan, which devastated Guatemala in 2005, to identify the short-term impact of a large-scale disaster on children's schooling and child labor.

A major concern about natural disasters is that they may increase poverty and its intergenerational transmission if they induce households to decrease their investment in human capital and increase child labor (Skoufias 2003, Ferreira and Shady 2009). Schooling generates pecuniary and non-pecuniary returns, affecting central aspects of individuals' lives both in and outside the labor market (see Oreopoulos and Salvanes 2011 for a review).[2] More schooling is

---

[1] The increasing trend of natural dissasters is related to a combination of the availability of more information, an increase in population and urbanization, and global climate change (CRED 2010, World Bank and United Nations 2010).

[2] For example, schooling may influence individuals' job satisfaction and their decisions about health, marriage, and parenting style (Oreopoulos and Salvanes 2011).

related to higher wages, lower probabilities of being unemployed, more prestigious jobs, and higher job satisfaction (Card 1999). Child labor is related to divestment of human capital formation, which might hurt the child in the future (Edmonds 2007, Basu 1999, Psacharopoulos 1997).

Theoretically, in the aftermath of natural disasters, households can alter their investment in children's human capital in both positive and negative ways. In developing countries, labor markets are usually quite imperfect and large reductions in income levels may lead households to shift their children out of schooling activities toward work. In addition, the disaster can reduce the quality of education through the destruction of public infrastructure (e.g., schools and roads) or the damage of complementary resources (e.g., teachers and textbooks). This decrease might reduce the demand for schooling. Conversely, if labor-market wages fall as a result of the slowdown in the economy, natural disasters can induce households to keep their children in school through a reduction in the relative price of schooling (Skoufias 2003, Ferreira and Shady 2009, Baez; de La Fuente; and Santos 2010). The net effect of natural disasters on a household's investment in children's human capital depends on the relative importance of all these effects and can only be assessed empirically. Some recent empirical evidence has shown mixed results of natural disasters on schooling outcomes (Cuaresma 2010, Hermida 2010, Santos 2010, Portner 2008, Baez and Santos 2007) and in general, negative impacts on child labor (Santos 2010, Baez and Santos 2007).

The current paper exploits heterogeneity in the magnitude of Tropical Storm Stan exposure across Guatemalan departments to study the impact of the natural disaster on child time allocation. This paper makes three main contributions to existing empirical literature. First, it uniquely identifies the short-term impact of a large-scale climate event in a developing country by means of a direct measure of shock exposure collected by a nationally representative household survey six to twelve months after the shock. The inclusion of questions related to a specific large-scale natural disaster in a national household survey is a rare feature and not a common practice observed in the literature. Additionally, measures of exposure that come from household surveys can be considered more reliable than those that come from administrative data. Taking advantage of the rich information provided by the survey, the analysis performed in this paper makes an effort to shed some light on the mechanisms by which natural disasters affect children's time allocation. Furthermore, to strengthen the robustness of the analysis performed, the study also incorporates an external administrative measure of exposure that captures the direct value of damages caused by the storm in each department of Guatemala.

Second, existing literature on the microeconomic impact of natural disasters has paid little attention to the differential effects of these events on children's schooling and child labor by age. The emphasis on differential impacts by child age is important in understanding human capital investment, in particular in Latin America where schooling dropout rates increase significantly at the transition between primary and secondary education (Cunningham et al. 2008). Unlike previous studies, the present paper pinpoints the impact of a natural disaster on two groups of children defined on the basis of the educational level they would normally be enrolled at for their age.[3] Third, the incidence of child labor in Guatemala is relatively high compared to other countries in the region. The question explored in this study contributes to a broader concern in Guatemala: what policies might be best to reduce children's work?

Results suggest that child labor is an important part of family self-insurance strategies. Findings also highlight the great deal of heterogeneity by gender and age in how child time allocation was impacted. On the one hand, households coped with Tropical Storm Stan by

[3] Edmonds (2007) highlighted the importance of taking into account schooling ages in child labor studies.

increasing child labor for children aged 13 to 15. In more affected departments, older boys were more likely to be engaged in paid market work and less likely to be enrolled in school while older girls were more likely to be engaged in unpaid agricultural work. By contrast, results suggest that households' protected younger children aged 7 to 12. Findings are robust to alternative specifications, including an instrumental variable strategy.

2. Aggregate Shocks and Human Capital

This paper is broadly related to a body of research that questions how aggregate shocks affect child human capital in developing countries. Many studies have considered the impact of aggregate economic shocks caused by macroeconomic crises on schooling outcomes, finding mixed results. For instance, studies performed in poor countries of Africa and Asia reported evidence that educational outcomes are pro-cyclical – i.e., school enrollment falls during recessions. Conversely, studies performed in middle-income countries of Latin America found that educational outcomes are generally counter-cyclical – i.e., school enrollment rises during recessions (Duryea and Arends-Kuenning 2003; see Ferreira and Shady 2009 for a detailed review).

A growing number of economic studies have explored the impact of aggregate economic shocks caused by natural disasters on children's schooling and child labor. This paper significantly adds to the existing literature by reporting the short-term impact of a large-scale climate event. At least two other studies have investigated the short or medium-term impact of two specific natural disasters in Latin America. Baez and Santos (2007) considered the medium-term impact of Hurricane Mitch in Nicaragua to report that labor force participation increased for children aged 6 to 15 living in affected areas. Nonetheless, the authors did not find an impact on school enrollment. Santos (2010) explored the short-term impacts in rural areas of the two 2001 earthquakes in El Salvador. The author found that rural children aged 6 to 15 who where highly exposed to the shocks became less likely to attend school and work. However, when the author explored the effect of the earthquake by type of work, she found that the probability of working outside the household increased for children living in affected areas.

An area of interest in economic literature has explored the long-term impacts of climate or geologic events on schooling. Maccini and Yang (2009) examined the effect of rainfall shocks around the time of birth on adult education to find that Indonesian women exposed to 20 percent higher rainfall (relative to normal local rainfall) attained more schooling. Hermida (2010) studied the effects of the 1976 Guatemalan Earthquake on adults' education attainment to find a reduction of schooling for the cohort of adults exposed to the disaster.

Others studies have investigated the impact of disaster risks on educational attainments. Portner (2008) combined data on hurricanes in Guatemala over the last 120 years with the 2000 Guatemalan Living Standards Measurement Studies (LSMS) survey to find that the educational attainment of adults aged 20 to 69 increases with the propensity to suffer from hurricanes.[4] Results from Porter (2008) also corroborated findings that human capital might be less prone to destruction by natural catastrophes than physical capital. Therefore, rational individuals would shift their investment toward human capital due to lower expected returns in physical capital. In contrast, Cuaresma (2010) reported a strong negative impact, across several countries, between the propensity to suffer geologic disasters and secondary school enrollment rates.

3. Conceptual framework

In developing countries where credit markets function very poorly, most of the financial investment in education has to be funded by the family (Banerjee 2004). Hence, both parental

[4] The hurricane risk measure is calculated as the percent probability of an hurricane occurring in a year, based on events from 1880 to 1997 (Porter 2008).

preferences and family wealth matter for educational investment. Drawn from a model outlined by Edmonds, Pavcnik, and Topalova (2010), this section presents a simple conceptual framework that illustrates how investment in education can be affected by natural disasters in a world where educational investment is largely financed by the family.

Consider a household with one adult, one child, and a single-family decision maker. A child could either work or acquire education at the school. A family sends the child to school if the utility from schooling is higher than the utility from not sending the child to school. Denoting the household income when the child is not in school as y_{ns} and the vector of consumer prices as p, the utility from not sending the child to school is given by $U(\mathrm{y_{ns}},0) = \mathrm{V}(\mathrm{y_{ns}},\mathrm{p})$ where $V(.)$ is the indirect utility associated with income y_{ns} at prices p.

Denote y_s as the net household income when the child is enrolled in school. y_s is the household income net of the child's economic contribution to the household w^* and direct/indirect schooling costs c (e.g., books, clothing, and transportation costs). Therefore, $y_s = y_{ns} - w^* - c$. Additionally, denote r as the linear rate of return of education and α as the family's weight on the child's return to education. It is assumed that the family views the return to schooling as a contribution to the child's future welfare and treats it as additively separable from current consumption.[5] The utility from schooling the child is given by $U(y_s, s) = V(y_{ns} - w^* - c, p) + \alpha r$.

Therefore, the probability of being enrolled in school is given by the following expression:

[5] The model implicitly assumes the existence of credit constraints, which prevent families from borrowing against future returns on education. This assumption is in line with the economic framework of Guatemala.

$$\begin{aligned}\Pr(s=1) &= \Pr\left(V(y_{ns} - w^* - c, p) + \alpha r + e_s \geq V(y_{ns}, p) + e_{ns}\right) \\ &= \Pr\left(e_{ns} - e_s \leq V(y_{ns} - w^* - c, p) + \alpha r - V(y_{ns}, p)\right)\end{aligned} \tag{1.1}$$

where e_{ns} and e_s are i.d.d stochastic terms. Assuming $\mu = e_{ns} - e_s$ with mean zero, cdf $F(\mu)$ and strictly positive density $f(\mu)$. Equation 1.1 can be written as:

$$\Pr(s=1) = F\left(V(y_{ns} - w^* - c, p) + \alpha r - V(y_{ns}, p)\right) \tag{1.2}$$

Differentiating equation 1.2, it is possible to explore the determinants of changes in school participation:

$$d\Pr(s=1) = f(u)\left(\underbrace{\left[\frac{\delta V_s}{\delta y} - \frac{\delta V_{ns}}{\delta y}\right]dy_{ns} + \left[\frac{\delta V_s}{\delta p} - \frac{\delta V_{ns}}{\delta p}\right]dp}_{(i)} + \underbrace{\alpha dr}_{(ii)} - \underbrace{\frac{\delta V_s}{\delta y}dc}_{(iii)} - \underbrace{\frac{\delta V_s}{\delta y}dw^*}_{iv}\right) \tag{1.3}$$

where $V_s = V\left(y_{ns} - w^* - c, p\right), V_{ns} = V\left(y_{ns}, p\right)$, and $\frac{\delta V_s}{\delta y} > \frac{\delta V_{ns}}{\delta y} > 0$.

The economic impact of a natural disaster consists of direct consequences on the local economy (e.g., damage to crops, infrastructure, and housing) and indirect consequences (e.g., loss of revenue, unemployment, and market destabilization). When a natural disaster hits a country, following equation 1.3, schooling may decline if: (i) the destruction of human and physical capital worsens living standards, (ii) the decline of school quality (e.g., school or material damages or reduction in public expenditures) reduces returns to education, (iii) the destruction of roads or school materials (e.g, textbooks) increases education costs. Conversely, (iv) schooling may increase if natural disasters reduce earnings opportunities of children through a slowdown in the economy. Ultimately, the net effect of natural disasters on child schooling depends on the relative strength of all these channels.

4. Data

4.1 Guatemalan Living Standards Measurement Studies survey

This paper uses the 2000 and 2006 Guatemalan Living Standards Measurement Studies (LSMS) developed by the World Bank and the Guatemalan Statistics Bureau (INE). The LSMS survey is a repeated cross-sectional survey with national coverage. There are some differences in the survey design between the 2000 and 2006 datasets. Nonetheless, the survey sampling-weights include factors of adjustment to account for changes in subsampling. Following the approach in Angrist and Kugler (2008), results in this study are weighted using survey sampling-weights to account for differences in survey design.[6]

The LSMS dataset is a comprehensive household survey that includes information on individual demographics for all family members, such as education, employment, activity status, and income. The 2006 LSMS survey was conducted six to twelve months after Tropical Storm Stan, allowing identification of its short-term impact. The survey included a detailed module related to Tropical Storm Stan, collecting information on the following: (i) whether households were affected by the disaster; (ii) whether the disaster produced a loss of dwellings, crops, business, animals, goods, or family members; (iii) whether households received aid in cash or goods as well as the source of the relief; and (iv) whether households were able to compensate for the welfare loss.

4.2 Preliminary Descriptive Statistics

The outputs of interest are children's schooling and labor participation. School enrollment is used as a measure of schooling participation, while being involved in economic work in the

[6] There are two main differences between the sampling in both surveys. First, the sample size increased in 2006. Second, the 2000 sample was drawn from the 1994 census, while the 2006 sample was drawn from the 2002 census. The Colombian data used by Angrist and Kugler (2008) presented the same sampling differences. The authors used sampling weights to account for these differences.

previous week is used as a measure of labor participation.[7] The analysis focuses on two groups of children who differ in terms of the educational level they would normally be enrolled at for their age: (i) children aged 7 to 12 who should be enrolled at primary school and (ii) children aged 13 to 15 who should be at the transition between primary and middle school.[8] Additionally, throughout the analysis the sample of children is divided by gender because gender might play an important role in the decision whether to attend school or participate in labor activities.

Table 1.1 reports descriptive statistics on schooling and child labor by gender and age groups in 2000 and in 2006. For all children, school enrollment improved between 2000 and 2006. School enrollment of girls aged 7 to 12 increased from 79.5 to 89.2 percent, while school enrollment of boys aged 7 to 12 increased from 84.6 to 90.9 percent. Not surprisingly, enrollment rates for older children who are supposed to be at the transition levels of education are lower, meaning that schooling dropout rates increase significantly after the age of 12. Between 2000 and 2006, school enrollment of girls aged 13 to 15 increased from 57.3 to 65.4 percent, while school enrollment of boys aged 13 to 15 increased from 63.7 to 72.1 percent.[9] Education is mostly public, and walking to school is the main means of transportation. Overall, the distance to school was less than 21 minutes both in 2000 and 2006.

Child labor slightly decreased between 2000 and 2006. Child labor is higher for boys than girls and work participation increases with age. About 18 percent of boys and less than 10

---

[7] Economic work activities include wage workers, self-employers, and unpaid workers.
[8] In Guatemala, Article 74 of the Constitution establishes that pre-primary, primary (first to sixth grade), and basic education (seventh to ninth grade) should be compulsory and free. The legal age to start pre-primary school is five or six years old. The legal age to start primary school is seven years old, but almost 15 percent of children normally delay entry into first grade. Children may complete their compulsory education between the ages of 15 and 18 (Bureau of International Labor Affairs 1998, World Bank 2009). The Guatemalan Constitution and the national Labor Code set the basic minimum age of work at 14 years (ILO et al. 2003).
[9] According to the 2000 and 2006 LSMS surveys, the main reason for not being enrolled in school for both groups of children is a lack of income or the necessity of working (almost half of children aged 6-12 and more than half of children aged 13-15 are not enrolled in school). It is worth emphasizing that a substantial proportion of children reported as not being enrolled in school cite lack of interest as the reason (results not shown).

percent of girls aged 7 to 12 worked in 2000 and 2006, demonstrating how relevant child labor is in Guatemala. Labor outcomes are considerably higher for the group of older children. More than 50 percent of boys and almost one third of girls aged 13 to 15 worked in 2000 and 2006. In general, children aged 7 to 12 are unpaid workers. Most male workers were engaged in agriculture activities, while girls worked both in agricultural and market work. Among those children aged 13 to 15 engaged in the labor market, about 40 percent participated in paid work. Older boys were more likely to be involved in agriculture activities, while girls were more likely to participate in market activities.[10]

In general, children work a substantial number of hours per week. Children worked 20 hours or more per week, though hours of work decreased between 2000 and 2006. Total hours worked were higher among children aged 13 to 15, who work for pay or in market activities (results not reported). Lastly, the relative importance of child labor income to total household labor income varies by age and gender. On average, paid workers aged 7 to 12 contributed to the total family labor income about 0.2 to 0.3 percent in 2000. As expected, the monetary contribution of an average paid worker aged 13 to 15 is higher. Furthermore, the monetary contribution of older boys (5.8 percent in 2000) doubles the monetary contribution of girls (2.8 in 2000).

5. Economic Framework and Tropical Storm Stan

Disaster risk analyses distinguish three important factors contributing to a disaster: (1) the vulnerability of the population, (2) the natural disaster event per se, and (3) the amount of population exposed to the event (Stromberg 2007). Section 5.1 discusses the first factor contributing to a disaster, while section 5.2 focuses in the remaining two factors.

---

[10]According to the 2000 and 2006 LSMS surveys, the majority of children working in market activities are engaged in commerce or manufacturing industries. The most common employment status for all unpaid working children is family worker (results not reported).

5.1 Economic Framework

Countries' economic and social development influences their resilience in dealing with natural shocks. The Tropical Stan emphasizes the country's level of vulnerability and the limited capacity to address the aggregate catastrophe. Guatemala is one of the poorest countries in Latin America; 56 and 51 percent of the population was poor in 2000 and 2006, respectively. In addition, social protection policies in the country did not function as an integrated system when the storm struck the country. Indeed, almost 85 percent of the Guatemalan population remained uninsured in 2006 and the social protection system was comprised by a large number of small, uncoordinated programs, which lacked adequate monitoring mechanisms (The World Bank 2009). As Ferreira and Robalino (2011) argued, poor integration among individual social assistance programs limits their insurance capability to shocks.

The effects of meteorological events have a strong impact on the Guatemalan economy given the country greater reliance on agriculture. Agriculture was the main source of employment (about 30 percent) in 2000, as well as being the sector with the lowest average earnings. Its relative importance modestly declined between 2000 and 2006, favoring manufacturing, commerce, construction, and services sectors. Additionally, a high level of informality characterizes the labor market. For instance, almost 75 percent of the workers were informal in 2004. Moreover, child labor is a historical phenomenon in Guatemala. The country ranks first in terms of child labor among the 10 Latin American countries where International Labor Office's (ILO's) statistics are available (see figure A.1 in appendix A). Estimations from ILO report that 23.4 percent of children aged 5 to 17 participated in the labor force in 2000.

5.2 Tropical Storm Stan

Tropical Storm Stan devastated Guatemala during the first ten days of October 2005. The 10-days of continuous torrential rains, adding to the soil saturation of the rainy season, caused catastrophic flooding and mudslides. Farmland, homes, even entire communities were swept away. The storm proved to be one of the most devastating since Hurricane Mitch struck the region in 1998. On October 6th, 2005, the government declared a state of national emergency, requesting international support. On October 22nd, 2005, the Guatemalan National Agency for Disaster Relief (CONRED) estimated that over 1,500 people had died or disappeared, 42,941 people were temporally displaced to shelters, 738 school classrooms suffered partial damage and 26 percent of the paved road network in the country was damaged (ECLAC 2005).

Based on the information collected by the 2006 LSMS survey, 23 percent of the population was negatively impacted by Tropical Storm Stan (see table 1.2). The large number of people affected by the shock contrasts with the proportion of the population who received relief in cash or goods from the government or other institutions. Within six to twelve months after the shock, only 3.3 percent of the population received any kind of assistance to mitigate the negative impacts of the storm. The type of damage most reported by households was crop loss (15.6 percent) and loss of dwellings (7 percent). Other damages suffered by households were loss of goods (3.2 percent), loss of livestock (3.1 percent), loss of family members (1.8 percent), and loss of business (1.2 percent). Lastly, only 7.1 percent of the population was able to completely recover from the economic impact of Tropical Storm Stan.

Tropical Storm Stan hit the country with differing intensity. Figure 1.1 and columns 2 through 5 in table 1.2 illustrate the great variability of shock exposure across Guatemalan departments. For instance, on average 55.2 percent of the population was severely affected by the storm in the relatively more affected departments, while 8.5 percent of the population was negatively impacted in the relatively less affected departments.

6. Empirical Identification Strategy

The empirical identification strategy relies on the fact that Tropical Storm Stan affected the departments of Guatemala with differing intensity, with some departments exposed significantly more than others. Identification comes from comparing, before and after Tropical Storm Stan, the schooling and labor participation of similar children in departments that experienced high and low damages as a result of the storm.[11] The department-level panel dimension of the LSMS Guatemalan data generates the variation used to identify the effects of the storm on schooling and child labor.

I use two different department-level intensity measures that directly capture the amount of damage caused by Tropical Storm Stan. Table A.1 in appendix A shows these measures by department. The first measure is the percentage of population affected by Tropical Storm Stan in each department and is based on the direct information collected by 2006 LSMS survey 6 to 12 months after the shock. The second measure was estimated by ECLAC almost 20 days after the shock and is based on information from local organizations and Guatemalan government ministries. This second measure refers to the ratio between the value of economic damages due to the storm and the GDP in each department. The value of economic damages was calculated as the sum of social damages (dwellings, health, and education), productive damages (agricultural, trade, tourism, and industry), infrastructure damages (water and sanitation, electricity, and transportation), and environmental damages. The use of intensity measures based on two sources of data (i.e., 2006 LSMS and ECLAC dataset) strengthens the robustness of the analysis

[11] For a similar identification strategy see Akresh, Lucchetti, and Thirumurthy (2011); Edmonds, Pavcnik, and Topalova (2010); Akresh and de Walque (2010); and Duflo (2001).

performed in this paper. As expected, the two intensities measures are highly correlated – i.e. the correlation of the two measures for the sample of children aged 7 to 15 is 0.9.

The baseline specification estimated is:

$$Y_{ijdt} = \lambda_d + Year\ 2006_t + \beta\left(Intensity\ Measure_d * \ Year\ 2006_t\right) + X_{ijdt}^{'}\delta + \varepsilon_{ijdt} \quad (1.4)$$

where Y_{ijdt} denotes the outcome of interest (child labor or schooling) for individual *i* in household *j* and department *d* at period *t*. λ_d are department fixed effects that control for time-invariant department characteristics, such as endowments, schooling facilities, and geography. $Year\ 2006_t$ is a binary variable that indicates children surveyed in year 2006, after the storm occurred. This year fixed effect controls for the average changes in the outcome of interest across all departments between 2000 and 2006. $Intensity\ Measure_d$ refers to the two department-level intensity measures described above (i.e., percentage of population affected by Tropical Storm and the ratio between the value of economic damages due to the storm and the GDP in each department). All regressions also control for a vector of individual characteristics X_{ijdt} that are not affected by the shock but that are likely to affect household choices of child activity, such as a child's gender, age, ethnic group, area of residence, and household head's gender, age, and education. ε_{ijdt} is a random, idiosyncratic error term. Standard errors are clustered at the department-level to allow for correlation across households within a department. The parameter of interest β measures the impact of Tropical Storm Stan on child labor and schooling and is identified under the assumption that unobserved department time varying shocks that affect schooling or child labor are uncorrelated with any of the two department-level intensity measures.

As a robustness test, I address two potential concerns. First, I contemplate the possibility that the department-level intensity measure that comes from ECLAC might potentially be estimated with error (Albala-Bertrand 1993). Second, I contemplate the possibility that intensity measures might be endogenous if they are correlated with departmental trends in child labor and schooling. Given the intensity of the rain and the fact that the LSMS survey was carried out only 6 to 12 months after the storm, this type of bias is less likely to occur. However, to address these two potential concerns I use cumulative rainfall data, registered between the first and tenth day of October in each department, as an instrumental variable for the department-level intensity measures. Departments with higher rainfall are more likely to experience higher damages. This strategy assumes that the amount of rainfall had no impact on children's human capital other than through the impact of Tropical Storm Stan. Daily historical rainfall data for weather stations comes from the Guatemalan Seismology, Volcanology, Meteorology, and Hydrology Bureau (INSIVUMEH). Due to the lack of latitude and longitude information for the household sample in the 2006 LSMS data, it is not possible to match each household to the closest weather station. Consequently, this paper uses the location information of the weather stations to match each department represented in the LSMS. I matched a total of 20 stations with the LSMS departments. Rainfall data is missing for Totonicapán and Suchitepéquez, because these departments do not have stations.

7. Empirical Results

7.1 Main findings

Tables 1.3 and 1.4 report the main results of the paper; table 1.3 presents the results for the group of children aged 7 to 12, while table 1.4 shows the results for the group of children aged 13 to

15.[12] Table 1.3 shows no substantial impact of Tropical Storm Stan on the probability of being enrolled in school or working for the group of children aged 6 to 12.[13] In line with these results, Baez and Santos (2008) did not find any impact of Hurricane Mitch on children's schooling for children aged 7 to 15. To further explore the effects of the shock in labor participation, table A.2 in appendix A reports the impact of Tropical Storm Stan by type of work. There is an indication that Tropical Storm Stan affected the composition of work for boys. Both intensity measures show that paid work decreased for boys after the storm in departments highly affected by the storm, a reduction that was distributed between paid and unpaid agricultural work and unpaid market work.

A different story is observed when exploring the impact of Tropical Storm Stan on the schooling and labor participation of children aged 13 to 15. Panel A of Table 1.4 shows a negative and statistically significant impact of the storm on school enrollment, independent of the department level intensity measure used. Boys mainly drive the observed decline in school participation, although the equality between boys' and girls' coefficients cannot be rejected. An increment of the population affected by one percent reduces boys' school enrollment by 0.374 percent, while an increment of the value of economic damages by one percent of GDP reduces boys' schooling participation by 0.967 percent. The indicator for Year 2006 is always positive and significant, showing that educational participation increased between 2000 and 2006, nationally.

[12] Each intensity measure in this paper represents a separate regression. Additionally, all regressions in this paper control for a child's gender, age, ethnic group, area of residence, and household head's gender, age, and education. All coefficients of these controls have the expected sign. Tables A.8 and A.9 in appendix A report coefficients of these controls using as intensity measure the percentage of population affected by Tropical Storm. Results are similar when using as intensity measure the ratio between the value of economic damages due to the storm and the GDP in each department (results not reported).

[13] Results are similar when examining the relationship between shock intensity and the joint probability of being enrolled in school and working (results not reported).

How large are these effects? Based on measure 1, the proportion of the population affected by the storm in each department ranges between 60.1 and 1.7 percentage points and the weighted average is 22.7 percent (see table A.1 in appendix A). For instance, in departments experiencing the average shock intensity, the probability of a boy being enrolled in school falls by 8.4 (0.374*22.7) percent compared to the increase of 15.6 percentage points observed in the national trend. Based on measure 2, the value of economic damages as a percentage of the GDP in each department varies between 34.9 and zero percentage points, and the weighted average is 6.3 percent (see table A.1 in appendix A). For instance, in departments experiencing the average shock intensity, the probability of a boy being enrolled in school falls by 6.0 (0.967*6.3) percent compared to the increase of 13.0 percentage points observed in departments with no economic damages.

Panel B of table 1.4 suggests Tropical Storm Stan increased child labor. The coefficients are always positive and statistically significant. How large are these effects? For instance, in the department experiencing the average value of the population affected by the shock, the probability of being engaged in labor activities increased by 7.3 (0.323*22.7) percent compared to the 10.6 percentage point decrease observed in the national trend. The table shows some evidence that both boys and girls increased their labor participation after the storm in departments highly affected by the shock. Point estimates are higher for boys than girls, although the equality of coefficients cannot be rejected.

Table 1.5 provides further evidence of the impact of the storm by examining the relationship between the intensity of the shock and the joint probability of being enrolled in school and working by gender. Panel A in the table suggests that Tropical Storm Stan increased girls' labor without reducing their schooling participation. On the contrary, panel B suggests that schooling and labor are almost substitutes for boys; Tropical Storm Stan increased boys' labor and reduced their school enrollment.

The possibility of a working child attending school may depend on the type of work in which they are engaged. Table 1.6 shows the impact of the storm on child labor, for children aged 13 to 15, by type of work and gender.[14] Results suggest that Tropical Storm Stan increased the likelihood of girls being engaged in unpaid agricultural activities. These results suggest that the increase of girls' labor activities is operating mainly through home-based agricultural businesses, which does not directly increase household income. For boys, the shock is associated with a higher likelihood of working in paid market activities, suggesting that boys are more involved in income-generating activities after the storm in departments highly affected by the shock.

Previous results showed that not all children experienced the negative impact of Tropical Storm Stan equally. Table 1.7 extends the analysis to examine the heterogeneity of Tropical Storm Stan by child's area of residence.[15] A fully interacted model is estimated and the triple interaction coefficient indicates the differential impact of Tropical Storm Stan on children's schooling and labor participation for children living in urban areas. There is some evidence that exposed girls aged 13 to 15 residing in urban areas are more likely not to be enrolled in school than their exposed peers residing in rural areas. Although the triple interaction coefficient suggests that the impact of the storm on child labor is lower for girls aged 7 to 12 living in urban areas, the net impact on work participation for this group of girls is zero. On the other hand, the

[14] As in previous analysis, results in table 1.5 and 1.6 were estimated using linear probability models.
[15] According to the LSMS surveys, 61 and 52 percent of the population lived in rural areas in 2000 and 2006, respectively.

triple interaction for boys is not statistically significant, suggesting that the impact of Tropical Storm Stan was similar for boys living in both urban and rural areas.

7.2 Robustness Check

Migration across departments after the shock may bias previous results. First, shock exposure is based on a child's current department of residence. Therefore, if a child resided in a different department during the storm, I would incorrectly determine a child's exposure to the shock (Akresh et al. 2011). Second, migration across departments might not be random. For example, it might be the case that households with a greater propensity to educate their children were more likely to migrate from departments more heavily hit by the shock to departments less affected by the storm, which would over-estimate the impact of the storm. Nonetheless, results suggest that selective migration might not be a significant concern. Permanent out of department migration is very low; the 2006 LSMS survey shows that 98.4 percent of children aged 7 to 15 belonged to households that had lived in the same place of residence for more than one year. Moreover, among the 1.6 percent of children aged 7 to 15 who lived in households that migrated within the previous year, 46.5 percent (i.e., 0.7 percent of the Guatemalan population) seem to have migrated within the same department.[16] To further check the robustness of the findings in the previous section, table 1.8 reports results restricting the sample to children whose families lived in their current place of residence during Tropical Storm Stan. If children of migrant households were systematically different than children in non-migrant households, then excluding these migrant households from the regressions should change the estimated impact of

[16] The later number was estimated using the information provided by the 2006 LSMS survey about the department where the household was located in 2001. Additionally, according to the 2006 LSMS survey, among the 1.6 percent of children aged 7 to 15 who lived in households that migrated within the previous year, only 10.5 percent reported having been affected by Tropical Storm Stan. This result suggests that Tropical Storm Stan might not be the main reason for migration for most of these families. Furthermore, ECLAC reported about 20 days after Tropical Storm Stan that around 0.7 percent of the Guatemalan population was displaced to temporary shelters within the departments.

the shock (Akresh et al. 2011). Result in the table shows that the magnitude of the impact and its level of statistical significance are consistent with the non-restricted sample, providing evidence of no bias due to migration.

Furthermore, I contemplate the possibility that department-level intensity variables could be measured with error or be correlated with departmental trends in child labor and schooling. I use cumulative rainfall data, registered between the first and tenth day of October, as an instrumental variable for the department-level intensity measures. Rainfall data is missing for two departments. To maintain a consistent sample with the instrumental variable regressions, table 1.9 also reports OLS estimates, restricting the sample to those departments that have rainfall data. OLS estimates are consistent with the non-restricted sample presented in tables 1.3 and 1.4. Though more precise, instrumental variable estimates in table 1.9 confirm previous results. For children aged 7 to 12, there is some evidence that girls increased their labor participation, although coefficients are statistically significant only at the 10 percent level. For children aged 13 to 15, Tropical Storm Stan had a negative impact on boys' schooling and increased labor participation for both girls and boys.

Table A.3 in appendix A reports first stage regressions of the IV estimations. Cumulative rainfall is a highly significant predictor of each department-level intensity measure. Overall, F-statistics for the test of the excluded instrument significance are well above the critical values for weak instruments, implying that the first stage has good power and the instrument is not weak. Furthermore, Table A.4 in appendix A shows the reduced-form estimates. Consistent with the main findings, there is no evidence that cumulative rainfall affects schooling or labor participation of children aged 7 to 12. For children aged 13 to 15, an increment of cumulative rainfall by 100 millimeters reduces boys' school enrollment by 2.3 percent and increases child labor by 1.8 and 2.6 percent for girls and boys, respectively.

7.3 Discussion of the likely mechanisms

The conceptual framework in section 3 highlights several mechanisms by which Tropical Storm Stan might affect child time allocation. The declines in living standards triggered by the damages caused by Tropical Storm Stan in each department seem to be largely driving the observed changes in schooling and labor participation for children aged 13 to 15.

Tables 1.10 and 1.11 explore this point using department-level intensity measures that disaggregate the damages/losses suffered by the population due to the storm.[17] Damages/losses in the table are not mutually exclusive. As in the previous analysis, each intensity measure represents a separate regression. Loss of crops is the main damage caused by the storm, on average 46.2 percent of the population suffered loss of crops in the relatively more affected departments, while 4.1 percent of the population suffered loss of crops in the relatively less affected departments (see table 1.2).

The evidence reported in table 1.11 confirms that declines in living standards caused by loss of crops induced boys aged 13 to 15 to reduce school enrollment and increase market work. On the contrary, table 1.10 reported that girls aged 13 to 15 did not reduce school enrollment. However, crop damages are associated with an increase in a girl's probability of working in unpaid agricultural activities, which are mostly family work. Family work may indirectly contribute to household income by increasing home production of goods or by allowing adults to increase their labor supply. Table A.6 in appendix A shows no evidence in favor of an increase

[17] Table A.5 in appendix A shows these measures by department. The proportion of the population in each department that suffered damages/losses of: (1) crops varies between 53 and 0.8 percentage points, (2) dwellings varies between 17.2 and 0.8 percentage points, (3) goods varies between 12.4 and 0 percentage points, (4) livestock varies between 11.6 and 0 percentage points, (5) family members varies between 6.6 and 0 percentage points, and (6) businesses varies between 2.6 and 0 percentage points.

in adults' labor participation due to Tropical Storm Stan.[18] Hence, it seems unlikely that the increase in girls' work favored adult labor supply.

Some additional evidence is also consistent with the decline in living standards hypothesis. Tables 1.10 and 1.11 also support the hypothesis that a decline in living standards triggered by loss/damage of dwellings, goods, livestock, or business increased the probability for older girls to be engaged in unpaid agriculture activities. For boys, coefficients in column 1 of table 1.11 also suggest that a decline in school participation is associated with dwelling, good, and livestock losses/damages. Moreover, column 2 shows that a decline in living standards triggered by loss/damage of dwellings and goods increased the probability of older boys being engaged in work activities. This increment in labor participation of older boys caused by dwelling and good losses/damages was distributed among the four types of work activities (i.e., paid and unpaid agriculture work and paid and unpaid market work). It is worth emphasizing that the loss of a family member did not affect child time allocation for either boys or girls.

In addition, lower living standards can force households to remove children from school if there are direct costs associated with sending children to school or if children are required to contribute to family income (Edmonds, Pavcnik, and Topalova 2010). Table A.7, columns 1 to 3 in appendix A, examines the impact of Tropical Storm Stan on schooling expenditures for children aged 13 to 15 enrolled in school.[19] Educational expenditure includes fees, books, materials, uniforms, and transportation costs. There is some evidence indicating that households reduced boys' educational expenditure in more affected departments after the storm. This

[18] The regression was run on the sample of adults living in households with children aged 7 to 15 years old. In addition, the regression included controls for adult's gender, age, ethnicity and place of residence, an indicator that denotes whether the adult is the household head, and household size. Similar evidence is found when the regression is run separately by gender.

[19] Educational expenditure is expressed in real value, where nominal expenditure is deflated by the Guatemalan consumer price index. Results are estimated using Selection MLE models, where the first-step participation equation determines whether the child is enrolled in school and the second-step outcome equation determines a child's educational expenditure. Similar results are obtained when using OLS estimations.

evidence, together with the findings reported for school participation for older children in table 1.4, suggests that Tropical Storm Stan induced households to reduce the direct cost of schooling for boys aged 13 to 15.

Furthermore, if Tropical Storm Stan is associated with an increase in children's wages, schooling of older children might decline. However, there is no evidence that the shock had an impact on child formal labor market wages, suggesting that changes in wages were not responsible for the results observed for older children. Column 4 to 6 in Table A.7 in appendix A examines the impact of Tropical Storm Stan on the logarithm of a child's hourly wages for employed children, finding no significant results.[20]

Lastly, it seems unlikely that the declines in school participation for older boys reflect changes in return to education caused by a reduction in school infrastructure quality due to the shock. School infrastructure was likely to be affected by the storm (for instance, ECLAC (2005) estimated that Tropical Storm Stan destroyed 25 schools and damaged 732 classrooms around the country). One would expect that the reduction of school infrastructure quality should homogeneously affect all children, independently of their age and gender. However, results observed for older boys are not consistent with this hypothesis.

8. Conclusion

In this paper, I explored the extent to which Tropical Storm Stan affected child labor and children's schooling. The identification strategy exploited the timing and geographical variation in the intensity of the shock across department in Guatemala. The findings emphasize the differential impact of the shock by children's gender and age. Results are consistent with the

---

[20]Child hourly wage is expressed in real value, where nominal hourly wage is deflated by the Guatemalan consumer price index. Results are estimated using Selection MLE models, where the first-step participation equation determines whether the child's work receives payment and the second-step outcome equation determines a child's hourly wages. Similar results are obtained when using OLS estimations.

hypothesis that exposed households used child labor of older children as a mechanism to cope with the declines in living standards triggered by the shock. Tropical Storm Stan significantly increased the probability of working for children aged 13 to 15, and the effect was higher for boys. Schooling participation decreased after the storm only for exposed boys aged 13 to 15, who were more likely to be engaged in market work that directly contributes to family income. On the contrary, the storm increased the probability that older girls were engaged in unpaid agricultural family work. Households appeared to protect younger children; results suggest that, in general, children aged 7 to 12 did not bear the burden of the disaster.

How substantive are the observed changes in time allocation? In recent years, a body of evidence established a negative relationship between child labor and later life outcomes, such as educational attainment and adult wages (see Edmonds 2007 for a comprehensive review). For instance, Beegle, Dehejia, and Gatti (2009) found that the mean level of child labor for Vietnamese children ages 8 through 13 attending school reduces educational attainment by 1.6 years five years later. Empirically, lower levels of education are associated with lower wages. Based on Beegle et al. (2009) estimations and the results discussed in this paper, I estimate the long-term consequences of Tropical Storm Stan. Inter-American Development Bank (2007) reported for Guatemala that the return to an extra year of education in 2004 was 12.4 percent. If Tropical Storm Stan is associated with an increase in child labor in the short-run and a decline of at least 1.6 years of schooling in the long run, wages in adulthood would be 19.8 percent lower for older children.

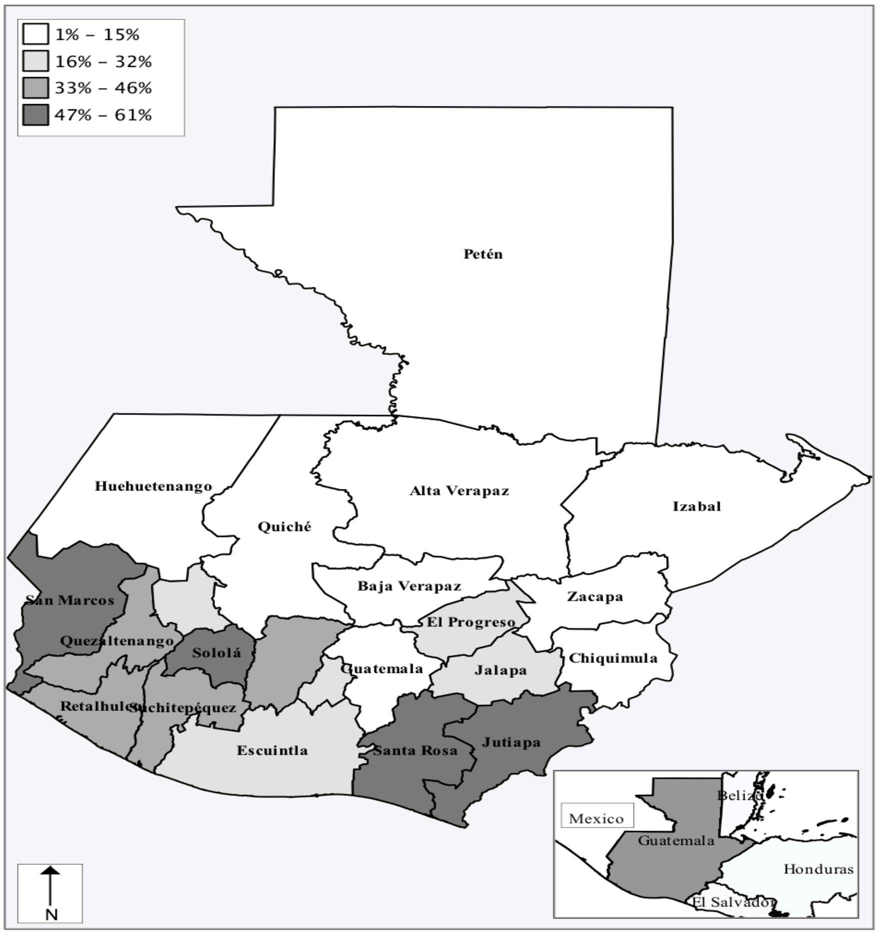
After natural disasters strike, knowledge and a better understanding of households' main coping strategies are crucial for setting priorities of public programs and safety nets (Skoufias 2003). The findings in this paper highlight that the decrease in human capital formation triggered by Tropical Storm Stan will have lasting impacts on children welfare. Exposed older children might enter adulthood poorly prepared for work. These negative impacts need to be addressed with educational and economic interventions (e.g., non-formal education initiatives or active labor market programs aimed at improving the quality of the labor force). Results also point towards a broader and deeper issue, the poor integration among individual social protection programs in Guatemala seems to limit their capability to protect households from Tropical Storm Stan. Because further increases in the number and intensity of severe weather events (Intergovernmental Panel on Climate Change 2007) are expected, policy attention strengthening social protection strategies in developing countries that increase household resilience to natural disasters seems highly merited.

In this regard, several developing countries in the last decades have shifted their national poverty alleviation strategies toward an innovation instrument called a Conditional Cash Transfer (CCT) program.[21] CCT programs target structurally poor families and provide monetary transfers conditioned on households investing in the health and education of their children. Scattered evidence indicated that CCT programs that were already in place had the potential to mitigate the effects of negative shocks in the human capital investment of targeted children (de Janvry et al. 2006, Maluccio 2005). Hence, further evidence evaluating the coverage expansion of CCT programs to households strongly affected by natural disasters deserves serious attention.

[21] In 2008, the goverment of Guatemala launched a Conditional CashTransfer program called "Mi Familia Progresa", which targeted extremely poor families with children aged 0–15 living in the 130 most vulnerable municipalities.

9. Figures and Tables

Figure 1.1: Guatemala Departmental Map Indicating the Population Affected by Tropical Storm Stan



Data source: Guatemalan 2006 LSMS survey.

Table 1.1
Child Labor and Schooling Statistics

	Female		Male	
	2000	2006	2000	2006
	[1]	[2]	[3]	[4]
Panel A: Children Aged 7-12				
Years of Schooling	1.5	1.8	1.6	1.7
School Enrollment	79.5	89.2	84.6	90.9
Enrolled in a Public School	69.4	76.0	74.1	77.8
Walk to School	73.0	78.2	75.7	78.8
Time in Min. to School	15.7	15.7	15.2	15.2
Work Participation	9.9	7.7	18.5	17.6
Paid Agriculture Work	0.7	0.2	1.4	1.0
Unpaid Agriculture Work	4.2	3.1	13.3	13.1
Paid Market Work	0.9	0.7	1.6	1.0
Unpaid Market Work	4.0	3.8	2.3	2.5
Weekly Hours of Work	29.3	18.3	29.5	20.0
Share of Child's Labor Income in Total Household's Labor Income (in %)	0.2	0.1	0.3	0.3
Panel B: Children aged 13-15				
Years of Schooling	3.8	4.7	4.4	4.7
School Enrollment	57.3	65.4	63.7	72.1
Enrolled in a Public School	42.7	47.7	49.0	52.8
Walk to School	48.4	48.2	53.6	52.2
Time in Min. to School	18.5	20.8	20.0	19.6
Work Participation	29.0	26.7	56.9	51.6
Paid Agriculture Work	2.3	1.3	11.1	8.2
Unpaid Agriculture Work	5.4	6.2	25.9	26.3
Paid Market Work	10.5	8.7	13.2	10.8
Unpaid Market Work	10.8	10.5	6.7	6.3
Weekly Hours of Work	44.6	30.1	42.1	32.3
Share of Child's Labor Income in Total Household's Labor Income (in %)	2.8	1.9	5.8	4.1

Source: Guatemalan 2000 and 2006 LSMS surveys.

Table 1.2: Tropical Storm Stan Descriptive Statistics based on 2006 LSMS Information

	National Level	By Department-intensity Interval			
		(61% - 47%)	(46% - 33%)	(32% - 16%)	(15% - 1%)
	[1]	[2]	[3]	[4]	[5]
Proportion of the Population Affected by Storm Stan	22.7	55.2	37.9	26.6	8.5
Proportion of the Population that Suffered Damage/loss of*:					
Crops	15.6	46.2	26.5	15.4	4.1
Dwelling	7.0	13.9	11.7	10.1	3.0
Goods	3.2	8.3	4.5	4.7	1.1
Livestock	3.1	6.9	6.9	5.1	0.5
Death of a HH. Member	1.8	3.0	1.2	2.9	1.3
Business	1.2	1.8	1.6	1.5	0.8
Proportion of the Population Receiving Assistance*:	3.3	9.2	6.3	6.2	0.2
In Goods	3.2	8.9	6.1	5.9	0.2
In Cash or Housing	0.6	1.2	1.1	1.7	0.0
From Government	2.2	5.8	3.8	4.7	0.2
From other Institutions	1.9	5.3	3.5	3.8	0.1
Proportion of the Population Recovered from Damage/loss of Income or Assets:	7.1	12.7	12.7	9.8	3.4

Note: (*) Answers are not mutually exclusive. Data source: Guatemalan 2006 LSMS survey.

Table 1.3: Measuring the Impact of the 2005 Tropical Storm Stan on School Enrollment and Work Participation for Children Aged 7 to 12

	Total [1]	Girls [2]	Boys [3]
Panel A: School Enrollment			
Measure 1:			
Affected Population (Ratio of Pop.) * Year 2006	-0.029	-0.007	-0.052
	[0.089]	[0.080]	[0.103]
Year 2006	0.081**	0.093***	0.071*
	[0.034]	[0.030]	[0.039]
Measure 2:			
Economic Damages (Ratio of GDP) * Year 2006	0.184	0.167	0.187
	[0.217]	[0.195]	[0.258]
Year 2006	0.063**	0.080***	0.047
	[0.025]	[0.023]	[0.029]
Panel B: Work Participation			
Measure 1:			
Affected Population (Ratio of Pop.) * Year 2006	0.056	0.063	0.053
	[0.067]	[0.062]	[0.094]
Year 2006	-0.024	-0.035	-0.014
	[0.016]	[0.024]	[0.017]
Measure 2:			
Economic Damages (Ratio of GDP) * Year 2006	0.168	0.138	0.206
	[0.118]	[0.111]	[0.172]
Year 2006	-0.022	-0.029	-0.015
	[0.014]	[0.020]	[0.015]
Demographics and HH. Controls	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes
N	18,377	9,038	9,339

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. Demographic controls include a child's age and an indigenous indicator. Households' controls include indicators for whether the child's household is located in an urban area, and controls for the gender, age and education level of the head of the child's household. "Affected Population (Ratio of Population)" comes from the Guatemalan 2006 LSMS survey and "Economic Damages (Ratio of GDP)" comes from the United Nations Economic Commission for Latin America and the Caribbean (ECLAC 2005). Each measure represents a separate regression. See section 6 for a definition of these intensity variables. Data source: Guatemalan 2000 and 2006 LSMS surveys.

Table 1.4: Measuring the Impact of the 2005 Tropical Storm Stan on School Enrollment and Work participation for Children Aged 13 to 15

	Total	Girls	Boys
	[1]	[2]	[3]
Panel A: School Enrollment			
Measure 1:			
Affected Population (Ratio of Pop.) * Year 2006	-0.208**	-0.069	-0.374**
	[0.084]	[0.073]	[0.149]
Year 2006	0.109***	0.076***	0.156***
	[0.028]	[0.026]	[0.037]
Measure 2:			
Economic Damages (Ratio of GDP) * Year 2006	-0.620***	-0.278	-0.967**
	[0.203]	[0.187]	[0.382]
Year 2006	0.099***	0.077***	0.130***
	[0.017]	[0.019]	[0.022]
Panel B: Work Participation			
Measure 1:			
Affected Population (Ratio of Pop.) * Year 2006	0.323*	0.219	0.417*
	[0.162]	[0.150]	[0.204]
Year 2006	-0.106**	-0.071	-0.135**
	[0.045]	[0.042]	[0.055]
Measure 2:			
Economic Damages (Ratio of GDP) * Year 2006	0.782*	0.652*	0.938
	[0.408]	[0.323]	[0.568]
Year 2006	-0.080**	-0.060*	-0.097**
	[0.036]	[0.032]	[0.044]
Demographics and HH. Controls	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes
N	8,005	3,961	4,044

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. Demographic controls include a child's age and an indigenous indicator. Households' controls include indicators for whether the child's household is located in an urban area, and controls for the gender, age and education level of the head of the child's household. "Affected Population (Ratio of Pop.)" measure comes from the Guatemalan 2006 LSMS survey and "Economic Damages (Ratio of GDP)" measure comes from the United Nations Economic Commission for Latin America and the Caribbean (ECLAC 2005). Each measure represents a separate regression. See section 6 for a definition of the intensity variables. Data source: Guatemalan 2000 and 2006 LSMS surveys.

Table 1.5: Measuring the Impact of the 2005 Tropical Storm Stan on the Joint Probability of Being Enrolled in School and Working for Children Aged 13 to 15

Dependent Variable:	Enrolled in School and Working	Enrolled in School but not Working	Not Enrolled in School but Working	Not Enrolled in School nor Working
	[1]	[2]	[3]	[4]
Panel A - Girls				
Measure 1 * Year 2006	0.156	-0.222	0.063	0.003
	[0.131]	[0.130]	[0.104]	[0.068]
Measure 2 * Year 2006	0.373	-0.644**	0.279	-0.008
	[0.308]	[0.285]	[0.256]	[0.148]
Panel B - Boys				
Measure 1 * Year 2006	0.095	-0.470**	0.322*	0.053
	[0.119]	[0.193]	[0.164]	[0.063]
Measure 2 * Year 2006	0.116	-1.084*	0.822**	0.146
	[0.292]	[0.551]	[0.391]	[0.141]
Year 2006	Yes	Yes	Yes	Yes
Demographics and HH. Controls	Yes	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes	Yes
N Girls	3,960	3,960	3,960	3,960
N Boys	4,044	4,044	4,044	4,044

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. Demographic controls include a child's age and an indigenous indicator. Households' controls include indicators for whether the child's household is located in an urban area, and controls for the gender, age and education level of the head of the child's household. Each measure represents a separate regression. See section 6 for a definition of the intensity variables. Data source: Guatemalan LSMS surveys 2000 and 2006.

Table 1.6: Measuring the Impact of the 2005 Tropical Storm Stan by Type of Work for Children Aged 13 to 15

Dependent Variable:	Paid Agriculture Work	Unpaid Agriculture Work	Paid Market Work	Unpaid Market Work
	[1]	[2]	[3]	[4]
Panel A - Girls				
Measure 1 * Year 2006	-0.007	0.192**	-0.02	0.055
	[0.028]	[0.075]	[0.064]	[0.118]
Measure 2 * Year 2006	0.059	0.368*	0.031	0.195
	[0.063]	[0.193]	[0.155]	[0.286]
Panel B - Boys				
Measure 1 * Year 2006	-0.018	0.081	0.272*	0.083
	[0.091]	[0.121]	[0.142]	[0.071]
Measure 2 * Year 2006	-0.021	0.083	0.768**	0.109
	[0.238]	[0.350]	[0.329]	[0.223]
Year 2006	Yes	Yes	Yes	Yes
Demographics and HH. Controls	Yes	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes	Yes
N Girls	3,960	3,960	3,960	3,960
N Boys	4,044	4,044	4,044	4,044

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. Demographic controls include a child's age and an indigenous indicator. Households' controls include indicators for whether the child's household is located in an urban area, and controls for the gender, age and education level of the head of the child's household. Each measure represents a separate regression. See section 6 for a definition of the intensity variables. Data source: Guatemalan LSMS surveys 2000 and 2006.

Table 1.7: Measuring the Impact of the 2005 Tropical Storm Stan on School Enrollment and Work Participation, by Urban/Rural Area

	Girls		Boys	
Dependent Variable:	School Enrollment	Work Participation	School Enrollment	Work Participation
	[1]	[2]	[3]	[4]
Panel A: Children Aged 7 to 12				
Measure1 * Year 2006	-0.065	0.115	-0.136	0.070
	[0.099]	[0.078]	[0.113]	[0.091]
(Measure 1 * Year 2006) * Urban	0.125	-0.134**	0.150	-0.047
	[0.096]	[0.053]	[0.111]	[0.107]
Measure 2 * Year 2006	0.077	0.254	0.013	0.236
	[0.247]	[0.158]	[0.299]	[0.175]
(Measure 2 * Year 2006) * Urban	0.125	-0.272**	0.217	-0.063
	[0.164]	[0.104]	[0.194]	[0.215]
Panel B: Children Aged 13 to 15				
Measure1 * Year 2006	-0.059	0.249	-0.463**	0.342*
	[0.091]	[0.155]	[0.218]	[0.191]
(Measure 1 * Year 2006) * Urban	-0.120	-0.119	0.165	0.178
	[0.072]	[0.150]	[0.187]	[0.156]
Measure 2 * Year 2006	-0.320	0.669	-1.146*	0.789
	[0.204]	[0.395]	[0.562]	[0.519]
(Measure 2 * Year 2006) * Urban	-0.214***	-0.126	0.206	0.341
	[0.075]	[0.340]	[0.458]	[0.368]
Year 2006 * Urban	Yes	Yes	Yes	Yes
Year 2006	Yes	Yes	Yes	Yes
Demographics and HH. Controls	Yes	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes	Yes
N Panel A	9,038	9,038	9,339	9,339
N Panel B	3,961	3,960	4,044	4,044

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. Demographic controls include a child's age and an indigenous indicator. Households' controls include indicators for whether the child's household is located in an urban area, and controls for the gender, age and education level of the head of the child's household. Each measure represents a separate regression. See section 6 for a definition of the intensity variables. Data source: Guatemalan 2000 and 2006 LSMS surveys.

Table 1.8: Measuring the Impact of the 2005 Tropical Storm Stan on School Enrollment and Work Participation for Non-Migrant Children

	School Enrollment		Work Participation	
Dependent Variable:	Girls	Boys	Girls	Boys
	[1]	[2]	[3]	[4]
Panel A: Children Aged 7 to 12				
Measure 1 * Year 2006	-0.017	-0.049	0.064	0.055
	[0.079]	[0.105]	[0.063]	[0.094]
Year 2006	0.098***	0.071*	-0.035	-0.016
	[0.029]	[0.040]	[0.024]	[0.017]
Measure 2 * Year 2006	0.142	0.191	0.14	0.212
	[0.188]	[0.259]	[0.113]	[0.172]
Year 2006	0.084***	0.048	-0.028	-0.016
	[0.022]	[0.029]	[0.020]	[0.015]
Panel B: Children Aged 13 to 15				
Measure 1 * Year 2006	-0.059	-0.373**	0.216	0.421*
	[0.074]	[0.151]	[0.155]	[0.203]
Year 2006	0.074***	0.156***	-0.07	-0.135**
	[0.025]	[0.037]	[0.043]	[0.053]
Measure 2 * Year 2006	-0.261	-0.980**	0.671*	0.937
	[0.187]	[0.383]	[0.333]	[0.565]
Year 2006	0.077***	0.131***	- 0.062*	-0.096**
	[0.019]	[0.022]	[0.033]	[0.043]
Demographics and HH. Controls	Yes	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes	Yes
N Panel A	8,947	9,234	8,947	9,234
N Panel B	3,916	4,009	3,915	4,009

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. Demographic controls include a child's age and an indigenous indicator. Households' controls include indicators for whether the child's household is located in an urban area, and controls for the gender, age and education level of the head of the child's household. Each measure represents a separate regression. See section 6 for a definition of the intensity variables. Data source: Guatemalan 2000 and 2006 LSMS surveys.

Table 1.9: Measuring the Impact of the 2005 Tropical Storm Stan on School Enrollment and Work Participation - Instrumental Variable Estimates without Totonicapán and Suchitepéquez Departments

	Enrolled in School		Work Participation	
Dependent Variable:	Girls	Boys	Girls	Boys
	[1]	[2]	[3]	[4]
Panel A: Children 7 Aged to 12				
OLS Estimates without Totonicapán and Suchitepéquez				
Measure 1 * Year 2006	-0.004	-0.045	0.043	0.040
	[0.079]	[0.103]	[0.064]	[0.106]
Measure 2 * Year 2006	0.147	0.171	0.153	0.218
	[0.193]	[0.260]	[0.122]	[0.186]
IV Estimates without Totonicapán and Suchitepéquez				
Measure 1 * Year 2006	0.027	-0.023	0.076*	0.085
	[0.079]	[0.062]	[0.042]	[0.085]
Measure 2 * Year 2006	0.066	-0.057	0.187*	0.212
	[0.189]	[0.159]	[0.111]	[0.217]
Panel B: Children Aged 13 to 15				
OLS Estimates without Totonicapán and Suchitepéquez				
Measure 1 * Year 2006	-0.066	-0.384**	0.194	0.406*
	[0.073]	[0.144]	[0.161]	[0.215]
Measure 2 * Year 2006	-0.282	-0.961**	0.680*	0.954
	[0.181]	[0.378]	[0.325]	[0.572]
IV Estimates without Totonicapán and Suchitepéquez				
Measure 1 * Year 2006	-0.037	-0.400***	0.291**	0.451**
	[0.114]	[0.133]	[0.116]	[0.177]
Measure 2 * Year 2006	-0.091	-0.980**	0.728***	1.106**
	[0.282]	[0.392]	[0.268]	[0.490]
Year 2006	Yes	Yes	Yes	Yes
Demographics and HH. Controls	Yes	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes	Yes
N Panel A	8,381	8,704	8,381	8,704
N Panel B	3,703	3,757	3,702	3,757

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. Demographic and HH. controls include a child’s age and ethnicity, whether the child’s household is located in an urban area, and controls for the gender, age and education level of the head of the child’s household. Each measure represents a separate regression. See section 6 for a definition of the intensity variables. Data source: Guatemalan 2000 and 2006 LSMS surveys.

Table 1.10: Measuring the Impact of the 2005 Tropical Storm Stan on School Enrollment and Work Participation for Girls Aged 13 to 15 by Loss

Dependent Variable:	School Enrollment	Work Participation	Paid Agriculture Work	Unpaid Agriculture Work	Paid Market Work	Unpaid Market Work
	[1]	[2]	[2.a]	[2.b]	[2.c]	[2.d]
Loss 1 (Crops) * Year 2006	-0.105	0.218	-0.012	0.181**	-0.027	0.076
	[0.088]	[0.187]	[0.028]	[0.087]	[0.073]	[0.132]
Loss 2 (Dwelling) * Year 2006	0.033	0.843*	0.041	0.806***	-0.026	0.023
	[0.252]	[0.410]	[0.106]	[0.207]	[0.193]	[0.372]
Loss 3 (Goods) * Year 2006	0.200	1.518**	-0.010	0.955***	-0.075	0.649
	[0.317]	[0.686]	[0.127]	[0.293]	[0.320]	[0.486]
Loss 4 (Livestock) * Year 2006	0.161	0.888	-0.102	0.941**	-0.211	0.261
	[0.447]	[0.815]	[0.165]	[0.370]	[0.284]	[0.549]
Loss 5 (Family) * Year 2006	-0.237	0.293	-0.121	0.709	-0.032	-0.263
	[1.176]	[1.781]	[0.451]	[1.028]	[0.860]	[0.911]
Loss 6 (Business) * Year 2006	-1.376	5.579*	0.344	6.145***	0.643	-1.554
	[2.189]	[3.174]	[0.803]	[2.154]	[1.689]	[3.500]
Year 2006	Yes	Yes	Yes	Yes	Yes	Yes
Ind. and HH. Controls	Yes	Yes	Yes	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
N Panel A	3,961	3,960	3,960	3,960	3,960	3,960
N Panel B	3,960	4,044	4,044	4,044	4,044	4,044

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. See section 6 for a definition of the loss and controls variables. Data source: Guatemalan 2000 and 2006 LSMS surveys.

Table 1.11: Measuring the Impact of the 2005 Tropical Storm Stan on School Enrollment and Work Participation for Boys Aged 13 to 15 by Loss

Dependent Variable:	School Enrollment	Work Participation	Paid Agriculture Work	Unpaid Agriculture Work	Paid Market Work	Unpaid Market Work
	[1]	[2]	[2.a]	[2.b]	[2.c]	[2.d]
Loss 1 (Crops) * Year 2006	-0.444***	0.496**	-0.067	0.125	0.331*	0.106
	[0.156]	[0.233]	[0.111]	[0.130]	[0.161]	[0.080]
Loss 2 (Dwelling) * Year 2006	-1.085*	1.340*	0.169	0.295	0.631	0.245
	[0.524]	[0.668]	[0.242]	[0.372]	[0.466]	[0.246]
Loss 3 (Goods) * Year 2006	-1.747**	1.889*	0.297	0.371	0.885	0.337
	[0.736]	[1.066]	[0.354]	[0.660]	[0.549]	[0.439]
Loss 4 (Livestock) * Year 2006	-1.384*	1.415	0.043	-0.104	1.269	0.208
	[0.792]	[1.133]	[0.358]	[0.568]	[0.757]	[0.424]
Loss 5 (Family) * Year 2006	-0.792	-0.236	1.101	0.111	-0.965	-0.482
	[1.443]	[1.937]	[0.778]	[1.197]	[1.466]	[0.764]
Loss 6 (Business) * Year 2006	-5.616	5.219	3.574*	1.537	0.248	-0.141
	[3.786]	[4.157]	[1.897]	[3.560]	[1.980]	[1.470]
Year 2006	Yes	Yes	Yes	Yes	Yes	Yes
Ind. and HH. Controls	Yes	Yes	Yes	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
N Panel A	3,961	3,960	3,960	3,960	3,960	3,960
N Panel B	3,960	4,044	4,044	4,044	4,044	4,044

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. See section 6 for a definition of the loss and controls variables. Data source: Guatemalan 2000 and 2006 LSMS surveys.

CHAPTER 2
PERSISTENT IMPACT OF NATURAL DISASTERS ON CHILD NUTRITION AND SCHOOLING: EVIDENCE FROM THE 1999 COLOMBIAN EARTHQUAKE[22]

1. Introduction

Natural disasters are unfortunate recurring events that happen worldwide. A great deal of evidence reveals that exposure of lives and property to disasters has increased in the last decades, with earthquakes and storms causing the most damage (CRED 2010, World Bank 2010).[23] Because risk of natural disasters is likely to become more significant in the years to come, increased attention has focused on the challenges that these events pose for economic development and poverty reduction.

Natural disasters may contribute to poverty and its intergenerational transmission if they force families to decrease their investment in children's human capital, inducing children to fail to reach their growth and educational potential (Ferreira and Shady 2009, Skoufias 2003). Investments in children's health and education establish the foundation for their lifelong welfare. An extensive body of economic literature on child development indicates that failure of children to fulfill their growth potential influences their life span, affecting morbidity, cognitive performance, educational attainment, and adult productivity (see Strauss and Thomas 2008, Schultz 2010 for a detailed review). More schooling is related to higher wages, lower probabilities of being unemployed, more prestigious jobs, and higher job satisfaction (Card 1999).

There is a nascent, but still limited literature that rigorously documents the impact of specific large-scale natural disasters on children's human capital in developing countries. These

[22] This work is co-authored with Mary Arends-Kuenning and Leonardo Lucchetti.
[23] The increasing trend of natural dissasters is related to a combination of the availability of more information, an increase in population and urbanization, and global climate change (CRED 2010, World Bank and United Nations 2010).

studies show negative impacts on children's nutrition (Baez and Santos 2007, Hoddinott and Kinsey 2001, Jensen 2000) and in general, on schooling outcomes (Bustelo 2011, Cuaresma 2010, Santos 2010, Baez and Santos 2007). However, considerably less is known about the degree to which these negative effects on human capital formation persist over time across child cohorts.[24] Documenting the degree of persistence of these effects is critical to designing well-targeted, effective, and timely interventions that protect children's welfare. Information that enhances policies to improve household resilience to natural disasters is of immediate value.

The present paper contributes to the existing literature on natural disasters in three ways. First, it reports on new evidence from the earthquake that devastated the west-central part of Colombia's Coffee Belt in 1999 to identify the consequences of an extreme geologic event on child nutrition and schooling. Second, this paper uniquely identifies both the short- and medium-term impact of the earthquake, combining two cross-sectional household surveys collected before the earthquake and two cross-sectional household surveys collected one and six years after the earthquake. Third, this paper provides evidence from a unique context in that the earthquake in Colombia prompted what the country has termed a model of reconstruction, involving the creation of a public entity called the Fund for the Reconstruction and Social Development of the Coffee-Growing Region (Fondo para la Reconstrucción y Desarrollo Social del Eje Cafetero [FOREC]) to better coordinate and channel international, state, and private reconstruction and donation efforts. Indeed, the Colombian FOREC model won a United Nations prize for its effectiveness in reconstruction. By focusing on both the short- and medium-run impacts, we are able to pin down how persistent the impact of the shock is on child nutrition and

[24] A growing body of research explores whether natural disasters lead to poverty persistence. For instance, Rosemberg, Fort, and Glave (2010) find that the probability of staying in chronic poverty between 2002 and 2006 in Peru is higher for those households that experience a natural disaster. Premand and Vakis (2010) report that exposure to natural disasters in Nicaragua between 1998 and 2005 increase the probability that households suffer downward mobility and poverty (see de la Fuente 2010 for a review).

schooling amid the successful relief aid received, something that has not yet been explored in the existing literature.

Results suggest that the 1999 Colombian earthquake forces households to decrease their investment in children's human capital. Findings report a strong negative impact of the earthquake on child nutrition and schooling in the short-term. Results from children living in Quindio, the most affected department, are the main driving force of these results. More importantly, amid the aid received by the affected area, the negative consequences of the earthquake persist with a lesser degree in the medium-term, particularly for boys. Our results are robust to a set of additional checks, including tests for pre-earthquake trends, differences in survey's sample design, and migration.

2. Aggregate Shocks and Human Capital

Some of the most important household choices refer to the human capital investments in children (Strauss and Thomas 1995). A large body of research has been quite concerned with household's responses to the impact of aggregate shocks on children's nutritional and schooling investments. This paper is broadly related to this literature, providing new evidence on the consequences of a natural hazardous shock caused by an earthquake in a developing country.

A considerably large number of studies focus on adverse shocks caused by macroeconomic crises in developing countries, finding mixed results on schooling outcomes and negative effects on child nutritional status. For instance, studies performed in poor countries of Africa and Asia reported evidence that educational outcomes are pro-cyclical – i.e., school enrollment falls during recessions. Conversely, studies performed in middle-income countries of Latin America found that educational outcomes are generally counter-cyclical – i.e., school enrollment rises during recessions. The evidence of economic shocks on child health seems more homogenous in developing countries: existing evidence indicates that child nutritional status is pro-cyclical – i.e., malnutrition increases during recessions (Duryea and Arends-Kuenning 2003; see Ferreira and Shady 2009 for a detailed review).

Earlier studies have used weather variability to identify the effects of adverse income shocks on child investment in low-income settings. Foster (1995) examined the impact of a major flood on children's weight in Bangladesh, finding negative effects on nutritional status for children in credit-constraint households. Jensen (2000) used historical rainfall data to construct a measure of shock for areas in the Cote d'Ivore between 1986 and 1987, finding that exposure to negative rainfall shocks increases children's malnutrition and decreases school enrollment rates.

Several studies have used weather shocks to identify the effects of health shocks early in life on subsequent health and schooling outcomes. Hoddinott and Kinsey (2001) estimated the impact of a severe drought in 1994-1995 in Zimbabwe on children's growth in height to find a reduction in linear growth among the youngest children (aged 12-24 months in 1993). Alderman, Hoddinott, and Kinsey (2006) exploited weather variation and a civil war in Zimbabwe to identify the impact of preschool height on later health and schooling outcomes. The authors found that exposed children become shorter adolescents, start school later, and attain fewer years of schooling. Alderman, Hoogeveen, and Rosi (2009) found similar results exploring weather shocks in early childhood among Tanzanian adolescents. Maccini and Yang (2009) examined the effect of rainfall shocks at about the time of birth on adult education to find that Indonesian women exposed to 20 percent higher rainfall (relative to normal local rainfall) attained more schooling, have better self-reported health status, and are taller.

In recent years, a growing, but still limited, body of economic literature explores the impact of aggregate economic shocks caused by specific large-scale natural disasters in developing countries. Almost all the evidence comes from Latin American countries. Baez and Santos (2007) studied the medium-term impact of Hurricane Mitch in Nicaragua to report a negative impact on child nutritional status (measured by weight-for-age Z-scores) for children aged 0 to 5 and a null impact on school enrollment for children aged 6 to 15 living in affected areas.[25] Santos (2010) explored the short-term impact in rural areas of the two 2001 earthquakes in El Salvador. The author found that rural children aged 6 to 15 who were highly exposed to the shocks became less likely to attend school. Bustelo (2011) examined the short-term impact of Tropical Storm Stan, which devastated Guatemala in 2005. Results in this study emphasize a great deal of heterogeneity by age and gender in terms of how children's time allocation was affected by the storm. Evidence shows that school participation decreased only for male children aged 13 to 15 who were more likely to be engaged in market work that directly contributes to family income. The study finds no effect on children below 13 years old.

Alternative to studying the impact of a specific natural disaster, Cuaresma (2010) explored the impact of disaster risks on educational attainments to report a strong negative impact across several countries, between the propensity to suffer geologic disasters and secondary school enrollment rates. Lastly, while a number of studies examined the impact of exogenous negative shocks on child growth, Yamano, Alderman, and Christiansen (2005) studied the impact of the food aid received by Ethiopian households to counter the effects of price or weather variability. The authors report evidence that food aid is positively related to child growth (in height).

[25] Weight-for-age Z-scores are short-term measures of current health and nutritional status and physical work capacity. This paper uses height-for-age Z-scores, which are considered long-term measures of health that reflect fetal and childhood nutritional limitations and disease environment (Schultz 2010).

3. The 1999 Colombia Coffee Belt Region Earthquake

3.1 Earthquake's Destruction

On January 25, 1999, a severe earthquake measuring 6.2 on the Richter scale struck the west-central part of Colombia's Coffee Belt Region, with unprecedented effects in the country. The area affected covered 6,772 km^2 in five departments: Caldas, Quindío, Risaralda, Tolima, and Valle de Cauca (see figure 2.1). The epicenter was located in the Quindío department, 16 kilometers southwest of the department capital Armenia, and had a depth of 10 kilometers. Experts conclude that its short distance from the surface was what caused the shaking to be so strong (Restrepo 2000). An aftershock of 5.8 on the Richter scale that followed brought down numerous houses and buildings that had been partially damaged by the first shock. More than 300 aftershocks occurred in the days following the initial earthquake, generating more destruction.

The 1999 earthquake is considered to be one of the most destructive in the history of Colombia. According to the Economic Commission for Latin America (ECLAC 1999), this event caused damages estimated at $1.6 billion dollars, close to 35 percent of the region's gross internal product and 1.4 percent of the country's 1998 GDP. More than 400,000 individuals in the affected departments suffered direct earthquake losses in terms of housing, family members, and/or employment. There were 1,185 deaths, about 9,000 injured individuals, and more than 160,000 people left homeless. Nonetheless, the severe earthquake also indirectly affected more than 1.5 million individuals living in the five affected departments and the departments of Bogota and Antioquia.[26]

[26] "Population Indirectly Affected" denotes the population who suffered indirect losses, such as disruption in the commercial relations (ECLAC 1999).

The earthquake devastated the affected region with differential intensity. Quindio was both directly and indirectly the most affected department; approximately 60 percent of the establishments suffered damages and around 90 percent of the population suffered from consequences caused by the disaster (World Bank 2003, ECLAC 1999). The departments of Caldas, Risaralda, Tolima, and Valle de Cauca were directly affected to a lesser extent. These four departments, together with Bogota and Antioquia, mainly experienced indirect consequences of the shock with great variability (see table B.1 in appendix B). For instance, the earthquake indirectly affected 27.2 percent of the population in Risalda, while 0.4 percent of the population in Caldas was indirectly impacted.

Housing was the sector most affected by the shock, which constituted about 70 percent of the total loss. The high number of families that lost their dwellings was a burden for the provision of basic sanitary services, water supplies, food, counseling, health care to prevent disease and epidemics, and psychosocial care. Temporary housing camps were built under the supervision of non-governmental organizations. For instance, some transitory camps in Quindio remained two years after the disaster (Lora-Suarez et al. 2002). The region's infrastructure also suffered considerable damage, including schools and health centers, primary and secondary roads, electricity networks, telephone systems, water and sewerage systems, markets, public offices, and the airport in Armenia (World Bank 2003).

One of the most affected infrastructure sectors was education, not only because of the number of schools affected, but also in the extent of the damage, largely attributable to non-compliance with construction norms (International Federation of the Red Cross and Red Crescent Societies 1999). After the earthquake, 509 schools in rural and urban areas needed to be repaired and 142 had to be rebuilt (World Bank 2003). This situation affected teachers and students at various levels in both public and private schools. Given the magnitude of the destruction, temporary facilities were provided so that children could complete the school year (ECLAC 1999).

The health sector suffered to a lesser degree. Seventy-four (63 urban and 11 rural) health care institutions, including hospitals, health care centers, and nutrition centers, were damaged by the earthquake (World Bank 2003). Fear of epidemics was high, but no outbreaks of infectious diseases, including diarrhea, dengue, or malaria occurred. Despite the lack of a real epidemic of diarrhea, there were increasing diarrheal events attributable mostly to alimentary problems, rather than infectious agents (Restrepo 2000).

3.2 Post-earthquake Reconstruction

Given the magnitude of the catastrophe, recovery of the areas affected by the earthquake was identified as one of the most critical concerns. The President of Colombia declared an economic and social state of emergency and five days after the earthquake created the Fund for Reconstruction and Social Development of the Coffee Region (FOREC), whose objective was to achieve the economic, social, and ecological reconstruction of the zone affected by the earthquake. To accomplish this it would provide assistance to the most vulnerable population, rebuild the affected dwellings (including the relocations of housing units located in high-risk zones), and the reconstruct the social and public infrastructure, while trying to minimize potential negative effects on the environment. FOREC received resources from the national government, bilateral donors, and external credits to finance the reconstruction effort (World Bank 2003).

FOREC decentralized the reconstruction process by distributing responsibility among 32 NGOs, putting each one in charge of a small town or sector of an affected city. NGOs were responsible for identifying recovery projects and families that needed relocation and new homes. They were also in charge of applying proper administrative practices, mechanisms to include the affected population in the reconstruction process, and environmental safeguards (World Bank 2003). The effective system of coordination of information, financial control, and quality management allowed the reconstruction process to be accomplished in just three-and-a half years.

Homes belonging to about 130,000 individuals were repaired or rebuilt. Another 16,700 new homes were built for people who had previously rented property in areas at high risk of seismic damage. These families were relocated and given permanent titles to new homes, creating a new class of low-income homeowners. Approximately 649 schools and 52 health centers were repaired or rebuilt in the five departments affected. Although the official goal of reconstruction was to rebuild infrastructure that was damaged or destroyed, in some instances the region was better off after then earthquake than before. For instance, the capital city of Quindio ended up with a gleaming new skyline, a new airport, a new police station, a new administrative center, and new hotels (Inter-American Development Bank 2003).

According to the National Coffee Survey conducted in 1997, the five departments affected in the Coffee Region accounted for 47 percent of the national coffee production. The 1999 earthquake exacerbated an existing economic recession in the area caused by low coffee prices. FOREC enhanced the economic revival and job creation in the region, considerably lowering its unemployment rate (e.g., from 52 percent in February of 1999 to 19 percent in 2000). FOREC generated a large number of temporary jobs through its various components of reconstruction. Other externalities were the increase of capital and activity in the financial and commercial sector and the access to loans for small and mid-size enterprises (World Bank 2003).

This post-disaster experience (one of the first in Latin America) was internationally recognized and received the United Nation's Sasakawa Award on October 2000 in Switzerland. The liquidation of FOREC was carried out on July 2002, when its work was considered complete (World Bank 2003).

4. Data

4.1 Colombian Demographic Households Survey

This paper uses the 1990, 1995, 2000, and 2005 Colombian Demographic Households Surveys (DHS) developed by the ProFamilia Institute in Colombia. The DHS is a repeated cross-sectional survey with national coverage. There are some differences in survey design between the first three surveys and the 2005 survey. Nonetheless, the survey sampling-weights include factors of adjustment to account for changes in subsampling. Following the approach in Angrist and Kugler (2008), results in this study are weighted using survey sampling-weights to account for differences in survey design.[27] Additionally, in 1990, 1995, and 2000, the DHS surveys excluded large areas with relatively low population (3 percent) from their sample for budgetary reasons (DHS Final Reports for 1990, 1995, 2000, and 2005). To maintain a consistent sample throughout our analysis, we exclude these large territories in the DHS sample of 2005. The map in figure 2.1 reports the departments included in our analysis.

The DHS dataset is a comprehensive health survey that includes information on fertility for all women aged 15 to 49, child mortality, child and maternal health service utilization, and the nutritional status of children under five and their mothers. The Colombian DHS surveys also collect information related to the education of all members in the household. The 2000 and 2005 surveys were collected 12 to 17 months and 69 to 77 months respectively after the geological

[27] The four samples - i.e. 1990, 1995, 2000, and 2005 - were drawn from the 1985 National Census. However, the sample size increased in 2005 compared to previous years. The Colombian data used by Angrist and Kugler (2008) presented the same sampling differences. The authors used sampling weights to account for these differences.

disaster. Taking advantage of the timing of the Colombian DHS datasets, we combine the four datasets to identify the short- and the medium-term impacts of the 1999 earthquake.

4.2 Preliminary Descriptive Statistics

The outputs of interest are the nutritional status of children under five and the schooling participation of children aged 6 to 15. Height is widely considered to be the best indicator of nutritional conditions and disease environments of childhood (Schultz 2010), hence we used height-for-age Z-scores as a measure of child nutrition. To perform our analysis, we computed height-for-age Z-scores for each child under five, where the Z-score is defined as the difference between the child's height and the mean height of the same-aged international reference population, divided by the standard deviation of the reference population.[28] Because information about height for children aged 0 to five was not collected in the 1990 DHS survey, we limited the nutritional analysis to data from 1995 through 2005.

We used school enrollment as a measure of schooling participation. To perform our analysis, we focused on two groups of children who differ in terms of the educational level they would normally be enrolled at for their age: (i) children aged 6 to 10 who should be enrolled in primary school and (ii) children aged 11 to 15 who should be enrolled in middle school. The emphasis on differential impacts by child age is important in understanding human capital investment, particularly in Latin America where schooling dropout rates increase significantly at the transition between primary and secondary education.

Table 2.1 reports descriptive statistics at the national level by survey year for the three samples of children analyzed in our study. Child nutrition shows a moderately increasing trend at the national level. On average, children were 0.9 and 0.7 standard deviations below the average height-for-age of a reference child in 1995 and 2005 respectively. Educational outcomes also

[28] Height-for-Age Z-score estimates are based on WHO Child Growth Standards for children age 0-60 months.

show a persistent increasing trend. For all children, school enrollment improved between 1990 and 2005. School enrollment of children aged 6 to 10 increased from 78.6 to 94.2 percent, while school enrollment of children aged 11 to 15 increased from 73.2 to 88.4 percent. Not surprisingly, enrollment rates for older children are lower, meaning that schooling dropout rates increase significantly after the age of 11. Concurrent with improvements in school enrollment for children, adults' cohorts have persistently reached higher educational attainment. Household heads or maternal average years of schooling increased by more than one year.

The urban sector expanded almost four points between 1990 and 2005, accounting for nearly 68 percent of the total population of children in 2005. Interestingly, the proportion of male-headed households dropped between 1990 and 2005, favoring an increase in female-headed ones. Roughly one percent of Colombian children aged 0 to 15 lived in Quindio, which was the department most affected by the 1999 earthquake, both directly and indirectly. Children living in the rest of the affected departments – i.e., Caldas, Risaralda, Tolima, and Valle de Cauca - represented around 17 percent of the child population.

5. Empirical Identification Strategy

Identification comes from comparing, before and after the 1999 earthquake, the nutritional status and schooling participation of similar children living in affected and non-affected departments. The department-level panel dimension of the DHS Colombian data generates the variation used to identify the effects of the earthquake on schooling and child nutrition.

The baseline specification is:

$$Y_{ijdt} = \lambda_t + \lambda_{0d} + \lambda_{1d} t + \sum_q \beta_q \left(Affected\ Departments_d * Year_{qt} \right) + X'_{ijdt}\delta + \varepsilon_{ijdt} \qquad (2.1)$$

where Y_{ijdt} denotes the outcome of interest (height-for-age Z-score or school enrollment) for individual *i* in household *j* and department *d* at period *t*; λ_t are year fixed effects that control for the average changes in the outcome of interest across all departments between 1990, 1995, 2000, and 2005; λ_{0d} are department fixed effects that control for time-invariant department characteristics, such as endowments, schooling facilities, and geography; $\textit{Affected Departments}_d$ is a binary variable indicating a child living in one of the five department most affected by the earthquake – i.e., Caldas, Quindío, Risalda, Tolima, and Valle del Cauca; and $Year_{qt}$ is a binary variable that indicates year *t* equal to *q*, where *q* is 1990, 2000, and 2005. All specifications separate the impact of the earthquake from any region-specific linear trend in outcomes.[29] This is done by including $\lambda_{1d}t$, where λ_{1d} is a region-specific time trend coefficient multiplied by a time trend *t*. All regressions also control for a vector of individual characteristics X_{ijdt} that are not affected by the shock but are likely to affect child investment decisions, such as a child's gender; age; area of residence; gender of the household head; and mother's or household head's age and education. ε_{ijdt} is a random, idiosyncratic error term. Standard errors are clustered at the department level to allow for correlation across households within a department. The parameter of interest β_q , where *q* is 1990, 2000 and 2005, measures the impact of the 1999 earthquake on child nutrition and schooling and is identified under the assumption that trends in child nutrition or schooling are uncorrelated with the interaction of interest.

One concern about the validity of this strategy is the potential existence of omitted variables that may change differently in affected and non-affected departments – e.g., a macroeconomic recession may have a different effect on one area compared to another area. As Meyer (1995) emphasizes the above concern is reduced when characteristics between affected and non-affected departments are similar before the shock. Table 2.2 formally tests this point,

[29] Regions in the survey are: (i) Atlantica, (ii) Oriental, (iii) Central, (iv) Pacifica, and (v) Bogota.

comparing affected and non-affected departments along a number of dimensions in year 1995, a pre-earthquake year. Before the earthquake, the outcomes of interest and child, household heads, and maternal demographics characteristics are statistically indistinguishable between affected and non-affected departments.

Equation 2.1 assumes that the earthquake is the only event that affected child nutrition or schooling during the period considered in this analysis. However, remaining concerns exist about other events that might have coincided with the earthquake that might also have affected child nutrition and schooling. We address this concern in two ways. First, we acknowledge that Quindio was the most affected department, both directly and indirectly. The Caldas, Risalda, Tolima, and Valle del Cauca departments were mainly indirectly affected (see table B.1 the appendix B). In order to account for this difference in the intensity of the earthquake, we consider several affected groups to account for differential impact of the earthquake on the outcomes of interest. We estimate the following regression:

$$(2.2) \quad Y_{ijdt} = \lambda_t + \lambda_{0d} + \lambda_{1d} t + \sum_q \beta_{1q} \left(QuindioDepartment_d * Year_{qt} \right) + \sum_q \beta_{2q} \left(Less\,Affected\,Departments_d * Year_{qt} \right) + X'_{ijdt} \delta + \varepsilon_{ijdt}$$

where $Quindio\ Department_d$ is a binary variable indicating a child living in Quindio, while $Less\ Affected\ Departments_d$ is a binary variable indicating a child living in one of the other four affected department – i.e., Caldas, Risalda, Tolima, and Valle del Cauca. The impact of the earthquake is better identified when using several treatments; the identification strategy relies on the fact that the Quindio department was affected significantly more than the rest of the departments.

Secondly, we acknowledge that there exists large variability in terms of the intensity of the earthquake's impact on the less affected departments. Therefore, we use the proportion of the population indirectly affected by the earthquake, taken from Table B1 in Appendix B, as a proxy for the earthquake's intensity.[30] $\textit{Less Affected Departments}_d$ is replaced by $\textit{Intensity}_d$, which refers to the proportion of the population indirectly affected by the shock in departments other than Quindio. The nutritional status and schooling participation of children living in areas highly indirectly affected by the earthquake are compared with the nutritional status and schooling participation of children living in areas less indirectly affected by the shock.

6. Empirical Results

Tables 2.3, 2.4, and 2.5 report the main results of the paper; table 2.3 presents the results of child nutrition for the group of children aged 0 to 5, while tables 2.4 and 2.5 show the results of child schooling for the group of children aged 7 to 10 and 11 to 15, respectively.[31]

6.1 Main findings

For the nutritional study, we have two groups of children that were exposed differently to the earthquake. Children aged 0 to 5 in 2000 were mostly born before the 1999 earthquake and consequently might have been highly affected by the shock. On the contrary, children aged 0 to 5 in 2005 were all born after the earthquake and consequently might have been affected by the shock to some extent, particularly the oldest children among this group. Previous evidence indicates that adverse environmental conditions that occur during both the prenatal period and between birth and age five have profound and persistence impacts for children's development (Almond and Currie 2011, Center on the Developing Child 2010, Schultz 2010, Strauss and Thomas 2008, Engle et. al 2007).

---

[30] Observe that this intensity measure includes Antoquia and Bogota D.C. as affected departments. Results are similar if these two departments are not considered as affected.

[31] All regressions in this paper control for a child's gender; age and age squared; area of residence; gender of the household head; and mother's or household head's education, age, and age squared. All coefficients of these controls have the expected sign. Table B.2 in appendix B reports coefficients of these controls using specification 3 of tables 2.3, 2.4, and 2.5. Results are similar when using specifications 1 and 2 (results not reported).

Column 1 of table 2.3 presents the baseline specification as outlined in equation 2.1. We find that the height-for-age Z-score is significantly lower by 0.182 standard deviations for children residing in affected departments right after the earthquake in 2000. Interestingly, this negative result seems to vanish in 2005, suggesting that the post-earthquake relief and improvement of living conditions might help mitigating the shock's negative effect on nutrition in the medium-term. Column 2 explores, as outlined in equation 2.2, the differential impact of the disaster depending on whether a child resides in Quindio, the department most affected by the earthquake both directly and indirectly, and the rest of the affected departments, which were mainly indirectly hit by the earthquake. In Quindio, children experience 0.296 standard deviations lower Z-scores in 2000, one year after the earthquake. Effects of lower magnitude, 0.175 standard deviations, are found for children residing in the less affected departments. We do not find any evidence of a significant impact of the earthquake in 2005. To test whether children living in Quindio experience a significantly different impact than children living in the less affected departments, Column 2 presents the p-values for the test of the null hypothesis that $\beta_1 = \beta_2$ in equation 2. In 2000, we are able to reject the null hypothesis of equality of these coefficients (p = 0.035). However, the opposite is observed in 2005, where we are not able to reject the null hypothesis (p = 0.118).

Column 2 of table 2.3 weights less affected departments equally. However, table B.1 in appendix B shows that there exists large variability in terms of the indirect impact of the earthquake – i.e., 27.2 percent of the population in Risalda was indirectly affected by the shock, while the earthquake indirectly affected only 0.4 percent of the population in Caldas. Column 3 of table 2.3 exploits the geographical variation in the intensity of the shock among the less affected departments. We compare, before and after the earthquake, the height-for-age Z-scores of children in departments that experienced high indirect effects as a result of the shock with the height-for-age Z-scores of children in departments that experienced low indirect effects of the earthquake. Results confirm that children living in Quindio have lower height-for-age Z-scores only in 2000. However, when exploiting the great variability of the shock on the less affected departments, estimates show no significant impact on child nutrition both in 2000 and 2005.[32]

Table 2.4 explores the impact of the 1999 earthquake on the schooling participation of children aged 6 to 10. Columns 1 through 3 show the same specifications as the corresponding columns of table 2.3. In the case of education, we are able to compare pre-earthquake trends between affected and non-affected departments. Columns 1 through 3 show no statistically significant differences across departments in the pre-earthquake estimates under the three specifications proposed in our analysis. These results give further support to the empirical identification strategy used in this paper, since no differential trend is observed prior to the shock. Column 1 in table 2.4 indeed shows no statistically significant reduction in school enrollment for children living in affected departments one year after the earthquake, although the point estimate is negative. On the contrary, the estimate coefficient for year 2005 is negative and statistically significant at the 10 percent level.

Note that the cohort of children aged 6 to 10 in 2005 was 4 years old or younger when the earthquake occurred. The persistent impact in 2005 might reflect two issues. First, the negative effect in the medium-term may reflect the adverse earthquake shock that they experienced early in life. Previous evidence in child developmental literature showed that inadequate nutrition in early years could have persistent consequences in later childhood on children schooling – e.g. late entry, early dropout, inattention, and poor learning (Almond and Currie 2011, Center on the

[32] Values of height-for-age Z-score below -2 are indicators of chronic malnutrition or stunting that reflects accumulated past growth failure. There is some evidence that the earthquake increse the probability of being stunting in 2000 for children residing in Quindio department (results not shown).

Developing Child 2010, Schultz 2010, Strauss and Thomas 2008, Orazen and King 2008, Engle et. al 2007, Grantham-McGregor et. al 2007).[33] Second, there could have been other events that happen together with the earthquake and that might have also affected school attendance for children aged 6 to 10. Consequently we might incorrectly attribute any variation of school attendance to the earthquake. Columns 2 and 3 in table 2.4 address this potential source of bias by introducing variables that capture earthquake's intensity that exploits the variation of the impact of the shock across departments.

Column 2 in table 2.4 reports the differential effect of the earthquake by department of residence, weighting less affected departments equally. Children residing in Quindio are 7 percent less likely to be enrolled in school in 2000. However, no significant impact is observed in 2005. In addition, although negative, there is no significant impact of the earthquake in the least affected departments in 2000, while there is an indication that the impact of the shock is significant in 2005. Column 3 in table 2.4 shows our preferred specification; it explores the differential impact of the earthquake exploiting the variability in the indirect damages caused by the disaster in less affected departments. This specification provides suggestive evidence that the earthquake only reduces, by 7 percent, the schooling participation of children aged 6 to 11 residing in Quindio in 2000. Note that the negative impact in 2005 observed in column 2 is no longer statistically significant when we exploits the variability of the shock in less affected departments.

Table 2.5 explores the impact of the earthquake on schooling participation of children aged 11 to 15. In line with the results found for the youngest group of children in table 2.4, no trend is observed prior to the shock (columns 1 through 3). Nonetheless, a different story is

[33] Table 2.3 shows that children aged 0 to 5 living in affected areas in 2000 have 0.182 height-for-age Z-score standard deviations lower than their peers residing in non-affected areas.

observed after the earthquake. Column 1 shows a negative and significant impact of the shock for children residing in affected departments both in the short term, in 2000, and the medium term, in 2005. Note that results for 2000 and 2005 refer to two different cohorts of children – i.e., in 2000 we measure the impact of the shock on children who were 10 to 14 years old when the 1999 earthquake struck, while in 2005 we measure the medium term impact of the earthquake on children who were 5 to 9 years old in 1999.

When considering the differential impact of the earthquake by department of residence, these impacts are large and meaningful. As column 2 reports, the probability of being enrolled in school for children residing in Quindio or the least affected departments falls both in 2000 and 2005. Column 3 presents our preferred specification, which exploits the great variability of the shock on the less affected departments. Results also confirm that the negative impact of the earthquake on schooling for children residing in Quindio persists in the medium term. The shock decreases the likelihood of being enrolled in school for children living in Quindio by 6.5 and 5.3 percent in 2000 and 2005, respectively. For children residing in the least affected departments, the coefficient is negative and statistically significant only in 2000, meaning that an increment of one percent of the proportion of the population indirectly affected by the earthquake reduces school attendance by 0.714 percent in 2000. For instance, the probability of being enrolled decreases by 3.9 (0.714*5.6) percent in 2000 in a department having the average value of the population indirectly affected by the earthquake (see table B.1 in the appendix).

6.2 Robustness Check

As described in the previous section, we constructed a panel dataset at the department level employing the DHS for the years 1990, 1995, 2000, and 2005. The four samples were drawn from the 1985 National Census. However, the sample size increased considerably in 2005 compared to previous years and, with the exception of the years 1995 and 2000, the municipalities where the data is collected differ between some surveys. Therefore, in tables 2.6 and 2.7, we examine the role of the sample design of the surveys.

In column 1 of the tables, we estimate our third specification, restricting the sample to the years 1995 and 2000, which are surveys that collect data on a representative sample from the 61 municipalities available in the 23 departments in 1995 and 2000. The magnitude of the impact and its level of statistical significance are consistent with the non-restricted sample (columns 3 of tables 2.3, 2.4, and 2.5), providing evidence the main results are unlikely to be influenced by the sample design.

In column 2 of tables 2.6 and 2.7, we perform a detailed exploration of whether unobserved heterogeneity at the municipality level, instead of at the department level, matters. The estimation of the results using municipality fixed effects and restricting the sample to years 1995 and 2000 leaves the main findings of our analysis unchanged. Lastly, and for the case of education, column 3 of table 2.7 compares pre-earthquake trends between affected and non-affected departments, restricting the sample to years 1990 and 1995. In line with our main results, there is no a differential trend before the earthquake.

An additional concern for our main findings is the existence of migration across departments, which could bias our results. First, shock exposure is based on child current department of residence. Therefore, if a child resided in a different department during the earthquake, we would incorrectly determine child exposure to the shock (Akresh, Lucchetti, and Thirumurthy 2011). Second, migration across departments might not be random. For instance, we could overestimate the impact of the earthquake if households with higher preferences for children's health and education are more likely to migrate from departments devastated by the earthquake to departments not affected by the shock. In this regard, we also explore whether migration across departments is a significant concern for our results. Table 2.8 compares the proportion of migrant children after the earthquake by Quindio, less affected, and non-affected departments. We define migrant children as those children: (1) living for one year or less in the current place of residence in 2000 or (2) living for six years or less in the current municipality in 2005.[34]

Results in table 2.8 suggest that in general migration after the earthquake is slightly higher in Quindio compare to less affected and non-affected departments. This result suggests that people are mostly moving within or returning to Quindio department; it is unlikely that people residing in less affected or non-affected departments before the earthquake move to Quindio after the shock. In line with this evidence, Unicef (2004) and Restrepo (2000) mention that migration was mainly observed between cities within affected areas. Indeed, Restrepo (2000) highlights that after the earthquake, around 30,000 individuals in the capital of Quindio left to neighboring areas. However, most of them returned in the short-term to receive governmental aid.

To further check the robustness of our previous findings, table 2.9 restricts the sample to children whose current place of residence is the same as the one during the earthquake. If migrant children are systematically different than non-migrant children, then excluding these migrant children from the regressions should change the estimated impact of the earthquake (Akresh, Lucchetti, and Thirumurthy 2011). Results in the table show that the magnitude of the

[34] The 2000 survey asks about the number of years women have been living in their current place of residence, while the 2005 survey asks about the number of years women have been living in their current municipality of residence.

impact and its level of statistical significance are consistent with the non-restricted sample, providing evidence of no bias due to migration.[35]

6.3 Heterogeneous impact by gender

Table 2.10 examines whether the impact of the earthquake differed by gender. Exploring the impact of the shock on child nutrition (columns 1 and 2), both boys and girls aged 0 to 5 residing in Quindio appear to be affected in 2000 by the earthquake. On the contrary, height-for-age improves in 2005 for girls residing in Quindio when compared with peers residing in non-affected department, while boys residing in Quindio are worse-off in 2005 compared to non-affected peers.[36] The effects on 2005 are particularly noteworthy; results suggest that the existing gap in 2000 between Quindio and non-affected departments tends to be small and reverses sign in 2005 for boys and girls, respectively. These gap changes favor girls and the effect observed for boys and girls in 2005 seem to balance the impact when we analyze the full sample of children in column 3 of table 2.3. In contrast with our findings, other studies in developing countries in Asia and Africa have found that the gender imbalance in the short-term impact of negative shocks favors boys over girls (World Bank 2011, Maccini and Yan 2009, Ferreira and Shady 2009).

Columns 3 and 4 of table 2.10, explore the differential impact on schooling participation by gender for children aged 6 to 10. Consistent with the findings for the full sample of children in table 2.4, the probability of not being enrolled in school is higher for both boys and girls residing in Quindio in 2000. The magnitude of the negative impact is larger for boys; indeed in a fully interacted model, we are able to reject the equality of coefficients for boys and girls (results not shown).

[35] A more accurate approach will classify children exposure considering the place of residence right before the earthquake. Unfortunately, this information is no available in the DHS Colombian survey.
[36] The equality of coefficients between boys and girls is rejected in a fully interacted model (results not shown).

Columns 5 and 6 report the findings for children aged 11 to 15. For children living in Quindio in 2000, the magnitude of the negative impact is slightly larger for boys, although we cannot reject the equality of coefficients for boys and girls in a fully interacted model (results not shown). On the contrary, boys living in Quindio are mainly driving the negative impact of the earthquake on schooling participation in 2005. For children residing in the least affected departments, both boys and girls in 2000 and boys in 2005 experience a significant decrease in schooling participation, although we cannot reject the equality of coefficients for boys and girls in a fully interacted model (results not shown).

Summarizing, the evidence shown in columns 3 to 6 suggests that boys tend to be slightly more affected by the earthquake than girls. Gender differences may reflect different opportunity cost of schooling for boys and girls, stemming from forgone wages (World Bank 2012). For instance, findings in chapter 1 showed that schooling participation decreases after Tropical Storm Stan in Guatemala only for exposed boys aged 13 to 15, who are more likely to be engaged in market work that directly contributes to family income. On the contrary, the storm increases the probability that older girls are enroll in school and engaged in unpaid agricultural family work.

7. Conclusion

Natural disasters can have severe consequences for child welfare. An important question related to these negative impacts is the degree to which their effects persist over time across children cohorts. In this paper, we uniquely assess the short- and medium-term impact of the 1999 Colombian earthquake on child nutrition and schooling, combining two cross-sectional household surveys collected before the earthquake and two cross-sectional household surveys collected one and six years after the earthquake. Colombia provides a unique setting for our study because the government launched a very successful reconstruction program after the earthquake. In this regard, we are able to explore how persistent the impact of the shock is amid the successful relief aid received.

Findings report a strong negative impact of the earthquake on child nutrition and schooling in the short-term. The adverse effects are mainly observed in Quindio, the department most affected by the shock, although schooling also decreases one year after the earthquake in less affected departments. More importantly, amid the aid received by the affected area, the negative consequences of the earthquake persist to a lesser degree in the medium-term, especially for boys. Boy's nutrition is particularly vulnerable in Quindio after six years of the disaster, while boys aged 11 to 15 in both Quindio and less affected departments are more likely than girls to decrease their school participation.

While our data do not allow us to definitively conclude the mechanisms by which the earthquake might affect child nutrition and schooling, evidence seems to indicate that the massive housing and infrastructure destruction caused by the geological shock might be a key pathway. Many families lost their homes and were internally displaced to temporary shelters, which caused difficulties in access to basic sanitary services, water supplies, and food. Additionally, the massive economic losses may have affected parent's mental health, impacting children's development. For instance, the child development literature indicates a positive relationship between child growth failure and maternal depression (see Wachs et al. 2009 for a review).

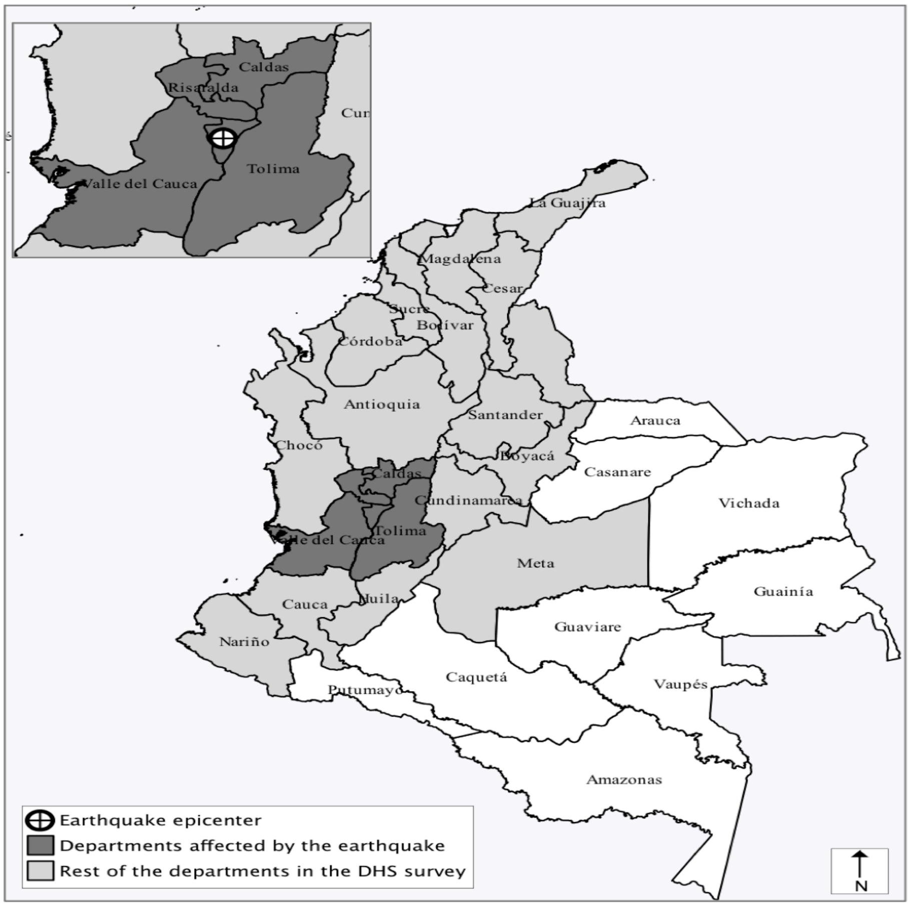
On the other hand, the sharp declines in living standards and destruction of educational infrastructure might have forced households to take children out of schools. Indeed, a schooling assessment study conducted by Unicef (2004) in the capital city of Quindio listed the 1999 earthquake as one of the causes for school desertion. The evidence for the children aged 11 to 15 in 2005 suggests that children whose schooling was affected by the earthquake when they were aged 5 to 9 were not able to overcome the shock to their school enrollment that occurred in 1999 and 2000. Schooling participation might have also decreased due to higher earnings opportunities for children triggered by FOREC reconstruction plan. Children's employment is related to lower educational attainment (Edmonds 2007, Duryea and Arends-Kuenning 2003, Psacharopoulos 1997). For instance, Duryea and Arends-Kuenning (2003) found that labor participation for children aged 14 to16 in urban Brazil increased as labor markets improved and children were more likely to leave school as local labor market conditions became more favorable. Lastly, indirect effects might also have played a role on the schooling of children aged 11 to 15 in less affected departments.

How substantive are the observed changes for child welfare? A body of empirical evidence established that (1) poorer child nutritional status is associated with subsequent lower educational attainments and adult earnings and (2) lower levels of education are associated with lower wages. To put our results in context, we can roughly estimate the long-term consequences that follow from our estimates and findings from previous studies for Zimbabwe and Peru. Alderman, Hoddinott and Kinsey (2006) reported that a one standard deviation decrease in height for preschoolers children correlates with 0.678 lower school grades completed in Zimbabwe. The World Bank (2005) estimated for Peru that the return to an extra year of education in 2003 is 11 percent. If the earthquake were associated with lower height-for-age Z-scores by 0.296 standard deviations for children residing in Quindío one year after the earthquake and a decline of at least 0.2 (0.678*0.296) years of schooling in the long term, wages in adulthood would be 2 percent lower for children younger than five in 2000. In addition, if affected children aged 7 to 15 in 2000 did not enroll in school after the earthquake and there is a decline of at least one year of schooling, the economic costs of the earthquake would be at least a 11 percent reduction in lifetime earnings.

The findings in this paper highlight three points for setting priorities of public programs. First, the destructive geological event forces households to adjust to the shock by reducing child nutrition or withdrawing children from school. Second, the successful remedial action plan that took place right after the disaster mitigates, but does not eradicate, the adverse effects in child human capital formation. The decrease of investment in children's human capital persists, to a lesser degree, across child cohorts many years after the shock. Third, the damage to human capital formation will have lasting impacts on children's welfare. This negative impact deserves serious policy attention and needs to be addressed with further economic interventions.

8. Figures and Tables

Figure 2.1: Colombian Departmental Map Indicating the Area Most Affected by the 1999 Earthquake



Data source: Own elaboration based on ECLAC 1999 and World Bank 2003.

Table 2.1: Descriptive Statistics at the National Level by Survey's Year

	1990	1995	2000	2005
Children Aged 0 to 5				
Child Height-for-Age Z-score		-0.9	-0.8	-0.7
Child Age in Months		29.2	28.9	29.3
Child is Male		50.6	51.0	50.3
Child Lives in Urban Area		63.0	68.6	67.8
Mother's Age		28.1	27.9	27.8
Mother's Years of Education		6.4	7.1	7.7
HH. Head is Male		84.5	79.4	77.0
Population in Quindío (in %)		1.2	1.0	1.1
Population in Rest of Affected Departments (in %)		16.9	15.6	16.2
N		4,508	4,180	10,020
Children Aged 6 to 10				
Child is Enrolled in School	78.6	91.3	92.1	94.2
Child Age	8.1	8.0	8.0	8.1
Child is Male	48.9	49.9	50.6	50.5
Child Lives in Urban Area	65.9	62.4	67.3	68.4
HH. Head Age	43.7	43.7	43.6	44.4
HH. Head Years of Education	5.1	5.2	5.9	6.2
HH. Head is Male	82.4	81.9	76.4	73.1
Population in Quindío (in %)	1.8	1.1	0.8	1.1
Population in Rest of Affected Departments (in %)	16.9	17.3	17.8	17.7
N	4,194	5,082	5,093	13,890
Children Aged 11 to 15				
Child is Enrolled in School	73.2	81.8	84.0	88.4
Child Age	13.0	13.1	13.0	13.0
Child is Male	49.3	49.6	51.7	50.6
Child Lives in Urban Area	65.1	64.1	67.4	69.4
HH. Head Age	46.4	46.2	46.3	47.1
HH. Head Years of Education	4.8	5.2	5.6	6.0
HH. Head is Male	79.7	78.3	74.3	71.1
Population in Quindío (in %)	2.4	1.5	0.9	1.3
Population in Rest of Affected Departments (in %)	19.3	17.5	17.5	17.6
N	3,811	5,007	4,848	14,108

Note: Results are weighted using survey-sampling weights. "Rest of Affected Departments" denotes the departments of Caldas, Risalda, Tolima, and Valle del Cauca. Data source: 1990, 1995, 2000, and 2005 Colombian Demographic and Health Surveys.

Table 2.2: Pre-earthquake Descriptive Statistics by Affected and Non-affected Departments – Year 1995

	Affected Departments	Non-affected Departments	Difference
Children Aged 0 to 5			
Child Height-for-age Z-score	-0.7	-0.9	0.3
Child Age in Months	29.9	29.0	0.9
Child is Male	50.9	50.6	0.4
Child Lives in Urban Area	69.9	61.5	8.4
Mother's Age	28.3	28.0	0.3
Mother's Years of Education	6.8	6.3	0.4
HH. Head is Male	81.8	85.0	-3.2
N	884	3,624	
Children Aged 6 to 10			
Child is Enrolled in School	90.7	91.5	-0.7
Child Age	8.0	8.0	-0.1
Child is Male	49.5	50.0	-0.4
Child Lives in Urban Area	66.7	61.4	5.3
HH. Head Age	43.7	43.8	-0.1
HH. Head Years of Education	5.6	5.2	0.4
HH. Head is Male	77.3	83.0	-5.6
N	1,002	4,080	
Children Aged 11 to 15			
Child is Enrolled in School	82.1	81.8	0.3
Child Age	13.0	13.1	0.0
Child is Male	47.6	50.0	-2.4
Child Lives in Urban Area	68.5	63.1	5.4
HH. Head Age	45.8	46.3	-0.4
HH. Head Years of Education	5.4	5.2	0.2
HH. Head is Male	78.7	78.1	0.5
N	1,026	3,981	

Note: Differences in pre-earthquake characteristics between affected and non-affected departments are statistically significant *** at 1%, ** at 5%, and * at 10%. Robust standard errors in brackets, clustered at the department level (results not reported). Results are weighted using survey-sampling weights. "Affected Departments" denotes the area most affected - i.e., the departments of Caldas, Quindio, Risalda, Tolima, and Valle del Cauca. Data source: 1995 Colombian Demographic and Health Survey.

Table 2.3: Measuring the Impact of the Earthquake on Height-for-age Z-Scores for Children Under Five

Dependent Variable: Height-for-age Z-score	[1]	[2]	[3]
Affected * Year 2000	-0.182***		
	[0.058]		
Affected * Year 2005	-0.009		
	[0.064]		
Quindio * Year 2000		-0.296***	-0.281***
		[0.038]	[0.035]
Quindio * Year 2005		0.084	0.088
		[0.056]	[0.056]
Less Affected * Year 2000		-0.175***	
		[0.061]	
Less Affected * Year 2005		-0.017	
		[0.066]	
Less Affected (Intensity) * Year 2000			-0.618
			[0.738]
Less Affected (Intensity) * Year 2005			-0.032
			[0.470]
P-value Testing Equality Between Quindio and Less Affected Departments in 2000		0.035	
P-value Testing Equality Between Quindio and Less Affected Departments in 2005		0.118	
Year Fixed Effects	Yes	Yes	Yes
Department Fixed Effects	Yes	Yes	Yes
Region-specific Time Trends	Yes	Yes	Yes
Demographics Controls	Yes	Yes	Yes
N	18,708	18,708	18,708

Note: Robust standard errors in brackets, clustered at the department level. Statistically significant *** at 1%, ** at 5%, and * at 10%. Results are weighted using survey-sampling weights. Demographic controls include child age in months; child age in months squared; child gender; area of residence (urban vs. rural); household head's gender; and age, age squared and years of education of the children's mothers. "Affected" indicates a child living in the most affected departments (Caldas, Quindio, Risalda, Tolima, and Valle del Cauca). "Quindio" indicates a child living in Quindio. "Less Affected (Intensity)" indicates for each department other than Quindio the proportion of the population indirectly affected by the earthquake. Data source: 1995, 2000, and 2005 Colombia Demographic and Health Surveys.

Table 2.4: Measuring the Impact of the Earthquake on School Enrollment for Children Aged 6 to 10

Dependent Variable: School Enrollment	[1]	[2]	[3]
Affected * Year 1990	0.018		
	[0.067]		
Affected * Year 2000	-0.073		
	[0.056]		
Affected * Year 2005	-0.155*		
	[0.075]		
Quindio * Year 1990		-0.031	-0.021
		[0.054]	[0.052]
Quindio * Year 2000		-0.072***	-0.071***
		[0.021]	[0.017]
Quindio * Year 2005		-0.051	-0.047
		[0.035]	[0.029]
Less Affected * Year 1990		0.025	
		[0.068]	
Less Affected * Year 2000		-0.074	
		[0.060]	
Less Affected * Year 2005		-0.163*	
		[0.079]	
Less Affected (Intensity) * Year 1990			0.343
			[0.431]
Less Affected (Intensity) * Year 2000			-0.353
			[0.434]
Less Affected (Intensity) * Year 2005			-0.724
			[0.719]
P-value Testing Equality Between Quindio and Less Affected Departments in 2000		0.979	
P-value Testing Equality Between Quindio and Less Affected Departments in 2005		0.141	
Year Fixed Effects	Yes	Yes	Yes
Department Fixed Effects	Yes	Yes	Yes
Region-specific Time Trends	Yes	Yes	Yes
Demographics Controls	Yes	Yes	Yes
N	28,259	28,259	28,259

Note: Robust standard errors in brackets, clustered at the department level. Statistically significant *** at 1%, ** at 5%, and * at 10%. Demographic controls include child age in months; child age in months squared; child gender; area of residence (urban vs. rural); household head's gender; and age, age squared and years of education of the children's mothers. See table 2.3 for a definition of the intensity variables. Data Source: 1990, 1995, 2000, and 2005 Colombia Demographic and Health Surveys.

Table 2.5: Measuring the Impact of the Earthquake on School Enrollment for Children Aged 11 to 15

Dependent Variable: School Enrollment	[1]	[2]	[3]
Affected * Year 1990	0.024		
	[0.062]		
Affected * Year 2000	-0.077*		
	[0.040]		
Affected * Year 2005	-0.148**		
	[0.067]		
Quindio * Year 1990		-0.062	-0.057
		[0.041]	[0.044]
Quindio * Year 2000		-0.057***	-0.065***
		[0.015]	[0.013]
Quindio * Year 2005		-0.049*	-0.053**
		[0.024]	[0.021]
Less Affected * Year 1990		0.037	
		[0.064]	
Less Affected * Year 2000		-0.081*	
		[0.044]	
Less Affected * Year 2005		-0.158**	
		[0.073]	
Less Affected (Intensity) * Year 1990			0.227
			[0.440]
Less Affected (Intensity) * Year 2000			-0.714**
			[0.263]
Less Affected (Intensity) * Year 2005			-0.921
			[0.545]
P-value Testing Equality Between Quindio and Less Affected Departments in 2000		0.585	
P-value Testing Equality Between Quindio and Less Affected Departments in 2005		0.136	
Year Fixed Effects	Yes	Yes	Yes
Department Fixed Effects	Yes	Yes	Yes
Region-specific Time Trends	Yes	Yes	Yes
Demographics Controls	Yes	Yes	Yes
N	27,774	27,774	27,774

Note: Robust standard errors in brackets, clustered at the department level. Statistically significant *** at 1%, ** at 5%, and * at 10%. Results are weighted using survey-sampling weights. See table 2.4 for a definition of Demographic controls and variables used. Data source: 1990, 1995, 2000, and 2005 Colombia Demographic and Health Surveys.

Table 2.6: Measuring the Impact of the Earthquake on Height-for-Age Z-scores for Children under 5, Restricting the Sample to Years 1995 and 2000

Dependent Variable: Height-for-age Z-score	[1]	[2]
Quindio * Year 2000	-0.242***	-0.244***
	[0.024]	[0.021]
Less Affected (Intensity) * Year 2000	-0.313	-0.186
	[0.684]	[0.652]
Year Fixed Effects	Yes	Yes
Department Fixed Effects	Yes	No
Municipality Fixed Effects	No	Yes
Region-specific Time Trends	Yes	Yes
Demographics Controls	Yes	Yes
N	8,688	8,688

Note: Robust standard errors in brackets, clustered at the department level. Statistically significant *** at 1%, ** at 5%, and * at 10%. Results are weighted using survey-sampling weights. Demographic controls include child age in months; child age in months squared; child gender; area of residence (urban vs. rural); household head's gender; and age, age squared and years of education of the children's mothers. “Quindio” indicates a child living in Quindio. "Less Affected (Intensity)” indicates for each department other than Quindio the proportion of the population indirectly affected by the earthquake. Data source: 1995 and 2000 Colombia Demographic and Health Surveys.

Table 2.7: Measuring the Impact of the Earthquake on School Enrollment, Restricting the Sample to Years 1990 and 1995 or Years 1995 and 2000

Dependent Variable: School Enrollment	[1]	[2]	[3]
Panel A: Children Aged 6 to 10			
Quindio * Year 1990			-0.006
			[0.053]
Quindio * Year 2000	-0.084***	-0.083***	
	[0.012]	[0.012]	
Less Affected (Intensity) * Year 1990			0.291
			[0.586]
Less Affected (Intensity) * Year 2000	-0.097	-0.087	
	[0.133]	[0.135]	
Panel B: Children Aged 11 to 15			
Quindio * Year 1990			-0.072
			[0.044]
Quindio * Year 2000	-0.051***	-0.049***	
	[0.011]	[0.011]	
Less Affected (Intensity) * Year 1990			-0.147
			[0.541]
Less Affected (Intensity) * Year 2000	-0.353***	-0.332***	
	[0.104]	[0.106]	
Year Fixed Effects	Yes	Yes	Yes
Department Fixed Effects	Yes	No	Yes
Municipality Fixed Effects	No	Yes	No
Region-specific Time Trends	Yes	Yes	Yes
Demographics Controls	Yes	Yes	Yes
N Panel A	10,175	10,175	9,276
N Panel B	9,855	9,855	8,818

Note: Robust standard errors in brackets, clustered at the department level. Statistically significant *** at 1%, ** at 5%, and * at 10%. Results are weighted using survey-sampling weights. Demographic controls include child age in months; child age in months squared; child gender; area of residence (urban vs. rural); household head's gender; and age, age squared and years of education of the children’s mothers. “Quindio” indicates a child living in Quindio. "Less Affected (Intensity)” indicates for each department other than Quindio the proportion of the population indirectly affected by the earthquake. Data source: 1990, 1995, and 2000 Colombia Demographic and Health Surveys.

Table 2.8: Migration by Quindio, Less Affected and Non-affected Departments - Years 2000 and 2005

	Quindio Department	Less Affected Departments	Non Affected Departments	Differences			
	[1]	[2]	[3]	[1-3]		[2-3]	
Panel A: Children Aged 0 to 5							
% of Migrants in 2000	14.9	13.7	12.6	2.3		1.1	
% of Migrants in 2005	32.5	23.2	26.6	5.9	**	-3.5	
Panel B: Children Aged 6 to 10							
% of Migrants in 2000	15.5	8.0	9.0	6.5	***	-1.0	
% of Migrants in 2005	25.1	19.6	18.4	6.7	**	1.2	
Panel C: Children Aged 11 to 15							
% of Migrants in 2000	2.8	8.8	6.6	-3.8	***	2.2	*
% of Migrants in 2005	21.8	15.4	15.0	6.8	***	0.4	

Note: Differences in migrants between affected and non-affected departments are statistically significant *** at 1%, ** at 5%, and * at 10%. Robust standard errors in brackets, clustered at the department level (results not reported). "Quindio" indicates a child living in Quindio. "Less Affected" indicates Caldas, Quindio, Risalda, Tolima, and Valle del Cauca. Migrants denote those children: (1) living for one year or less in the current place of residence in 2000 or (2) living for six years or less in the current municipality in 2005. Data source: 2000 and 2005 Colombian Demographic and Health Survey.

Table 2.9: Measuring the Impact of the Earthquake on Height-for-age Z-scores and School Enrollment on Non-Migrants

Dependent Variable:	Height-for-age Z-score	School Enrollment	
		Aged 6-10	Aged 11-15
	[1]	[2]	[3]
Quindio Department * Year 1990		-0.025	-0.058
		[0.050]	[0.042]
Quindio Department * Year 2000	-0.236***	-0.097***	-0.068***
	[0.036]	[0.017]	[0.013]
Quindio Department * Year 2005	0.095	-0.037	-0.069***
	[0.056]	[0.028]	[0.022]
Less Affected (Intensity) * Year 1990		0.354	0.243
		[0.421]	[0.421]
Less Affected (Intensity) * Year 2000	-0.584	-0.309	-0.723***
	[0.582]	[0.452]	[0.247]
Less Affected (Intensity) * Year 2005	0.029	-0.740	-0.887
	[0.468]	[0.724]	[0.534]
Year Fixed Effects	Yes	Yes	Yes
Department Fixed Effects	Yes	Yes	Yes
Region-specific Time Trends	Yes	Yes	Yes
Demographics Controls	Yes	Yes	Yes
N	15,366	22,530	21,443

Note: Robust standard errors in brackets, clustered at the department level. Statistically significant *** at 1%, ** at 5%, and * at 10%. Results are weighted using survey-sampling weights. Demographic controls include child age in months; child age in months squared; child gender; area of residence (urban vs. rural); household head's gender; and age, age squared and years of education of the children's mothers. "Quindio" indicates a child living in Quindio. "Less Affected (Intensity)" indicates for each department other than Quindio the proportion of the population indirectly affected by the earthquake. Migrants denote those children: (1) living for one year or less in the current place of residence in 2000 or (2) living for six years or less in the current municipality in 2005. Data source: 1990, 1995, 2000, and 2005 Colombia Demographic and Health Surveys.

Table 2.10: Measuring the Impact of the Earthquake on Height-for-age Z-scores and School Enrollment by Gender

Dependent Variable:	Height-for-age Z-score		School Enrollment			
			Aged 6-10		Aged 11-15	
	Male	Female	Male	Female	Male	Female
	[1]	[2]	[3]	[4]	[5]	[6]
Quindio Department * Year 1990			-0.072	0.027	-0.069	-0.028
			[0.054]	[0.053]	[0.050]	[0.041]
Quindio Department * Year 2000	-0.480***	-0.284***	-0.104***	-0.038**	-0.071***	-0.061***
	[0.037]	[0.056]	[0.020]	[0.018]	[0.019]	[0.015]
Quindio Department * Year 2005	-0.234***	0.313***	-0.045	-0.044	-0.067***	-0.032
	[0.027]	[0.100]	[0.034]	[0.028]	[0.022]	[0.026]
Less Affected (Intensity) * Year 1990			0.406	0.274	-0.15	0.595
			[0.461]	[0.453]	[0.452]	[0.459]
Less Affected (Intensity) * Year 2000	-0.330	-0.893	-0.368	-0.343	-0.640***	-0.762*
	[0.814]	[0.829]	[0.505]	[0.403]	[0.208]	[0.380]
Less Affected (Intensity) * Year 2005	0.077	-0.022	-0.767	-0.678	-0.953*	-0.884
	[0.356]	[0.921]	[0.853]	[0.613]	[0.525]	[0.572]
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Department Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Region-specific Time Trends	Yes	Yes	Yes	Yes	Yes	Yes
Demographics Controls	Yes	Yes	Yes	Yes	Yes	Yes
N	9,442	9,266	14,365	13,894	13,995	13,779

Note: Robust standard errors in brackets, clustered at the department level. Statistically significant *** at 1%, ** at 5%, and * at 10%. Results are weighted using survey-sampling weights. Demographic controls include child age in months; child age in months squared; area of residence (urban vs. rural); household head's gender; and age, age squared and years of education of the children's mothers. See table 2.7 for a definition of the intensity variables. Data source: 1990, 1995, 2000, and 2005 Colombia Demographic and Health Surveys.

CHAPTER 3
WHO ELSE BENEFITS FROM CONDITIONAL CASH TRANSFERS PROGRAMS? INDIRECT EFFECTS ON SIBLINGS IN NICARAGUA

1. Introduction

Conditional Cash Transfers (CCT) are social assistance programs whose main objectives are (1) to reduce poverty through the provision of cash transfers to poor families and (2) to reduce the inter-generational transmission of poverty by making these transfers conditional on the compliance of key human capital investments. Mexico and Brazil first adopted CCT programs in the 1990's. Since then, similar social programs have been popularly implemented in more than a dozen countries in Latin American and the Caribbean (LAC). More recently, these programs have begun to spread to a number of countries in Africa and Asia.

CCT programs are designed to ensure that households invest in the health and schooling of their children. To this end, the monetary transfers offered to the beneficiaries' families typically combine two core components that aim at producing synergies to the beneficiaries' households. The first component is a food security, health, and nutrition grant designed to promote healthcare. This grant is offered in exchange for free preventative interventions - i.e. nutritional supplements and education on hygiene and nutrition - or monetary transfers for the purchase of food. The second component is an educational grant designed to increase the school enrollment of targeted child populations. This grant is offered upon proof of regular school attendance for the targeted children.

When the educational component is conditional on the school attendance of only certain children in the household, others siblings within the same household might be indirectly affected. With the program inducing behavioral changes among the beneficiaries' households, the program might indirectly affect non-targeted siblings by means of a combination of several mechanisms. The CCT program could have a positive effect on the human capital accumulation of non-targeted siblings if: (1) the extra income that the household receives reduces the opportunity cost of schooling for all the children, (2) parents respond to the new information stressed by these programs about the return of investment in education, (3) non-targeted siblings becomes more interested in school as a result of the educational supply guaranteed by the program. Nevertheless, the CCT program might have a negative effect on non-targeted siblings if parents compensate for a reduction in work of the targeted children by increasing the labor participation of non-targeted siblings. Attaching the educational grant only to certain kids in the household could reinforce parental preferences that favor certain children.

This paper reports on new evidence from an experimental CCT pilot program in Nicaragua called *Red de Proteccion Social* (RPS) to identify indirect effects on non-targeted siblings. One specific objective of the RPS program was to reduce school desertion during the first four years of primary school (Maluccio and Flores 2005). As a result, education transfers were made conditional on the enrollment of those children aged 7 to 13 who had not completed 4^{th} grade. No requirements were made on the school enrollment of their siblings in other ages and grades ranges. A rich literature has traditionally concentrated on addressing the effects of the program on targeted children (Maluccio and Flores 2005; Maluccio 2005; Gitter and Barham 2008, 2009; Dammert 2009; Maluccio, Murphy, and Regalia 2010). In contrast, the potential indirect effects of the RPS program on non-targeted siblings have received little attention in the academic literature. Considering indirect effects is critical for measuring the full impact of CCT interventions.

This paper fills this gap, contributing to the existing CCT literature in two main ways. First, it complements previous RPS evaluations by studying the indirect effects within households on the schooling and employment of two groups of non-targeted siblings: those aged 9 to 13 who have already completed 4th grade and those aged 14 to 17 who are too old to be eligible.[37] Second, this paper adds to the nascent literature addressing indirect effects of CCT programs through spillovers effects between neighborhoods (Angelucci and De Giorgi 2009; Bobonis and Finan 2009; Lalive and Cattaneo 2009; Macours and Vakis 2009) and within households (Ferreira, Filmer and Shady 2009; Takamatsu 2009; Barrera-Osorio et al. 2011).[38]

Evidence of negative or null indirect effects for non-targeted siblings has been found under child-specific CCT settings. Child-specific programs are characterized by their lack of a health and nutrition component. They only direct educational grants towards households with children in certain transition grades upon their regular school attendance. Ferreira et al. (2009) evaluated the CESSP Scholarship program in Cambodia and found that although the program significantly increases school attendance and decreases work participation for middle school aged students; it has a null effect for their non-targeted siblings. Barrera-Osorio et al. (2011) studied the program Conditional Subsidies for School Attendance in Bogota to find that the

[37] The legal starting age for first grade is seven years old. However a child is allowed to start at an earlier age if he has attended pre-school (Maluccio et al. 2009).
[38] Using the Oportunidades CCT evaluation data in Mexico, Bobonis and Finan (2009) identified neighborhood spillover effects on secondary school enrollment and grade promotion. The authors presented evidence that Oportunidades benefits ineligible children living in both treated and non-treated communities. Lalive and Cattaneo (2009) provided additional evidence to the previous study, focusing on both children who are still in primary school as well as those facing the transition from primary to secondary school. Their results indicate that the ineligible children acquire more schooling. Angelucci and de Giorgi (2009) analyzed whether cash transfers directed to eligible households have some impact on the consumption of ineligible households living in the same villages. The authors showed that ineligible households in treatment villages consume more than ineligible households in non-treated communities. Using the "Atencion a la Crisis" CCT data in Nicaragua, Macours and Vakis (2009) addressed the role of social interactions. The authors found large social externality effects on human and physical capital accumulation and aspirations, depending on the proximity of households to beneficiaries' women with leadership responsibilities in the community.

siblings (particularly sisters) of targeted students in grades 6 to 11 are less likely to participate in school.[39]

Most relevant to the current study, Takamatsu (2009) analyzed indirect effects on school participation, education expenditures, and hours of work within families in the RPS program.[40] The author found positive effects on schooling and labor for siblings aged 14 to 17 with fewer than 4 years of education, with effects being similar for both males and females. While similar in some respects, the present study differs from Takamatsu's paper in several important ways. First, it uses a conventional identification strategy to estimate the impact of the program.[41] Second, it analyzes a larger set of heterogeneous impacts to better understand the mechanisms that drive the effects on the human capital accumulation of non-targeted siblings - i.e. gender, type of work, pre-intervention household poverty status, pre-intervention level of education, and pre-intervention school supply conditions. Third, this paper explores the impact of the RPS program on the joint probability of attending school and working and on school grade progression. School progression is considered a broader measure that summarizes school enrollment, repetition, and dropout indicators.

Results from the current study show that the RPS program increases school participation of non-targeted siblings aged 14 to 17. Unlike those in Takamatsu (2009), findings from this paper indicate that boys mainly drive these impacts. Indeed, the gains on school participation for boys are associated with a reduction of their labor supply. Impacts are concentrated among male siblings with considerable low pre-intervention year of education or living in settings with poor

[39] While the CSP program offers small transfers, equivalent to 3 percent of the total expenditures of the average recipient household, Conditional Subsidies for School Attendance offers reasonably larger transfers, equivalent to about 8 percent of expenditures for the median recipient household (Ferreira et al. 2009).
[40] This paper and Takamatsu's paper were written independently.
[41] Takamatsu (2009) used non-linear random effect panel probit models for school participation and Selection MLE models for hours of work. Then, difference-in-difference estimates were constructed using the predicted estimations that arose from these model specifications.

pre-intervention school supply conditions. Grade progression also shows significant gains with the program for both male and female siblings aged 14 to 17, who progressed two years in primary education during the intervention.

Overall, findings provide some indications that the RPS program constitutes a substantial infusion of liquidity among beneficiary households. RPS program particular settings -i.e. considerable credit-constraint households, large transfer amount, poor pre-intervention levels of education, and guarantee of primary school services- likely drive the positive impacts reported in this paper.

2. Background

2.1 Review of previous RPS evaluations

The RPS literature concentrates on studying the effects of the program on the schooling and employment of targeted children and on adult labor supply.[42] This paper differs from the existing literature by studying the indirect effects within households on the schooling and employment of non-targeted siblings.

The International Food Policy Research Institute (IFPRI) conducted an evaluation of the RPS pilot, identifying program effects on the basis of random assignment. Reports from these evaluations, including Maluccio and Flores (2005) and Maluccio (2005), showed that the RPS program has overwhelmingly positive impacts. Maluccio and Flores (2005) found that the RPS significantly increased school enrollment by 18 percent for targeted children, with the largest gains being among the poorest families. Similarly the authors presented evidence that the percentage of targeted children who work declined by 5.6 percent.

[42] See Fiszbein and Shady (2009) for a detailed review of the impacts of CCT programs adopted in other countries. Those evaluations showed uniformly positive results on short-term indicators: better health, greater school attendance, less child work, and improved household consumption.

During the two-year of the intervention, beneficiaries' areas suffered a record decline on coffee prices in the world market. Maluccio (2005) studied the differential effect of the RPS program by coffee-growing communities and found that the RPS has an important risk-coping role in times of shocks. Gitter and Barham (2009) analyzed the differences between coffee and non-coffee communities among households at varying wealth levels. Their evidence showed that RPS had the largest positive impacts on the school enrollment of poorer targeted children in coffee communities.

Two papers explored RPS differential effects on targeted children by observable demographics characteristics. Gitter and Barham (2008) examined heterogeneous impacts through intra-household power differences, measuring power as the ratio of years of education between the female and male head of the household. The authors found that greater female power leads to higher school enrollment. Dammert (2009) studied heterogeneous impact by children demographics characteristics and found that boys experienced a larger positive impact on schooling and a larger negative impact on work participation and hours worked. While children located in more impoverished areas experienced larger impacts on schooling, they experienced smaller impacts on working hours. Further, older children experienced smaller impacts on both school and work participation.

Maluccio, Murphy, and Regalia (2010) combined administrative with household data to explore the impact of the program by pre-intervention school supply condition. The authors found that initial supply conditions led to heterogeneous effects. Grade progression of targeted children was higher in areas with autonomous schools and poorer pre-intervention supply conditions (measured by indicators of grade availability and distance to school).

Since CCT programs modify the income of the household and, potentially, the allocation of time within the household through their impact on targeted children's work and school enrollment, they could affect the labor supply of adults in beneficiary households. Empirical literature has shown that the RPS program appears to have either no effect or modest effects on adult work. Maluccio (2007) analyzed the potential impact of the RPS program on the labor supply of adults (measured by the total hours of work per household). His findings indicated a small but significant effect of the program on adult labor supply. Alzua, Cruces, and Ripani (2010) provided additional evidence; studying the impact on adult labor supply in three CCT experimental programs, which include the RPS. Their findings suggested that the RPS program had no effect on the labor supply of eligible adults.[43]

2.2 Indirect mechanisms

Since CCT programs induce household behavioral change, non-targeted siblings might be indirectly affected by means of a combination of several mechanisms.

2.2.1 Displacement and Income effects

Ferreira et al. (2009) presented a theoretical model that highlights two economics mechanisms through which educational grants that are conditional on the school attendance of only certain children could indirectly affect other siblings within the same household. The main prediction of the theoretical model is that educational grants increase the school enrollment of targeted children. Nonetheless the effect on schooling for the non-targeted siblings is ambiguous, reflecting a combination of two mechanisms: displacement and income.

Among those households that only enroll one child in school, there might be a negative displacement effect. The opportunity cost of going to school for the non-targeted child remains

[43] The authors presented similar evidence for two additional experimental CCT programs, Oportunidades in Mexico and PRAF in Honduras. Skoufias and Di Maro (2008) presented similar evidence for Mexico.

equal to her forgone wage, whereas the opportunity cost of going to school for the targeted child decreases. In this situation, parents might replace the non-targeted child already in school with the targeted sibling. Nonetheless, among those households that would not send any children to school in the absence of the program, there might be a positive income effect. If household income rises as a consequence of the program, parents might forego the non-targeted child's wage to enroll him in school.

2.2.2 Behavioral change, supply conditions, and misunderstanding of the conditionality

The effect of these programs on non-targeted siblings schooling outcomes might be associated with the exposure of parents to new information and practices, which stress the importance of investing in the human capital of their children (Fiszbein and Shady 2009). It also might be associated with the fact that transfers are made to the mothers. Theoretical and empirical work shows that females, more so than males, generally devote a larger share of the income to children (Thomas 1990; Lundberg and Pollak 1993; Rubalcava, Teruel and Thomas 2004; Gitter and Barham 2008).

Additionally, school supply should be guaranteed in areas where CCT are concentrated. As a result, non-targeted siblings who are least likely to use services in the absence of the intervention could become more interested in school. Nonetheless, it might be the case that the increase in enrollment rates may not lead to learning if higher enrollment induces crowding and lower school quality (Ahmed and Arends-Kuenning 2006; Parker, Rubalcava and Teruel 2008). Lastly, indirect effects on non-targeted siblings could be driven by the fact that beneficiaries misunderstand the conditionality attached to the transfers, e.g. they incorrectly believe it is required to send all their children to school in order to receive the educational grant.

3. The RPS Program in Nicaragua

3.1 Country overview

Nicaragua is a low-income country, the second poorest country in LAC after Haiti. In 1998, Nicaragua had a GDP per capita of $741 and 47 percent of the Nicaraguan population was living with less than $2 per day (see figure 3.1, panel (a)). Nicaragua's education system has substantial inequities in access and quality between both richer and poorer households and urban and rural areas (World Bank 2008). The 1998 Living Standards Measurement Survey data showed that differences in socioeconomic background had a large impact on enrollment rates for children at all ages. Schooling dropout rates increased significantly at the transition between primary and middle school (after the age of 12), particularly among the poorest (see figure 3.1, panel (b)). Estimations from the World Bank (2008) showed that delayed entry into first grade is a widespread phenomenon among the poor and in rural areas. Furthermore, only 32 percent of the population aged 20 to 24 had completed a secondary level of education. RPS was born as part of a comprehensive Nicaraguan social safety net for poverty reduction and was one of the first CCT program implemented in a low-income economy.

3.2 Intervention and experimental design

The RPS pilot program lasted from 2000 to 2002, and its budget was equivalent to 0.2 percent of Nicaragua's GDP (Moore 2009). The pilot was implemented in the rural states of Madriz and Matagalpa, known to have high poverty rates, low levels of development, and some capacity to implement the program - i.e. these states had relatively adequate supply-side supports, such as primary schools.[44] From these two states, 42 communities were selected to participate in the pilot. The geographic target selection was based on the ranking of a marginality index that was

[44] Between 36 to 61 percent of the rural population living in the communities located in the states of Madriz and Matagalpa were considered poor, whereas between 78 to 90 percent were considered extremely poor (Maluccio and Flores 2004).

constructed with information from the 1995 Census. Of these 42 communities, 21 were randomly selected to receive the intervention and the other 21 served as control communities. Lastly, 42 households were randomly selected in each community. Households were selected by means of a census carried out three months prior to the first pre-intervention evaluation survey, yielding an initial target sample of 1,764 households.

The RPS program was designed to achieve three specific goals: (1) supplement household income for up to three years to increase expenditures on food, (2) reduce school desertion during the first four years of primary school, and (3) increase the nutritional status of children under age 5 (Maluccio and Flores 2005). The transfer had two core components and was distributed to the female head of each household, so long as the household fulfilled certain responsibilities:

(i) Food security, health, and nutrition monetary grants were offered bi-monthly to all beneficiaries' households. Reception of the transfer was contingent on attending bi-monthly educational workshops and on bringing children under the age of 5 for scheduled preventive healthcare appointments.

(ii) Education monetary grants were offered bi-monthly to beneficiary families that had at least one child between the ages of 7 and 13 who had not completed the 4th grade. This grant, known as the "school attendance transfer", was contingent on school enrollment and regular school attendance of targeted children. The transfer was fixed per-household, regardless of the number of targeted children in school. Additionally, for each targeted child, the household received an annual per-student transfer for school supplies, known as the "school supplies transfer" which was contingent only on enrollment. There was also a small supply-side transfer, known as the "teacher transfer." The transfer was per-student and it was intended to compensate teachers for

their increased workload due to the RPS intervention. Each student was to deliver this transfer to the teacher and RPS officials monitored the delivery of these funds.

Overall the monetary transfers were about 21 percent of the total annual household expenditures in beneficiaries' households in the pre-intervention year.[45] Uptake and compliance with the responsibilities were relatively high among eligible households. During the two-years pilot, approximately 10 percent of beneficiaries were penalized at least once; they either did not receive their transfer or received only one component. Less than one percent of the households were expelled (Maluccio and Flores 2005).

3.3 Data

The data used in the present analysis was collected for the evaluation of the RPS program in its pilot phase. The survey is based on a stratified random sample at the community level. The data is from an annual household panel survey implemented in both treatment and control areas before and after the program started in 2000. The first wave of the survey was carried out in late August and early September 2000. In October 2001, when beneficiaries had been receiving transfers for 13 months, a second wave was conducted. Finally, in October 2002, when beneficiaries had received transfers for 25 months, a third wave was carried out. Attrition rates in the data were reasonably low, approximately 12 percent over the two years. There were no differences in attrition between the control and treatment areas, suggesting no systematic attrition bias in the analysis (Maluccio and Flores 2005; Fiszbein and Shady 2009).

The analysis in this study used a balanced panel of households to avoid changes in sample composition when estimating the differences between 2000 and 2001 and between 2000 and 2002 (Maluccio 2005; Dammert 2009). To study indirect effects within the household, I

[45] The food security transfer represented 13 percent of the total annual household expenditures in beneficiaries' households before the program. Beneficiaries' households with targeted children received additional transfers of about eight percent.

restricted the sample of households to those that have targeted children with non-targeted siblings. The household sample at the pre-intervention year represents 34 percent of the total RPS household population. Throughout the analysis, I divided the sample of non-targeted siblings into two groups because of the likelihood that they would be affected differently by the intervention: (i) those aged 9 to 13 who had completed 4^{th} grade, called "younger non-targeted siblings", and (ii) those aged 14 to 17, called "older non-targeted siblings". The final panel sample yielded 2,867 targeted children, 481 younger non-targeted siblings, and 1,884 older non-targeted siblings. Each group of children was evenly distributed in control and treatment households.

3.4 Descriptive statistics and the random assignment process

The first question to ask about a randomized experiment is whether the randomization successfully balanced individual and household characteristics for the treatment and control groups. Table 3.1 reports descriptive characteristics at the pre-intervention year for the sample of households with targeted children and non-targeted siblings. At the baseline, characteristics between the control and the treatment samples are statistically indistinguishable. Furthermore, tables 3.2 and 3.3 report school and labor descriptive statistics for the sample of targeted children and non-targeted siblings at the pre-intervention year. While columns 1 and 2 report some differences in means that are statistically significant between gender groups, columns 3 and 4 show that outputs between treatment and control groups are not statistically significant with the exception of labor participation and work for pay among females' younger non-targeted siblings.

Tables 3.2 and 3.3 also report that the overall educational distribution of the children is concentrated on considerable lower levels of attainment. For targeted children, the average years of schooling is 0.9 and the enrollment rates are above 70 percent. As expected, school attainment and enrollment rates for younger non-targeted siblings are the highest. The average years of schooling are 4.5, and school participation rates are above 80 percent. Nevertheless, within this group, there is a significant difference in the enrollment rates between boys and girls. For older non-targeted siblings, the average years of schooling are fewer than 4 and the enrollment rates are lower than 40 percent. Girls are, on average, one year more educated than boys. Among those siblings enrolled, 10 percent reported to be at a walking distance further than 30 minutes to the nearest primary school. Results suggest that older non-targeted siblings are likely to drop out of school before finishing a primary level of education.

Child labor is higher for boys than girls.[46] Work participation increased by age. While 21 percent of boys' targeted children participate in work, 78 percent of older non-targeted male siblings are engage in labor activities. A large proportion of those who work are engaged in unpaid labor activities. In general, older non-targeted siblings work in agriculture activities.[47]

4. Empirical identification strategy

Figure 3.2 illustrates the empirical identification strategy of this paper. The upper panel of figure 3.2 presents enrollment rates by age for the treatment and control groups of targeted children and non-targeted siblings at the pre- and post-intervention years. The figure mimics the pattern of national enrollment rates as school participation declines considerably after the age of 13. The lower panel of the figure reports the difference in enrollment rates between the control and treatment groups with a 95 percent bootstrap confidence interval. Before RPS intervention, and due to the randomization of the program, differences in enrollment rates between the control and treatment groups are not statistically significant. Nonetheless, after the first and second year of

[46] The RPS evaluation survey asks all individuals over age six whether work was their primary activity in the previous week. The question was oriented to recollect information toward economically productive activities aside from housework. Employment denotes working for pay or other remuneration outside the household, as well as unpaid labor in household enterprises such as agriculture or small business.

[47] The differences in employment rates between boys and girls might reflect the underreporting of domestic work.

the intervention, the figure shows a substantial improvement in the enrollment rates for both targeted children (children aged 7 to 13) and non-targeted siblings (children aged 14 to 17). This result provides suggestive evidence that the RPS program might have indirectly affected the school participation of non-targeted siblings.

The empirical identification strategy relies on a difference-in-difference (DD) estimator, which compares school enrollment and work participation differences between treatment and control groups before and after the RPS program intervention. The identification assumption required for DD estimation is that, in the absence of any treatment, the outcomes would have evolved similarly in both treatment and control groups.

The randomization, and the fact that the control and treatment samples are balanced in observed characteristics, implies that performing a simple DD estimator likely provide the causal effect of interest. However, I controlled for any unobserved community factors that remain constant over time by using community fixed effects. In addition, I controlled for observable individual characteristics, such as age and gender that are uncorrelated with the treatment status. The inclusion of additional covariates in random experiments allows to control for any potential differences not accounted for in the randomization and to improve the precision of the estimates of the causal effect of interest. If these controls are not systematically related with the treatment, they do not affect the estimates of the parameter of interest (Getler 2004). The following standard DD model specification estimates the impact of the RPS program:

$$y_{ijct} = \beta_0 + \gamma_c + \sum_s \beta_{1s} year_{st} + \sum_s \beta_{2s} \left(year_{st} * Treat_c \right) + x'_{ijct}\beta_3 + \varepsilon_{ijct} \quad (3.1)$$

where subscript t refers to years 2000, 2001, and 2002 and subscript s refers to post-intervention surveys 2001 and 2002. y_{ijct} denotes the outcome of interest for individual i in household j and community c at period t, γ_c denotes community fixed effects, $year_{st}$ is a time fixed effect which is equal to one when observation t is in year s and zero otherwise, $Treat_c$ is an indicator variable representing treatment status for community c, x_{ijct} is a vector of individual characteristics and ε_{ijct} is a random error term. The parameter of interest is β_{2s}, which captures the average treatment effect of the program.

Since eligibility for the program is defined at the community level, the standard errors of the DD estimates account for the likely serial correlation to avoid a potential bias. Indeed, the specifications are estimated using robust standard errors clustered at the community level.[48] I used linear probability models to estimate consistent causal effects. Because gender might play an important role in the decision to attend school and to participate in labor activities, in particular for the older non-targeted siblings, I estimated the model for the total sample of children and then separately by gender.

5. Empirical Results

5.1 Sample of targeted children living in households with non-targeted siblings

Panel A of table 3.4 reports the impact of the RPS program on both schooling and employment for the sample of targeted children living in households with non-targeted siblings. These results are consistent with those reports in previous evaluations where the total population of targeted children is considered. On average, the RPS program increases the enrollment for targeted children by 18 and 14 percent in 2001 and 2002, respectively. The point estimates indicate that the program has a slightly greater impact for girls than for boys. After the intervention, treated

[48] Bertrand, Duflo, and Mullainathan (2004) highlighted the consequences of serial correlation for clustered panels.

girls are 21 and 19 percent more likely to be enrolled in school than girls in the control group. Moreover, enrollment rates for treated boys increase 17 and 10 percent after the intervention. In reference to the participation in the labor market, the RPS decreased the number of targeted children working in 2002 by 7 percent.

5.2. Sample of non-targeted siblings

5.2.1 Main impacts

Panels B and C of table 3.4 present the main results of the paper. Panel B reports the results for the sample of younger non-targeted siblings. As expected, the enrollment rates of this group are not affected by the RPS, largely because participation in school is already high before the intervention. Child labor is also not affected in this group.

Panel C reports the results for the sample of older non-targeted siblings. RPS has a positive and large impact on this group of siblings. Enrollment rates increased for siblings living in treated households with targeted children by 13 and 14 percent in 2001 and 2002, respectively. In the first year of the intervention, the positive gains seem to be mainly driven by the increase in school participation of male siblings, who are 16 percent more likely to participate in school. In the second year of the intervention, female and male siblings are 12 and 16 percent more likely to be enrolled in school than those who lived in control households. For each year of intervention, the gains for males represent an increase of 47 percent of the enrollment rate in the pre-intervention year. In addition, the gains for females represent an increase of 31 percent of the enrollment rate in the pre-intervention year.

The RPS program has a negative impact on work participation for older non-targeted siblings. These gains are mainly driven by the labor supply reduction of male siblings. Due to the intervention, the proportion of older male siblings who work decreased by 13 and 15 percent.

This impact represents a decrease of 16 and 19 percent of the work participation rates in the pre-intervention year. These results suggest that the gains in school enrollment for male siblings come hand in hand with a reduction of their labor supply. Table 3.5 confirms previous results, reporting the impact of the RPS on the joint probability of being enrolled in school and working. The table presents evidence that for boys, the reduction in the participation in labor activities is similar to the increase in schooling, implying that school and work operate as substitutes. Nevertheless, this is not the case for the female siblings who have lower pre-program labor force participation rates and higher levels of education. These results are consistent with those found by Skoufias and Parker (2001) in the Mexican CCT program Progresa, where for boys most of the increase in school enrolment came from a reduction in work.

To further analyze the effect of the RPS program on work participation, table 3.6 presents evidence of the impact of the program by types of work. Results show that the RPS has a significantly negative effect on the likelihood of work receiving a payment in 2002. However, this change in employment is not significant when the sample is divided by gender. Particularly, the reduction in the participation in labor activities for boys is mainly driven by a decrease in the likelihood of work in the agriculture sector.

5.2.2 Heterogeneous impacts

I also explored some heterogeneous impacts of the program to understand who benefits the most within the group of older non-targeted children.[49] Table 3.7 reports heterogeneous impacts by pre-intervention poverty level, dividing the sample into two groups. The first group included those children who are located in the two lowest quintiles of the per capita consumption distribution in the pre-intervention year, while the second group included those children who are

[49] The three variables used to estimate heterogeneous effects were determined before the intervention started and were not systematically related to the treatment status.

located in the three upper quintiles. Results suggest gains in schooling participation for male siblings over the entire distribution of per capita consumption in 2000. However, point estimates are slightly greater for the poorest group. On the contrary, results imply that the least poor population significantly drove the reduction on male labor supply.

Table 3.8 reports heterogeneous effects by level of education in the pre-intervention year. Before the RPS intervention, 52 percent of male and 36 percent of female older non-targeted siblings had two or fewer years of education.[50] I then divided the sample into two educational groups: (i) those who had two or fewer years of education in 2000 and (ii) those who had three or more years of education in 2000. Results showed that the increase in school enrollment and the decline in work participation are considerably larger for those non-targeted siblings with very low levels of education before the RPS intervention, particularly for boys.

Table 3.9 reports heterogeneous effects on school and labor participation by distance to the nearest school (in minutes) at the pre-intervention year. For the targeted children, Maluccio et al. (2010) presented evidence of larger effects in settings with poor pre-intervention supply conditions.[51] Base on their study, I divided the sample of older non-targeted siblings into three groups: (i) those living at a close walking distance (less than 10 minutes), (ii) those living at an intermediate walking distance (between 10 and 30 minutes), and (iii) those living at a far walking distance (30 minutes or more).

Like the findings presented in Maluccio et al. (2010) for targeted children, results from the current study suggest significant gains in schooling and labor participation for male non-targeted siblings living at a walking distance larger than 30 minutes to the nearest primary school

[50] Before the RPS intervention, the median year of education is two and four for male and female older non-targeted siblings respectively. 97 percent of boys have six or fewer years of education and 92 percent of girls have six or fewer years of education.
[51] Maluccio et al. (2009) measured initial supply conditions with indicators of grade availability and nearest distance to school.

before the intervention. These results might reflect, in part, that the RPS program encouraged non-targeted children in remotes areas to go to the school to take care of their younger targeted siblings.

5.2.3 Grade progression

Additionally, I investigated whether the RPS program had an effect in grade progression for older non-targeted siblings. Like Maluccio and Flores (2005), I defined grade progression as the probability of advancing two grades in the two years of RPS operation - i.e between 2000 and 2002. Given that two points in time are required to calculate progression and because randomization of the RPS eliminates any potential bias, I identified the impact of the program in grade progression using a first difference in 2002.

Panel A of table 3.10 reports results for the total sample of older non-targeted siblings. The RPS program had a positive and significant effect on grade progression. Both female and male siblings living in treated households are 17 and 12 percent more likely to attain 2 years more of education than those living in control ones, respectively. Panels B and C of table 3.10 reports heterogeneous effects on grade progression by pre-intervention educational level. Like the analysis presented in the previous section, I divided the sample of non-targeted siblings into two educational groups: (i) those who had two or fewer years of education in 2000 and (ii) those who had three or more years of education in 2000. Results suggest the largest impacts of the program for siblings whose schooling outcomes were initially lower. These findings are suggestive that RPS increased progression for older non-targeted siblings in primary levels of education.

5.3. Discussion of the indirect mechanisms

A thorough understanding of the mechanisms by which RPS impacted older male non-targeted siblings would require having detailed household level data on income, including wages and the total amount of transfer that each household received during the RPS intervention. Despite an absence of this information, previous findings provide some suggestions of the likely mechanisms.

First, there is some evidence that the extra income received by beneficiaries' households reduced the opportunity cost of schooling for all the children. The theoretical model presented by Ferreira et al. (2009) indicated that poor households, who would not send any children in the absence of the program, would enroll the targeted child and perhaps their non-targeted siblings if the amount of the monetary transfer was large enough. This fact seems to account for the results observed in the RPS program where beneficiaries were considerably credit-constrained families, the average cash transfer was considerably large, and the pre-intervention school participation of both targeted children and non-targeted siblings was low.

Second, RPS may have also positively affected non-targeted siblings through the guarantee of primary school services. Maluccio et al. (2010) reported evidence that RPS program lead to an increase in primary school services, measured by indicators of grade availability, number of sessions per day, and number of teachers, in the areas with poor pre-interventions supply conditions. The positive gains in enrollment for the older non-targeted siblings are driven by the fact that older children who completed few schooling years and dropped out (or who had no education at all), re-entered (or began) at a primary school level.

Third, the impact of the RPS on non-targeted siblings is unlikely to be explained by mistaken beliefs about the condition attached to the educational transfer. The qualitative evaluation of the RPS pilot acknowledged that beneficiaries clearly understood the benefits of the intervention and its required co-responsibilities (Adato and Roopnaraine 2004; Moore 2009). In addition, to verify that the children fulfilled the RPS schooling conditionality requirements, the RPS monitoring system requested that local teachers record households' compliance with the program requirements. RPS officials regularly collected these forms and recorded the data in a management information system, which was the basis for payment. Lastly, local RPS team in each municipality helped the mothers at the payment post (Moore 2009; Regalia and Castro 2009). Administrative records showed that during the two years of operation, 11 percent of non-targeted siblings aged 14 to 17 living in beneficiaries' households were mistakenly registered in the monitoring system to receive the "school supplies transfer". However, at the payment post, the mothers did not receive these transfers for those children (RPS program administrators kindly provided this data). This evidence suggests that in general, mothers and RPS officials were aware of the conditionality attached to the educational transfer.

6. Conclusion

The RPS educational component was designed to be conditional on enrollment of children aged 7 to 13 that have not completed 4th grade. However, no requirements were made for their siblings. This paper contributes to the growing literature on CCT, addressing the potential indirect effects of the RPS on non-targeted siblings.

This paper presented evidence that there are indirect positive schooling effects for the non-targeted siblings aged 14 to 17 that were too old to be eligible to receive the educational grant. Male siblings mainly drive these impacts, having been 16 percent more likely to participate in school during the two years of the intervention. Indeed, the increase in school participation for boys comes hand in hand with a decline in their labor supply. This is not the case for the female siblings who have lower pre-program labor force participation rates and higher levels of education. RPS encouraged male siblings with no education or only a few years of education to enter or re-enter primary school. Gains seem to be concentrated among boys living in settings with poor pre-intervention primary supply conditions, measured by distance to the nearest school. Increases in boys' enrollments are homogenous over the entire distribution of pre-intervention per capita consumption, although the decline in work is higher for the least poor population.

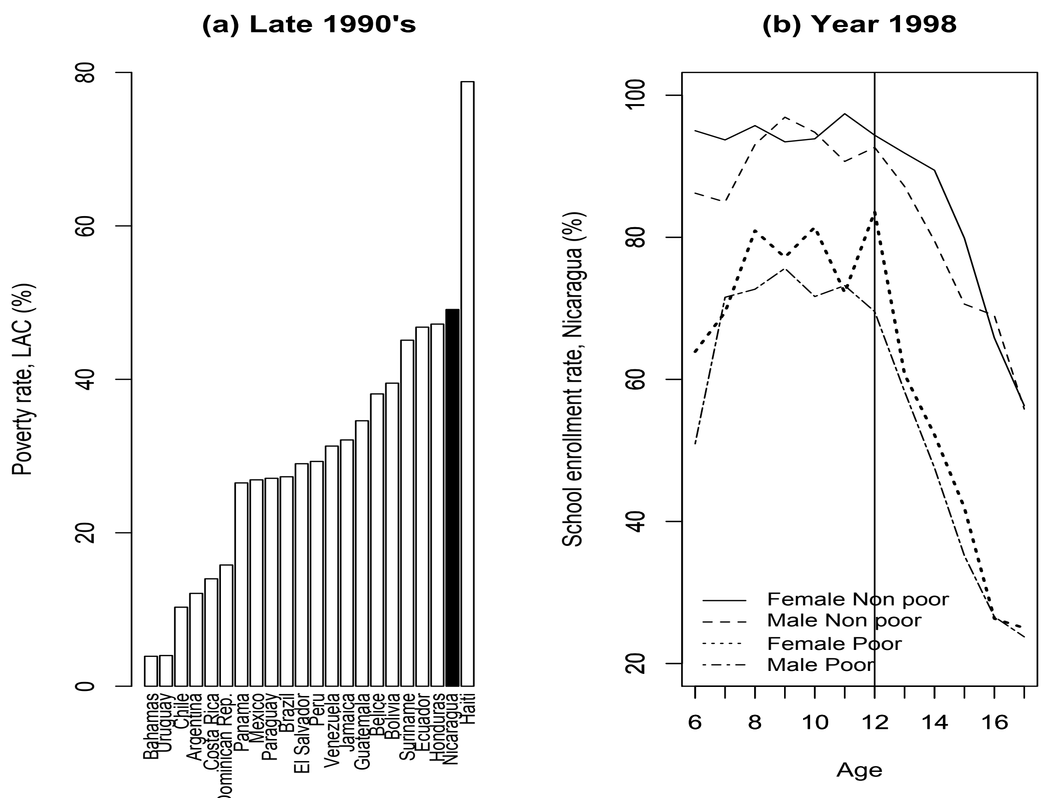
The RPS program increased the probability for both female and male older non-targeted siblings to progress two years in primary school. The World Bank (2008) estimated that for Nicaragua, the return to an extra year of education in 2001 in rural areas was 7.7 percent. Based on this estimation and the results discussed above, wages in adulthood will be 15.4 percent higher for older non-targeted siblings living in beneficiaries' households. Nevertheless, it seems likely that these children will continue living in poverty if they are not able to complete a secondary level of education. Estimations from the World Bank (2008) presented evidence that averages wages for Nicaraguans with complete primary or incomplete secondary level of education are below the poverty line.

Results in the current study are consistent with the notion that the RPS decreases the opportunity cost of schooling for all children within families. However, increases in school enrollment and years of completed schooling may not necessarily result in future poverty reduction if there is no actual learning, undermining the actual effects of the program for both targeted children and non-targeted siblings. Higher unintended school participation may induce reductions in the quality of education as a result of crowding in schools, unless education authorities could identify these constraints and increase school resources.

The findings in this paper highlight the need to consider indirect effects on non-targeted siblings in greater detail when evaluating CCT programs. Studying the indirect effects of CCT programs allow us to quantify the full impact of these interventions and improves our knowledge of a broader issue; how best to implement CCT programs in the future. In this regard, when designing CCT interventions, it is crucial to consider all children who are at higher risk of not attending school in the absence of the program to ensure the supply of adequate education.

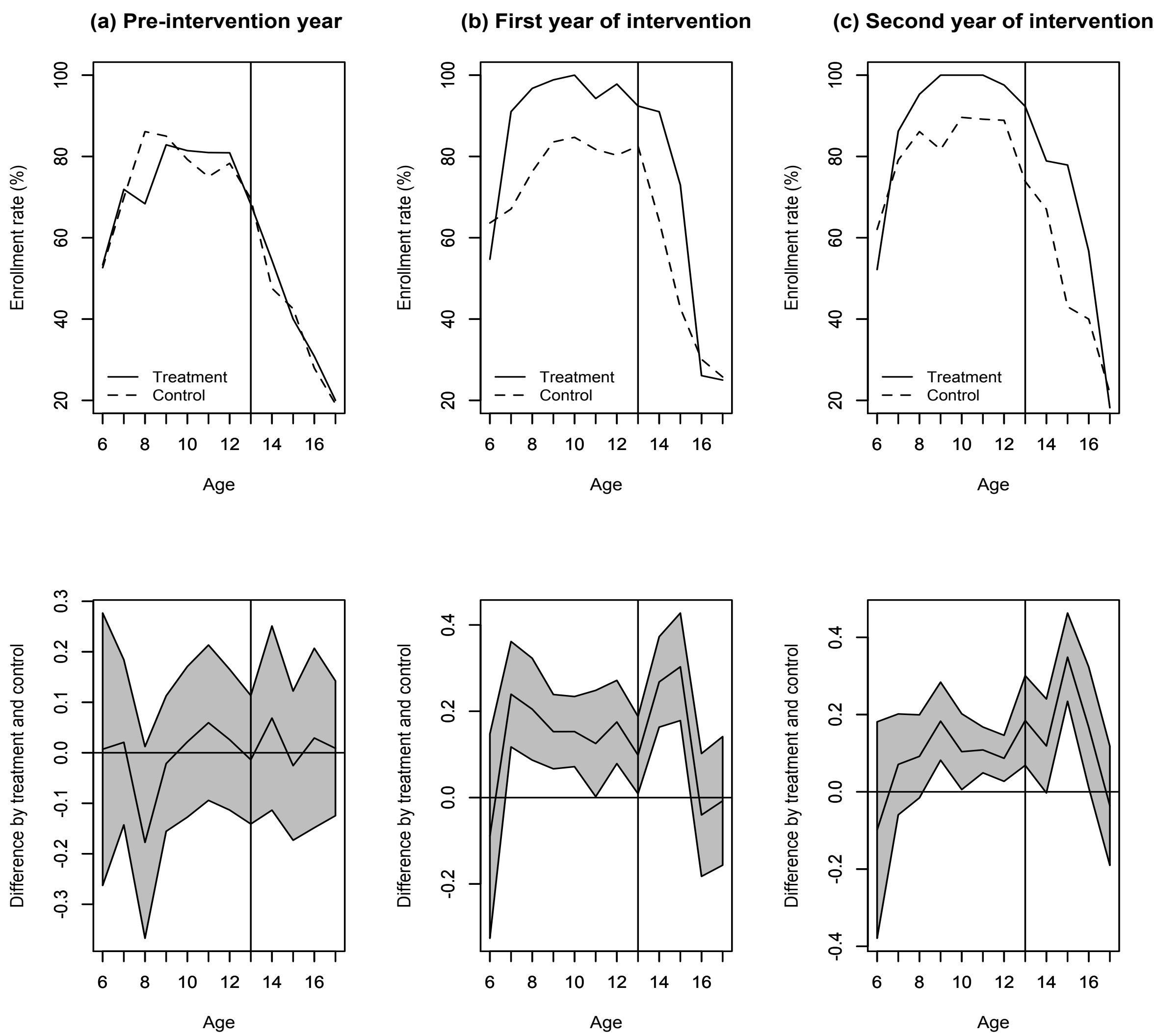
7. Figures and Tables

Figure 3.1: Poverty and school enrollment rates in Nicaragua in the late 1990'



Note: In panel (a) poverty is computed with the USD 2.5 a day line, which coincides with the median value of the extreme poverty lines officially set by the LAC governments (CEDLAS and The World Bank 2010). In panel (b) poverty is defined as having a per capita consumption below the Nicaraguan official poverty line. The vertical line at the age of 12 highlights the age limit for primary education completion.

Figure 3.2: Enrollment rates by age for pre- and post-intervention year



Note: In the upper panel, the solid lines correspond to treatment group and the dashed lines to control group. In the lower panel, the solid lines correspond to the difference in means between treatment and control groups, while the gray area indicates the 95% bootstrapped confidence interval, reflecting standard errors clustered at community level. The vertical line at the age of 13 denotes the age limit for being eligible to receive the RPS educational grant. Data source: based on 2000, 2001, and 2002 Nicaragua's RPS evaluation data.

Table 3.1: Descriptive statistics for the sample households that have targeted children and non-targeted siblings. Pre-intervention year (2000)

	Control	Treatment	Difference
	(1)	(2)	(3)
Head: Male	0.85	0.90	0.04
	[0.03]	[0.02]	[0.03]
Head: Age	46.61	47.33	0.72
	[0.53]	[0.60]	[0.81]
Head: Years of education	1.34	1.56	0.23
	[0.13]	[0.18]	[0.22]
Head: Employed	0.92	0.93	0.01
	[0.02]	[0.02]	[0.02]
Head: In agricultural labor	0.90	0.88	-0.02
	[0.04]	[0.03]	[0.05]
Head: Weekly hours of work	40.55	41.12	0.57
	[1.21]	[1.32]	[1.79]
Wife: Age	41.12	40.72	-0.40
	[0.70]	[0.62]	[0.93]
Wife: Years of education	1.41	1.59	0.18
	[0.15]	[0.18]	[0.24]
Wife: Employed	0.29	0.31	0.02
	[0.06]	[0.04]	[0.07]
Per capita consumption (C$)	2,984.31	3,003.29	18.98
	[158.74]	[139.20]	[211.36]
Household size	8.27	8.20	-0.07
	[0.17]	[0.24]	[0.29]
Drinking water: piped into house	0.10	0.17	0.07
	[0.03]	[0.05]	[0.06]
Lighting: electricity from power	0.22	0.24	0.03
	[0.06]	[0.05]	[0.08]
Toilet: Flush	0.00	0.00	0.00
	[0.00]	[0.00]	[0.00]
Number of rooms	1.65	1.62	-0.03
	[0.07]	[0.08]	[0.11]
N	227	236	

Note: Differences in pre-intervention characteristics between control and treatment are statistically significant *** at 1%, ** at 5%, and * at 10%. Robust standard errors clustered at community level in brackets. Data source: based on 2000 Nicaragua's RPS evaluation data.

Table 3.2: Schooling and employment for the sample of targeted children and younger non-targeted siblings. Pre-intervention year (2000)

	Female	Male	Female		Male	
			Control	Treatment	Control	Treatment
	(1)	(2)	(3)		(4)	
Panel A: Targeted children who have non-targeted siblings						
Years of schooling	0.93	0.91	0.98	0.89	0.97	0.86
	[0.07]	[0.07]	[0.07]	[0.12]	[0.09]	[0.11]
School enrollment	0.78	0.74	0.83	0.73	0.72	0.76
	[0.04]	[0.03]	[0.03]	[0.06]	[0.05]	[0.04]
Work participation	0.07	0.22***	0.04	0.09	0.25	0.19
	[0.02]	[0.02]	[0.01]	[0.04]	[0.04]	[0.03]
Work for pay	0.04	0.02	0.01	0.06	0.04	0.01
	[0.02]	[0.01]	[0.01]	[0.04]	[0.02]	[0.01]
Work without pay	0.03	0.20***	0.03	0.03	0.21	0.18
	[0.01]	[0.02]	[0.01]	[0.02]	[0.03]	[0.03]
Panel B: Non-targeted siblings aged 9 to 13 with 4th grade complete						
Years of schooling	4.56	4.50	4.65	4.46	4.40	4.58
	[0.08]	[0.09]	[0.11]	[0.12]	[0.12]	[0.13]
School enrollment	0.91	0.82*	0.88	0.94	0.80	0.84
	[0.04]	[0.04]	[0.06]	[0.04]	[0.07]	[0.04]
Participate in the labor market	0.08	0.35***	0.12	0.03*	0.37	0.34
	[0.03]	[0.07]	[0.05]	[0.03]	[0.09]	[0.09]
Work for pay	0.01	0.01	0.00	0.03	0.03	0.00
	[0.01]	[0.02]	[0.00]	[0.03]	[0.03]	[0.00]
Work without pay	0.07	0.34***	0.12	0.00**	0.33	0.34
	[0.03]	[0.07]	[0.05]	[0.00]	[0.09]	[0.09]

Note: Differences in pre-intervention characteristics between control and treatment are statistically significant *** at 1%, ** at 5%, and * at 10%. Robust standard errors clustered at community level in brackets. Data source: based on 2000 Nicaragua's RPS evaluation data.

Table 3.3: Schooling and employment for the sample of non-targeted siblings aged 14 to 17. Pre-intervention year (2000)

	Female	Male	Female		Male	
			Control	Treatment	Control	Treatment
	(1)	(2)	(3)		(4)	
Years of schooling	3.52	2.55***	3.76	3.30	2.40	2.73
	[0.18]	[0.19]	[0.19]	[0.29]	[0.25]	[0.28]
School enrollment	0.38	0.34	0.40	0.37	0.31	0.37
	[0.03]	[0.04]	[0.04]	[0.03]	[0.04]	[0.06]
Time to school < 30 min.	0.29	0.24	0.30	0.29	0.22	0.27
	[0.03]	[0.04]	[0.05]	[0.04]	[0.05]	[0.07]
Time to school ≥ 30 min.	0.09	0.10	0.10	0.08	0.09	0.10
	[0.02]	[0.02]	[0.04]	[0.02]	[0.03]	[0.03]
Work participation	0.23	0.78***	0.23	0.23	0.79	0.76
	[0.03]	[0.03]	[0.04]	[0.04]	[0.03]	[0.04]
Work for pay	0.16	0.31***	0.17	0.14	0.35	0.27
	[0.02]	[0.03]	[0.03]	[0.03]	[0.05]	[0.04]
Work without pay	0.07	0.47***	0.06	0.08	0.45	0.49
	[0.02]	[0.04]	[0.02]	[0.03]	[0.06]	[0.05]
Work in agriculture activities	0.11	0.74***	0.08	0.13	0.74	0.74
	[0.02]	[0.03]	[0.02]	[0.04]	[0.04]	[0.05]
Work in non-agriculture activities	0.12	0.04***	0.14	0.10	0.06	0.02
	[0.02]	[0.01]	[0.03]	[0.03]	[0.02]	[0.01]

Note: Differences in pre-intervention characteristics between control and treatment are statistically significant *** at 1%, ** at 5%, and * at 10%. Robust standard errors clustered at community level in brackets. Data source: based on 2000 Nicaragua's RPS evaluation data.

Table 3.4: RPS impact on school and work participation on targeted children and non-targeted siblings

Dependent Variable:	School enrollment			Work participation		
	Total	Female	Male	Total	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Targeted children who have non-targeted siblings						
Treat*Year 2001	0.187***	0.213***	0.169***	-0.034	-0.046	-0.034
	[0.052]	[0.067]	[0.056]	[0.036]	[0.050]	[0.042]
Treat*Year 2002	0.140**	0.187**	0.101*	-0.073*	-0.075	-0.074
	[0.052]	[0.071]	[0.058]	[0.038]	[0.049]	[0.051]
Panel B: Non-targeted siblings aged 9 to 13 with 4th grade completed						
Treat*Year 2001	-0.051	-0.085	0.028	0.016	0.061	-0.070
	[0.055]	[0.052]	[0.086]	[0.094]	[0.064]	[0.177]
Treat*Year 2002	0.013	-0.035	0.047	0.058	0.073	0.020
	[0.057]	[0.076]	[0.101]	[0.093]	[0.066]	[0.163]
Panel C: Non-targeted siblings aged 14 to 17						
Treat*Year 2001	0.129**	0.098	0.158***	-0.105*	-0.062	-0.129**
	[0.048]	[0.068]	[0.054]	[0.053]	[0.072]	[0.061]
Treat*Year 2002	0.145**	0.124*	0.164**	-0.110*	-0.060	-0.155*
	[0.058]	[0.069]	[0.073]	[0.060]	[0.066]	[0.078]
N Panel A	2,867	1,343	1,524	2,867	1,343	1,524
N Panel B	481	242	239	481	242	239
N Panel C	1,884	940	944	1,884	940	944

Note: Robust standard errors clustered at community level in brackets. *** statistically significant at 1%, ** at 5%, and * at 10%. All specifications include controls for child's age, years, and communities' fixed effects, while models in columns 1 and 4 also include controls for child's gender. Data source: based on 2000, 2001, and 2002 Nicaragua's RPS evaluation data.

Table 3.5: RPS impact on the joint probability of being enrolled in school and working for non-targeted siblings aged 14 to 17

	Total (1)	Female (2)	Male (3)
Dependent Variable: Enrolled in school and work			
Treat*Year 2001	0.016	0.011	0.024
	[0.031]	[0.032]	[0.049]
Treat*Year 2002	0.022	0.013	0.029
	[0.050]	[0.041]	[0.079]
Dependent Variable: Enrolled in school but not work			
Treat*Year 2001	0.113**	0.087	0.135**
	[0.051]	[0.080]	[0.057]
Treat*Year 2002	0.124*	0.112	0.135*
	[0.062]	[0.073]	[0.068]
Dependent Variable: Not enrolled in school but working			
Treat*Year 2001	-0.121***	-0.073	-0.153**
	[0.044]	[0.059]	[0.059]
Treat*Year 2002	-0.131**	-0.073	-0.184**
	[0.054]	[0.056]	[0.079]
Dependent Variable: Not enrolled in school nor working			
Treat*Year 2001	-0.008	-0.025	-0.005
	[0.037]	[0.069]	[0.028]
Treat*Year 2002	-0.014	-0.052	0.020
	[0.044]	[0.081]	[0.029]
N	1,884	940	944

Note: Robust standard errors clustered at community level in brackets. *** statistically significant at 1%, ** at 5%, and * at 10%. All specifications include controls for child's age, years, and communities' fixed effects, while model in column 1 also includes a control for child's gender. Data source: based on 2000, 2001, and 2002 Nicaragua's RPS evaluation data.

Table 3.6: RPS impact by type of work for non-targeted siblings aged 14 to 17

	Total	Female	Male
	(1)	(2)	(3)
Panel A: By paid/unpaid work			
Dependent Variable: Work for pay			
Treat*Year 2001	-0.059	-0.022	-0.058
	[0.046]	[0.061]	[0.059]
Treat*Year 2002	-0.078*	-0.029	-0.104
	[0.041]	[0.056]	[0.068]
Dependent Variable: Work without a pay			
Treat*Year 2001	-0.046	-0.039	-0.072
	[0.045]	[0.041]	[0.070]
Treat*Year 2002	-0.032	-0.031	-0.052
	[0.057]	[0.040]	[0.100]
Panel B: By agriculture/non-agriculture work			
Dependent Variable: Work in agriculture activities			
Treat*Year 2001	-0.111**	-0.076	-0.130*
	[0.048]	[0.051]	[0.065]
Treat*Year 2002	-0.116*	-0.078	-0.153*
	[0.058]	[0.053]	[0.085]
Dependent Variable: Work in non-agriculture activities			
Treat*Year 2001	0.005	0.012	0.001
	[0.032]	[0.056]	[0.029]
Treat*Year 2002	0.003	0.010	-0.001
	[0.035]	[0.049]	[0.037]
N	1,884	940	944

Note: Robust standard errors clustered at community level in brackets. *** statistically significant at 1%, ** at 5%, and * at 10%. All specifications include controls for child's age, years, and communities' fixed effects, while model in column 1 also includes a control for child's gender. Data source: based on 2000, 2001, and 2002 Nicaragua's RPS evaluation data.

Table 3.7: RPS impact on school and work participation by pre-intervention per capita consumption for non-targeted siblings aged 14 to 17

Dependent Variable:	School enrollment			Work participation		
	Total	Female	Male	Total	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: 1st and 2nd quintile of pre-intervention per capita consumption						
Treat*Year 2001	0.214***	0.177*	0.216***	-0.045	-0.027	-0.040
	[0.059]	[0.100]	[0.071]	[0.062]	[0.105]	[0.079]
Treat*Year 2002	0.190**	0.139	0.218**	-0.131*	-0.134	-0.137
	[0.073]	[0.100]	[0.097]	[0.076]	[0.080]	[0.106]
Panel B: 3rd, 4th, and 5th quintile of pre-intervention per capita consumption						
Treat*Year 2001	0.085	0.019	0.149*	-0.134*	-0.023	-0.243**
	[0.060]	[0.089]	[0.089]	[0.072]	[0.092]	[0.103]
Treat*Year 2002	0.139*	0.121	0.157*	-0.095	0.016	-0.213*
	[0.072]	[0.105]	[0.092]	[0.089]	[0.114]	[0.107]
N Panel A	893	436	457	893	436	457
N Panel B	930	458	472	930	458	472

Note: Robust standard errors clustered at community level in brackets. *** statistically significant at 1%, ** at 5%, and * at 10%. All specifications include controls for child's age, years, and communities' fixed effects, while models in columns 1 and 4 also include controls for child's gender. Data source: based on 2000, 2001, and 2002 Nicaragua's RPS evaluation data.

Table 3.8: RPS impact on school and work participation by pre-intervention years of education for non-targeted siblings aged 14 to 17

Dependent Variable:	School enrollment			Work participation		
	Total	Female	Male	Total	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: 2 or fewer pre-intervention years of education						
Treat*Year 2001	0.257***	0.241**	0.252***	-0.178**	-0.197	-0.158*
	[0.054]	[0.096]	[0.076]	[0.075]	[0.123]	[0.093]
Treat*Year 2002	0.228***	0.086	0.313***	-0.216**	-0.202*	-0.242***
	[0.061]	[0.102]	[0.074]	[0.080]	[0.115]	[0.086]
Panel B: 3 or more pre-intervention years of education						
Treat*Year 2001	0.009	-0.037	0.030	-0.018	0.030	-0.052
	[0.055]	[0.082]	[0.087]	[0.064]	[0.095]	[0.087]
Treat*Year 2002	0.046	0.081	-0.024	0.006	0.049	-0.027
	[0.084]	[0.103]	[0.107]	[0.081]	[0.088]	[0.115]
N Panel A	888	384	504	888	384	504
N Panel B	937	512	425	937	512	425

Note: Robust standard errors clustered at community level in brackets. *** statistically significant at 1%, ** at 5%, and * at 10%. All specifications include controls for child's age, years, and communities' fixed effects, while models in columns 1 and 4 also include controls for child's gender. Data source: based on 2000, 2001, and 2002 Nicaragua's RPS evaluation data.

Table 3.9: RPS impact on school and work participation by pre-intervention distance to the nearest primary school for non-targeted siblings aged 14 to 17

Dependent Variable:	School enrollment			Work participation		
	Total	Female	Male	Total	Female	Male
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Time to school < 10 min.						
Treat*Year 2001	0.071	0.075	0.135	-0.058	-0.067	-0.053
	[0.065]	[0.095]	[0.093]	[0.090]	[0.107]	[0.119]
Treat*Year 2002	0.074	0.188*	-0.006	0.001	-0.042	-0.004
	[0.088]	[0.093]	[0.145]	[0.088]	[0.101]	[0.128]
Panel B: 10 min. ≤ time to school < 30 min.						
Treat*Year 2001	0.097	0.059	0.109	-0.037	-0.046	-0.072
	[0.065]	[0.092]	[0.079]	[0.083]	[0.121]	[0.099]
Treat*Year 2002	0.107	0.011	0.181*	-0.010	0.043	-0.128
	[0.073]	[0.115]	[0.092]	[0.095]	[0.101]	[0.118]
Panel C: Time to school ≥ 30 min.						
Treat*Year 2001	0.200**	0.125	0.201*	-0.150	-0.057	-0.248**
	[0.086]	[0.151]	[0.100]	[0.096]	[0.129]	[0.112]
Treat*Year 2002	0.256***	0.104	0.343***	-0.197	-0.175	-0.317**
	[0.090]	[0.148]	[0.116]	[0.117]	[0.137]	[0.130]
N Panel A	609	320	289	609	320	289
N Panel B	687	335	352	687	335	352
N Panel C	588	285	303	588	285	303

Note: Robust standard errors clustered at community level in brackets. *** statistically significant at 1%, ** at 5%, and * at 10%. All specifications include controls for child's age, years, and communities' fixed effects, while models in columns 1 and 4 also include controls for child's gender. Note source: based on 2000, 2001, and 2002 Nicaragua's RPS evaluation data.

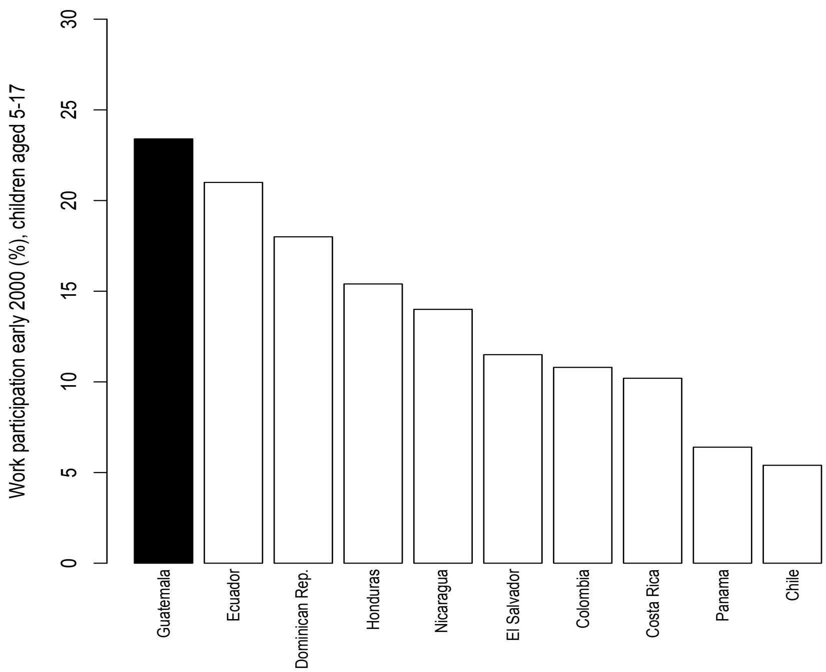
Table 3.10: RPS impact on grade progression for non-targeted siblings aged 14 to 17

Dependent Variable:	Advance 2 grades between 2000 and 2002		
	Total	Female	Male
	(1)	(2)	(3)
Panel A: Total sample			
Treat	0.145***	0.174***	0.122**
	[0.045]	[0.057]	[0.057]
Panel B: Two or fewer pre-intervention years of education			
Treat	0.170***	0.232***	0.213**
	[0.048]	[0.058]	[0.085]
Panel C: 3 or more pre-intervention years of education			
Treat	0.092	0.089	0.031
	[0.070]	[0.075]	[0.079]
N Panel A	596	280	316
N Panel B	426	142	181
N Panel C	170	138	135

Note: Robust standard errors clustered at community level in brackets. *** statistically significant at 1%, ** at 5%, and * at 10%. All specifications include controls for child's age and pre-intervention years of education. Models in column 1 also include controls for child's gender. Note source: based on 2000, 2001, and 2002 Nicaragua's RPS evaluation data.

APPENDIX A

Appendix Figure A.1: Child Labor in some Latin American Countries in the Early 2000s



Data source: International Labor Office (ILO) - International Program for the Elimination of Child Labor (IPEC).

Appendix Table A.1: Department-level Intensity Measures

Departments	Population	Affected Population (in %)	Economic Damages (in %)
	[1]	[2]	[3]
Alta Verapaz	923,400	1.7	0.0
Baja Verapaz	236,400	1.8	0.0
Chimaltenango	515,800	40.1	8.6
Chiquimula	328,200	13.9	0.0
El Progreso	145,300	15.4	0.0
Escuintla	609,500	30.9	9.1
Guatemala	2,821,400	8.3	0.3
Huehuetenango	973,600	14.7	9.8
Izabal	355,900	8.6	0.0
Jalapa	272,400	26.4	5.3
Jutiapa	400,900	48.3	16.0
Petén	489,200	4.8	0.0
Quetzaltenango	690,000	39.0	7.3
Quiche	778,000	10.9	2.0
Retalhuleu	266,300	37.8	19.9
Sacatepéquez	277,500	21.4	2.9
San Marcos	888,000	59.1	21.9
Santa Rosa	315,800	47.9	7.7
Sololá	362,100	60.1	34.9
Suchitepéquez	449,100	33.9	4.7
Totonicapán	394,600	27.8	6.4
Zacapa	207,100	10.2	0.0
Weighted Average		22.7	6.3

Note: "Affected Population (% of Population)" comes from the Guatemalan 2006 LSMS survey and "Economic Damages (% of GDP)" comes from the United Nations Economic Commission for Latin America and the Caribbean (ECLAC 2005). See section 6 for a definition of the intensity variables. Data source: Guatemalan 2006 LSMS survey and ECLAC (2005).

Appendix Table A.2: Measuring the Impact of the 2005 Tropical Storm Stan by Type of Work for Children Aged 7 to 12

Dependent Variable:	Paid Agriculture Work	Unpaid Agriculture Work	Paid Market Work	Unpaid Market Work
	[1]	[2]	[3]	[4]
Panel A - Girls				
Measure 1 * Year 2006	0.018	0.054	0.016	-0.025
	[0.019]	[0.044]	[0.013]	[0.036]
Measure 2 * Year 2006	0.054	0.062	0.049*	-0.028
	[0.037]	[0.101]	[0.026]	[0.082]
Panel B - Boys				
Measure 1 * Year 2006	0.012	0.04	-0.034**	0.035
	[0.018]	[0.079]	[0.014]	[0.020]
Measure 2 * Year 2006	0.067*	0.136	-0.075**	0.079*
	[0.034]	[0.163]	[0.030]	[0.042]
Year 2006	Yes	Yes	Yes	Yes
Demographics and HH. Controls	Yes	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes	Yes
N Girls	9,038	9,038	9,038	9,038
N Boys	9,339	9,339	9,339	9,339

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. Demographic controls include a child's age and an indigenous indicator. Households' controls include indicators for whether the child's household is located in an urban area, and controls for the gender, age and education level of the head of the child's household. Each intensity measure in the panels represents separate regression. See section 6 for a definition of the intensity variables. Data source: Guatemalan LSMS surveys 2000 and 2006.

Appendix Table A.3: First Stage Regression of the IV Estimations

	Affected Population (Ratio of Pop.)		Economic Damages (Ratio of GDP)	
	Girls	Boys	Girls	Boys
	[1]	[2]	[3]	[4]
Panel A: Children Aged 7 to 12				
Rainfall (in mm) [1/100] * Year 2006	0.059***	0.059***	0.024***	0.024***
	[0.009]	[0.009]	[0.004]	[0.004]
Kleibergen-Paap rk Wald F statistic	106.52	102.26	72.98	69.80
Partial R^2	0.70	0.70	0.67	0.66
N	8,381	8,704	8,381	8,704
Panel B: Children aged 13 to 15				
Rainfall (in mm) [1/100] * Year 2006	0.061***	0.058***	0.024***	0.024***
	[0.009]	[0.009]	[0.004]	[0.004]
Kleibergen-Paap rk Wald F statistic	102.52	84.30	70.67	59.17
Partial R^2	0.69	0.68	0.64	0.64
N	3,702	3,757	3,702	3,757
Demographics and HH. Controls	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes	Yes

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. Demographic controls include a child's age and an indigenous indicator. Households' controls include indicators for whether the child's household is located in an urban area, and controls for the gender, age and education level of the head of the child's household. See section 6 for a definition of the intensity variables. The Guatemalan Seismology, Volcanology, Meteorology, and Hydrology Bureau (INSIVUMEH) collected rainfall data. Rainfall denotes total amount of rainfall, in millimeters, registered between the first and tenth day of October. Data source: Guatemalan 2000 and 2006 LSMS surveys.

Appendix Table A.4: Reduced Form Estimation of IV Estimations

	Enrolled in School		Work Participation	
Dependent Variable:	Girls	Boys	Girls	Boys
	[1]	[2]	[3]	[4]
Panel A: Children Aged 7 to 12				
Rainfall (in mm) [1/100] * Year 2006	0.002	-0.001	0.004	0.005
	[0.005]	[0.004]	[0.003]	[0.006]
Year 2006	0.085***	0.064**	-0.044**	-0.024
	[0.018]	[0.023]	[0.016]	[0.028]
Panel B: Children Aged 13 to 15				
Rainfall (in mm) [1/100] * Year 2006	-0.002	-0.023**	0.018*	0.026*
	[0.007]	[0.010]	[0.009]	[0.013]
Year 2006	0.069**	0.131***	-0.078*	-0.120***
	[0.025]	[0.025]	[0.040]	[0.041]
Demographics and HH. Controls	Yes	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes	Yes
N Panel A	8,381	8,704	8,381	8,704
N Panel B	3,703	3,757	3,702	3,757

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. Demographic controls include a child's age and an indigenous indicator. Households' controls include indicators for whether the child's household is located in an urban area, and controls for the gender, age and education level of the head of the child's household. The Guatemalan Seismology, Volcanology, Meteorology, and Hydrology Bureau (INSIVUMEH) collected rainfall data. Rainfall denotes total amount of rainfall, in millimeters, registered between the first and tenth day of October. Data source: Guatemalan 2000 and 2006 LSMS surveys.

Appendix Table A.5: Type of Damage/Loss caused by Tropical Storm Stan

Departments	Percentage of the Population that Suffered Damage/loss of*:					
	Crops	Dwelling	Goods	Livestock	Family Member	Business
	[1]	[2]	[3]	[4]	[5]	[6]
Sololá	53.0	16.1	10.2	8.2	1.9	2.5
San Marcos	49.4	15.6	12.4	7.6	3.0	1.9
Jutiapa	42.5	8.8	2.6	7.8	1.0	1.6
Santa Rosa	34.9	13.7	2.2	2.3	6.6	1.0
Chimaltenango	33.8	6.9	0.5	4.9	1.3	1.4
Quetzaltenango	29.4	9.4	5.0	7.3	1.0	0.8
Retalhuleu	24.7	17.2	6.0	8.5	0.2	1.6
Suchitepéquez	24.1	3.2	0.6	0.0	0.7	0.0
Escuintla	20.2	9.8	1.0	3.4	1.9	2.5
Totonicapán	19.6	9.6	6.1	6.3	2.6	2.6
Jalapa	13.5	8.3	2.5	1.2	1.6	0.9
Sacatepéquez	11.5	2.6	1.0	1.1	0.1	0.4
El Progreso	10.5	15.6	10.7	11.6	5.8	2.1
Huehuetenango	9.9	4.6	2.4	0.5	0.7	0.4
Chiquimula	9.6	2.8	0.0	0.7	0.2	0.2
Quiche	9.3	4.6	2.0	1.3	0.6	1.2
Zacapa	6.6	2.1	0.9	0.5	0.7	0.6
Izabal	2.3	2.5	0.0	0.5	0.0	0.0
Guatemala	2.1	3.1	2.4	0.4	2.5	0.9
Petén	1.6	3.3	1.3	0.1	2.5	1.3
Baja Verapaz	1.0	0.8	0.4	0.1	0.0	0.0
Alta Verapaz	0.8	1.5	0.6	0.8	0.2	0.0

Note: (*) Answers are not mutually exclusive. Data source: Guatemalan 2006 LSMS survey.

Appendix Table A.6: Measuring the Impact of the 2005 Tropical Storm Stan for Adult Work Participation in Households with Children Aged 7 to 15

Dependent Variable:	Work Participation of Adults Aged 25 or more
Measure 1 * Year 2006	0.082
	[0.058]
Year 2006	0.000
	[0.016]
Measure 2 * Year 2006	0.164
	[0.148]
Year 2006	0.009
	[0.013]
Demographics and HH. Controls	Yes
Departments Fixed Effect	Yes
N Adults	25,293

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. Each measure represents a separate regression. See section 6 for a definition of the intensity variables. Demographic controls include age, gender, ethnicity, and an indicator that denotes whether the adult is the household head. Households' controls include indicators for household size and area. Data source: Guatemalan 2000 and 2006 LSMS surveys

Appendix Table A.7: Measuring the Impact of the 2005 Tropical Storm Stan on Hourly Wages and Educational Expenses for Children Aged 13 to 15
Selection MLE Estimations

Dependent variable:	Educational Expenses (In Logarithm)			Hourly Wages (In Logarithm)		
	Total	Girls	Boys	Total	Girls	Boys
	[1]	[2]	[3]	[4]	[5]	[6]
Measure 1 * Year 2006	-0.442*	-0.245	-1.201***	-0.857	-0.069	-1.317
	[0.240]	[0.385]	[0.463]	[0.641]	[0.323]	[0.843]
Year 2006	0.133*	0.146	0.492***	0.506*	0.422***	0.563*
	[0.077]	[0.110]	[0.120]	[0.266]	[0.137]	[0.336]
Measure 2 * Year 2006	-0.433	0.251	-1.004	-2.267	-0.732	-1.726
	[0.525]	[0.595]	[0.696]	[1.505]	[0.882]	[1.269]
Year 2006	0.054	0.073	0.037	0.442**	0.446***	0.262**
	[0.068]	[0.092]	[0.082]	[0.197]	[0.123]	[0.115]
Demographics and HH. Controls	Yes	Yes	Yes	Yes	Yes	Yes
Departments Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
N	7,816	3,862	3,954	8,005	3,961	4,044

Note: Robust standard errors in brackets, clustered at the department level. * significant at 10%, ** at 5%, and *** at 1%. Demographic controls include a child's age and an indigenous indicator. Households' controls include indicators for whether the child's household is located in an urban area, and controls for the gender, age and education level of the head of the child's household. Each measure represents a separate regression. See section 6 for a definition of the intensity variables. Results are estimated using Selection MLE models, but similar results are obtained using OLS estimations. Observations in columns 1 to 3 are lower because there are children who are enrolled in school with null educational expenses. Results for Measure 2 in column 6 are unweighted because the solution is not concave when using a/the survey sampling weight. Data source: Guatemalan 2000 and 2006 LSMS surveys.

Appendix Table A.8: Measuring the Impact of the 2005 Tropical Storm Stan on School Enrollment and Work Participation for Children Aged 7 to 12 using intensity measure 1

	School enrollment		Work participation	
Dependent variable:	Girls [1]	Boys [2]	Girls [3]	Boys [4]
Affected Population (Ratio of Pop.) * Year 2006	-0.007	-0.052	0.063	0.053
	[0.080]	[0.103]	[0.062]	[0.094]
Year 2006	0.093***	0.071*	-0.035	-0.014
	[0.030]	[0.039]	[0.024]	[0.017]
Child's Age	0.011***	0.016***	0.029***	0.059***
	[0.003]	[0.002]	[0.004]	[0.009]
Child Lives in Urban Area	0.013	0.016	-0.029**	-0.068***
	[0.013]	[0.014]	[0.011]	[0.019]
Child is Indigenous	-0.048*	-0.011	0.048*	0.077**
	[0.026]	[0.013]	[0.024]	[0.032]
Household Head’s Years of Education	0.014***	0.013***	-0.003**	-0.008***
	[0.002]	[0.001]	[0.001]	[0.002]
Household Head's Age	0.001	-0.001	0.00	-0.001*
	[0.001]	[0.001]	[0.000]	[0.000]
Household Head is a Male	-0.033**	- 0.037***	-0.027	0.055***
	[0.013]	[0.009]	[0.024]	[0.017]
Departments Fixed Effect	Yes	Yes	Yes	Yes
N	9,038	9,339	9,038	9,339

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. “Affected Population (Ratio of Population)” comes from the Guatemalan 2006 LSMS survey. See section 6 for a definition of this intensity variable. Data source: Guatemalan 2000 and 2006 LSMS surveys.

Appendix Table A.9: Measuring the Impact of the 2005 Tropical Storm Stan on School Enrollment and Work Participation for Children Aged 13 to 15 using intensity measure 1

	School enrollment		Work participation	
	Girls	Boys	Girls	Boys
Dependent variable:	[1]	[2]	[3]	[4]
Affected Population (Ratio of Pop.) * Year 2006	-0.069	-0.374**	0.219	0.417*
	[0.073]	[0.149]	[0.150]	[0.204]
Year 2006	0.076***	0.156***	-0.071	-0.135**
	[0.026]	[0.037]	[0.042]	[0.055]
Child's Age	-0.120***	-0.115***	0.044***	0.092***
	[0.013]	[0.010]	[0.011]	[0.008]
Child Lives in Urban Area	0.177***	0.107***	0.029	-0.131***
	[0.015]	[0.020]	[0.026]	[0.020]
Child is Indigenous	-0.063	0.063**	0.067	0.092*
	[0.040]	[0.030]	[0.049]	[0.045]
Household Head’s Years of Education	0.024***	0.029***	-0.012***	-0.026***
	[0.005]	[0.002]	[0.002]	[0.002]
Household Head's Age	0.003***	0.003***	-0.002**	-0.002*
	[0.001]	[0.001]	[0.001]	[0.001]
Household Head is a Male	-0.03	-0.019	-0.061**	0.083***
	[0.038]	[0.023]	[0.029]	[0.023]
Departments Fixed Effect	Yes	Yes	Yes	Yes
N	3,961	4,044	3,960	4,044

Note: Robust standard errors in brackets, clustered at the department level.* significant at 10%, ** at 5%, and *** at 1%. “Affected Population (Ratio of Population)” comes from the Guatemalan 2006 LSMS survey. See section 6 for a definition of this intensity variable. Data source: Guatemalan 2000 and 2006 LSMS surveys.

APPENDIX B

Appendix Table B.1: Department-level Intensity Measures

Departments		Population	Proportion of the Population Directly Affected	Proportion of the Population Indirectly Affected
		[1]	[2]	[3]
1	Quindio	547,312	59.7	87.7
2	Risaralda	920,737	5.4	27.2
3	Tolima	1,282,591	0.5	15.6
4	Valle del Cauca	4,071,491	0.4	8.6
5	Caldas	1,085,656	0.1	0.4
6	Antioquia	5,257,790	0.0	3.8
7	Bogota, D.C.	6,225,989	0.0	0.8
8	Atlantica	2,064,314	0.0	0.0
9	Bolivar	1,934,950	0.0	0.0
10	Boyaca	1,343,783	0.0	0.0
11	Cauca	1,223,965	0.0	0.0
12	Cesar	936,307	0.0	0.0
13	Cordoba	1,297,602	0.0	0.0
14	Cundinamarca	2,082,323	0.0	0.0
15	Choco	402,828	0.0	0.0
16	Huila	903,628	0.0	0.0
17	La Guajira	470,978	0.0	0.0
18	Magdalena	1,249,798	0.0	0.0
19	Meta	680,972	0.0	0.0
20	Nariño	1,590,052	0.0	0.0
21	Norte Santander	1,305,542	0.0	0.0
22	Santander	1,923,329	0.0	0.0
23	Sucre	773,107	0.0	0.0
Average [2] Through [5]			0.4	4.3
Average [2] Through [7]			0.4	5.6

Note: "Population Directly Affected" denotes the population who suffered direct losses in terms of housing, family members, and/or employment. "Population Indirectly Affected" denotes the population who suffered indirect losses such as disruption in commercial relations. Data source: ECLAC (1999).

Appendix Table B.2: Measuring the Impact of the Earthquake on Child Nutrition and Schooling Participation

Dependent variable:	Height-for-age Z-score of children under five	School enrollment of children aged 6 to 10	School enrollment of children aged 11 to 15
	[1]	[2]	[3]
Quindio Department * Year 1990		-0.021	-0.057
		[0.052]	[0.044]
Quindio Department * Year 2000	-0.281***	-0.071***	-0.065***
	[0.035]	[0.017]	[0.013]
Quindio Department * Year 2005	0.088	-0.047	-0.053**
	[0.056]	[0.029]	[0.021]
Less Affected (Intensity) * Year 1990		0.343	0.227
		[0.431]	[0.440]
Less Affected (Intensity) * Year 2000	-0.618	-0.353	-0.714**
	[0.738]	[0.434]	[0.263]
Less Affected (Intensity) * Year 2005	-0.032	-0.724	-0.921
	[0.470]	[0.719]	[0.545]
Age (in months col. [1] - in years cols. [2-3])	-0.030***	0.193***	0.158***
	[0.004]	[0.018]	[0.027]
Age squared (in months col. [1] - in years cols. [2-3])	0.000***	-0.011***	-0.008***
	[0.000]	[0.001]	[0.001]
Male	-0.078***	-0.019***	-0.021***
	[0.014]	[0.003]	[0.004]
Urban	0.168***	0.031***	0.124***
	[0.036]	[0.007]	[0.015]
Mother's Age	0.011		
	[0.008]		
Mother's Age Squared	0.000		
	[0.000]		
Mother's Years of Education	0.063***		
	[0.003]		

Appendix Table B.2 Continuation: Measuring the Impact of the Earthquake on Child Nutrition and Schooling Participation

Dependent variable:	Height-for-age Z-score of children under five	School enrollment of children aged 6 to 10	School enrollment of children aged 11 to 15
	[1]	[2]	[3]
Household Head's Age		0.000	0.008***
		[0.001]	[0.002]
Household Head's Age Squared		0.000	-0.000***
		[0.000]	[0.000]
Household Head's Year of Education		0.007***	0.011***
		[0.001]	[0.001]
Household Head is Male	0.035*	0.003	0.008
	[0.018]	[0.006]	[0.006]
Year 1990		-0.124***	-0.047
		[0.040]	[0.034]
Year 2000	-0.054	-0.005	-0.004
	[0.035]	[0.015]	[0.016]
Year 2005	-0.107**	0.007	0.001
	[0.042]	[0.025]	[0.020]
Trends Oriental Region	0.095**	-0.009	0.018
	[0.040]	[0.008]	[0.012]
Trends Central Region	0.117***	-0.004	0.042***
	[0.036]	[0.018]	[0.014]
Trends Pacifica Region	0.109***	0.124***	0.119***
	[0.029]	[0.042]	[0.034]
Trends Bogota Region	0.110***	-0.036***	-0.003
	[0.020]	[0.006]	[0.005]
Department Fixed Effects	Yes	Yes	Yes
N	18,708	28,259	27,774

Note: Statistically significant *** at 1%, ** at 5%, and * at 10%. Results are weighted using survey-sampling weights. “Quindio” indicates a child living in Quindio. "Less Affected (Intensity)” indicates for each department other than Quindio the proportion of the population indirectly affected by the earthquake. Data source: 1990, 1995, 2000, and 2005 Colombia Demographic and Health Surveys.

REFERENCES

Adato, Michelle, and Terry Roopnaraine. 2004. "Sistema de evaluación de la Red de Protección Social de Nicaragua: Un análisis social de la 'Red de Protección Social' (RPS) en Nicaragua." International Food Policy Research Institute, Washington, DC.

Ahmed, Akhter and Mary Arends-Kuenning. 2006. "Do Crowded Classrooms Crowd Out Learning? Evidence from the Food for Education Program in Bangladesh." *World Development,* 34(4):665-84.

Akresh, Richard and Leonardo Lucchetti and Harsha Thirumurthy. 2011. "Wars and Child Health: Evidence from the Eritrean-Ethiopian Conflict." BREAD Working Paper No. 310.

Akresh, Richard and Damien de Walque. 2010. "Armed Conflict and Schooling: Evidence from the 1994 Rwandan Genocide." Household in Conflict Network Working Paper 47.

Albala-Bertrand, Jose M. 1993. "Natural Disaster Situations and Growth: A Macroeconomic Model for Sudden Disaster Impacts." *World Development*, 71(9): 1417-1434.

Alderman, Harold, John Hoddinott, and William Kinsey. 2006. "Long term consequences of early childhood malnutrition." *Oxford Economics Papers*, 58(3):450–474.

Alderman, Harold, Hans Hoogevee, and Mariacristina Rossi. 2009. "Preschool Nutrition and Subsequent Schooling Attainment: Longitudinal Evidence from Tanzania." *Economic Development and Cultural Change*, 57(2):239–260.

Almond, Douglas and Janet Currie. 2011. "Human Capital Development before Age Five." In O. Ashenelter and D. Card (Eds), Handbook of Labor Economics 4:1315-1486.

Alzua, Maria L., Guillermo Cruces, and Laura Ripani. 2010. "Welfare Programs and Labor Supply in Developing Countries. Experimental Evidence from Latin America." Working paper no. 95, CEDLAS.

Angelucci, Manuela, and Giacomo De Giorgi. 2009. "Indirect Effects of an Aid Program: How Do Cash Transfers Affect Ineligibles' Consumption?" *American Economic Review*, 99(1):486–508.

Angrist, Joshua and Adriana Kugler. 2008. "Rural Windfall or a New resource Curse? Coca, Income, and Civil Conflict in Colombia." *The Review of Economics and Statistics*, 90(2): 191–215.

Baez, Javier, Alejandro de La Fuente, and Indhira Santos. 2010. "Do Natural Disasters Affect Human Capital? An Assessment Based on Existing Empirical Evidence." IZA Discussion Paper No. 5164.

Baez, Javier, and Indhira Santos. 2007. "Children's Vulnerability to Weather Shocks: A Natural Disaster as a Natural Experiment." Unpublished manuscript.

Barrera-Osorio, Felipe, Marianne Bertrand, Leigh Linden, and Francisco Perez-Calle. 2011. "Improving the Design of Conditional Transfer Programs: Evidence from a Randomized Education Experiment in Colombia." *Applied Economic Journal: Applied Economics*, forthcoming.

Basu, Kaushik. 1999. "Child labor: cause, consequences, and cure with remarks on international labor standards." *Journal of Economic Literature*, 37(3): 1083-1119.

Beegle, Kathleen, Rajeev Dehejia, and Roberta Gatti. 2009. "Why should we care about child labor? The education, labor market, and health consequences of child labor." *Journal of Human Resources*, 44(4): 871-889.

Benerjee, Abhijit V. 2004. "Educational policy and the economics of the family." *Journal of Development Economics*, 74: 3-32.

Bertrand, Marianne, Esther Duflo, and Sendhil. 2004. "How Much Should We Trust Differences-in-Differences Estimates?" *Quarterly Journal of Economics*, 119:249-75.

Bobonis, Gustavo and Frederico Finan. 2009. "Neighborhood peer effects in secondary school enrollment decisions." *Review of Economics and Statistics,* 91(4):695-716.

Bureau of International Labor Affairs. 1998. "By the Sweat and Toil of Children: Efforts to Eliminate Child Labor." Volume V, U.S. Department of Labor.

Bustelo, Monserrat. 2011. "Bearing the Burden of Natural Disasters: Child Labor and Schooling in the Aftermath of Tropical Storm Stan in Guatemala." Unpublished manuscript.

Card, David. 1999. "The causal effects of education on earnings" In O. Ashenelter and D. Card (Eds), Handbook of Labor Economics 3:1802-1859.

Center on the Developing Child. 2010. "The Foundations of Lifelong Health Are Built in Early Childhood." Harvard University. Retrieve from: http://www.developingchild.harvard.edu

Cuaresma, Jesus. 2010. "Natural Disasters and Human Capital Accumulation." *World Bank Economic Review* 24(2): 280-302.

Cunningham, Wendy, Lorena M. Cohan, Sophie Naudeau, and Linda McGinnis. 2008. "Supporting Youth at Risk." World Bank, Washington, DC.

Dammert, Ana. 2009. "Heterogeneous Impacts of Conditional Cash Transfers: Evidence from Nicaragua." *Economic Development and Cultural Change*, 58(1):53-83.

de Janvry, Alain, Frederico Finan, Elisabeth Sadoulet, and Renos Vakis. 2006. "Can Conditional Cash Transfer Programs Serve as Safety Nets in Keeping Children at School and from Working When Exposed to Shocks?" *Journal of Development Economics*, 79(2): 349–373.

De la Fuente, Alejandro. 2010. "Natural Disasters and Poverty in Latin Amercia: Welfare Impacts and Social Protection Solutions." *Well-being and Social Policy* 6(1): 1-15.

Duryea, Suzanne and Mary Arends-Kuenning. 2003. "School Attendance, Child Labor, and Local Labor Markets in Urban Brazil." *World Development*, 31(7): 1165–1178.

Duflo, Esther. 2001. "Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment." *American Economic Review*, 91(4): 795-813.

ECLAC. 2005. "Efectos en Guatemala de las LLuvias Torrenciales y La Tormenta Tropical Stan, Octubre 2005." Economic Commission for Latin America and the Caribbean, United Nations.

ECLAC. 1999. "El Terremoto de enero de 1999 en Colombia: Impacto socioeconomico del desastre en la zona del Eje Cafetero." Economic Commission for Latin America and the Caribbean, United Nations.

Edmonds, Eric V., Nina Pavcnik, and Petia Topalova. 2010. "Trade Adjustment and Human Capital Investments: Evidence from Indian Tariff Reform." *American Economic Journal: Applied Economics*, 2(4): 42-75.

Edmonds, Eric V. 2007. "Child Labor." In T.P. Schultz and J. Strauss (Eds), Handbook of Development Economics 4: 3607-3709.

Engle, Patrice L., Maureen M. Black, Jere R Behrman, Meena Cabral de Mello, Paul J Gertler, Lydia Kapiriri, Reynaldo Martorell, Mary Eming Young, and the International Child Development Steering Group. 2007. "Strategies to avoid the loss of developmental potential in more than 200 million children in the developing world." *The Lancet*, 369: 229-242.

Ferreira, Francisco and David Robalino. 2011. "Social Protection in Latin America: Achievements and limitations." In Ocampo and Ros (Eds.), Oxford Handbook of Latin American Economics.

Ferreira, Francisco H. G. and Norbert Schady. 2009. "Aggregate Economic Shocks, Child Schooling, and Child Health." *The World Bank Research Observer*, 24(2): 147-181.

Ferreira, Francisco, Deon Filmer, and Norbert Schady. 2009. "Own and Sibling Effects of Conditional Cash Transfer Programs." World Bank Policy Research Working paper no. 5001, The World Bank, Washington, DC.

Fiszbein, Ariel and Norbert Schady. 2009. “Conditional Cash Transfers: Reducing Present and Future Poverty.” World Bank Policy Research Report, The World Bank, Washington, DC.

Foster, Andrew. 1995. “Prices, credit markets, and child growth in low-income rural areas.” *Economic Journal*, 105: 551-570.

Gertler, Paul. 2004. “Do conditional cash transfers improve child health? Evidence from PROGRESA's control randomized experiment.” *American Economic Review*, 94(2): 336-41.

Gitter, Seth R. and Bradford Barham. 2008. “Women's power, conditional cash transfers, and schooling in Nicaragua.” *World Bank economic Review*, 22(2): 271-90.

_. 2009. “Conditional cash transfers, shocks, and school enrollment in Nicaragua.” *Journal of Development Studies*, 45(10):1747-67.

Grantham-McGregor, S., Yin Bun Cheung, Santiago Cueto, Paul Glewwe, Linda Richter, Barbara Strupp, and the International Child Development Steering Group. 2007. “Developmental potential in the first 5 years for children in developing countries.” *The Lancet,* 369:60–70

Hermida, Priscila. 2010. “The Long Term effects of Natural Disasters: Health and Education in Guatemala after the 1976 Earthquake.” Unpublished manuscript.

Hoddinott, John and William Kinsey. 2001. “Child growth in the time of drought.” *Oxford Bulletin of Economics and Statistics*, 63(4):409–436.

IFPRI. 2005. “Nicaragua: Red de Proteccion Social (RPS). Evaluation Dataset, 2000-2002.” International Food Policy Research Institute, Washington, DC.

Inter-American Development Bank. 2007. “Tearing Down the Walls: Growth and Inclusion in Guatemala.” IADB Working paper, Washington, D.C.

Inter-American Development Bank. 2003. “Reconstruction of the Coffee-Growing Region in Colombia.” Web stories. Retrieve from: http://www.iadb.org/en/news/webstories/2003-04-18/reconstruction-of-the-coffee-growing-region-in-colombia,1970.html

International Federation of the Red Cross and Red Crescent Societies. 1999. “Colombia Earthquake. Joint Federation/ICRC Appeal.” Appeal No. 04/99, Situation report No. 03. Retrieve from: http://www.ifrc.org

ILO, UNICEF, and The World Bank. 2003. “Understanding Children’s Work in Guatemala.” ILO manuscript.

Intergovernmental Panel on Climate Change (IPCC). 2007. "Climate Change 2007: The Physical Science Basis." Contribution of Working Group I to the Fourth Assessment Report of the IPCC, Geneva.

Jha, Abhas, Jennifer D. Barenstein, Priscilla M. Phelps, Daniel Pittet, and Stephen Sena. 2010. "Safer Homes, Stronger Communities: A Handbook for Reconstructing after Natural Disasters." The World Bank, Washington, DC.

Jensen, Robert. 2000. "Agricultural Volatility and Investments in Children." *American Economic Review*, 90(2): 399–404.

Lalive, Rafael and Cattaneo, Maria A. 2009. "Social Interactions and Schooling Decisions." *Review of Economics and Statistics*, 91(3):457-77.

Lora-Suarez, Fabiana, Carolina Marin-Vasquez, Nelsy Loango, Martha Gallego, Elizabeth Torres, Maria Mercedes Gonzalez, Jhon Carlos Castaño-Osorio and Jorge Enrique Gómez-Marín. 2002. "Giardiasis in children living in post-earthquake camps from Armenia (Colombia)." *BMC Public Health*, 2(5):1-6.

Lundberg, Shelly and Robert A. Pollak. 1993. "Separate spheres and the marriage market." *Journal of Political Economy*, 101:988–1010.

Maccini, Sharon and Dean Yang. 2009. "Under the Weather: Health, Schooling, and Economic Consequences of Early-Life Rainfall." *American Economic Review*, 99(3):1006–1026.

Macours, Karen and Renos Vakis. 2009. "Changing households' investments and aspirations through social interactions: Evidence from a randomized transfer." World Bank Policy Research Working paper no. 5137, The World Bank, Washington, DC.

Maluccio, John, Alexis Murphy, and Ferdinando Regalia. 2010. "Does Supply Matter? Initial Supply Conditions and the Effectiveness of Conditional Cash Transfers for Grade Progression in Nicaragua." *Journal of development effectiveness*, 2(1):87–116.

Maluccio, John, and Raphael Flores. 2005. "Impact Evaluation of the Pilot Phase of the Nicaraguan Red de Protección Social." Research Report no. 141, International Food Policy Research Institute, Washington, DC.

Maluccio, John. 2007. "The Impact of Conditional Cash Transfers in Nicaragua on Consumption, Productive Investments, and Labor Allocation." ESA Working Paper no. 07-11, Agricultural and Development Economics Division, UN's Food and Agriculture Organization.

_. 2005. "Coping with the Coffee Crisis in Central America: The Role of the Nicaraguan Red de Proteccion Social." Food Consumption and Nutrition Division Discussion Paper no. 188, International Food Policy Research Institute, Washington, DC.

Meyer, Bruce. 1995. “Natural and Quasi-Experiments in Economics”. *Ecological Economics*, 68(5): 1441-1453.

Moore, Charity. 2009. “Nicaragua's Red de Proteccion Social: An exemplary but short-lived conditional cash transfer program.” Country Study No 17, International Policy Centre for Inclusive Growth, United Nations Development Program.

Orazem, Peter F. and Elizabeth M. King. 2008. “Schooling in Developing Countries: The Roles of Supply, Demand and Government Policy.” In Paul Schultz and John Strauss (Eds.), Handbook of Development Economics 4:3475-3559.

Oreopoulos, Philip and Kjell G. Salvanes. 2011. “Priceless: The Non pecuniary Benefits of Schooling.” *Journal of Economic Perspectives*, 25(1): 159–184.

Parker, Susan W., Luis Rubalcava and Graciela Teruel. 2007. “Evaluating conditional schooling and health programs.” Handbook of Development Economics 4, Chapter 62:3963-4035.

Portner, C. 2008. “Gone with the Wind? Hurricane Risk, Fertility and Education.” Unpublished manuscript.

Premand, Patrick and Renos Vakis. 2010. “Do Shocks Affect Poverty Persistence? Evidence using Welfare Trajectories from Nicaragua.” *Well-being and Social Policy* 6(1): 95-129.

Psacharopoulos, George. 1997. “Child labor versus educational attainment. Some evidence from Latin America.” *Journal of Population Economics*, 10:377–386.

Regalia, Ferdinando and Leslie Castro. 2009. “Nicaragua: Combining Demand- and Supply-Side Incentives.” In Performance Incentives for Global Health: Potentials and Pitfalls. Rena Eichler, Ruth Levine and the Performance-Based Incentives Working Group, Center for Global Development, Washington, DC.

Restrepo, Helena E. 2000. “Earthquake in Colombia: the tragedy of the coffee growing region. Health impact and lessons for the health sector.” *J Epidemiol Community Health,* 54:761–765.

Rosemberg, Cristina, Ricardo Fort, and Manuel Glave. 2010. “Effect of Natural Disasters on Poverty Transitions and Consumption Growth. Evidence from Rural Peru.” *Well-being and Social Policy* 6(1): 55-94.

Rubalcava, Luis, Graciela Teruel and Duncan Thomas. 2004. “Spending, saving and public transfers paid to women.” Working Paper no CCPR-024-04, California Center for Population Research.

Santos, Indhira. 2010. “The Effects of Earthquakes on Children and Human Development in Rural El Salvador.” In R. Fuentes-Nieva and P. Sheck (Eds.), Risks, Shocks, and Human Development: On the Brink, pg. 128-144.

Schultz, Paul T. 2010. “Population and Health Policies.” In Dani Rodrik and Mark Rosenzweig (Eds), Handbook of Development Economics 5:4785-4881.

Socio-Economic Database for Latin America and the Caribbean. 2010. “Poverty Statistics.” CEDLAS and The World Bank, Washington, DC.

Skoufias, Emmanuel and Vicenzo Di Maro. 2008. “Conditional cash transfers, adult work incentives, and poverty.” *Journal of development studies*, 44(7):935-60.

Skoufias, Emmanuel. 2003. “Economic Crises and Natural Disasters: Coping Strategies and Policy Implications.” *World Development*, 31(7): 1087–1102.

Skoufias, Emmanuel and Susan W. Parker. 2001. “Conditional cash transfers and their impact on child work and schooling: Evidence from the PROGRESA program in Mexico.” *Economia*, 2:45–96.

Strauss, John and Thomas Duncan. 2008. “Health over the life course.” In Paul Schultz and John Strauss (Eds.), Handbook of Development Economics 4:3375-3474.

Strauss, John and Thomas Duncan. 1995. “Human Resources: Empirical Modeling of Household and Family Decisions”. In J. Behrman and T.N. Srinivasan (Eds), Handbook of Development Economics 3:1885- 2005.

Stromberg, David. 2007. “Natural Disasters, Economic Development, and Humanitarian Aid.” *Journal of Economic Perspectives*, 21(3): 199 –222.

Takamatsu, Shina. 2009. “Conditional Cash Transfer Programs and Spillover Effects within Households.” Unpublished manuscript, University of Minnesota.

Thomas, Duncan. 1990. “Intrahousehold resource allocation: An inferential approach.” *Journal of Human Resources*, 25: 635–64.

Unicef. 2004. “La escuela busca al niño.” Unicef report retrieve from http://unicef.org.co/EBN/publicaciones.htm.

Wachs, Theodore D., Maureen M. Black, and Patrice L. Engle. 2009. “Maternal Depression: A Global Threat to Children’s Health, Development, and Behavior and to Human Rights.” *Child Development Perspectives*, 3(1): 51–59.

World Bank. 2011. “Gender Equality and Development.” World Development Report 2012, Washington, DC.

World Bank and United Nations. 2010. “Natural Hazards, UnNatural Disasters: The Economics of Effective Prevention.” Washington, DC.

World Bank. 2009. “Guatemala Poverty Assessment: Good Performance at Low Levels.” Report No.43920-GT, Washington, DC.

World Bank. 2008. “Nicaragua Poverty Assessment.” Report no. 39736 - NI, Washington, DC.

World Bank. 2003. “Implementation Completion Report (FSLT-70090) on a loan in the amount of US$225 million to the government of Colombia for the Earthquake recovery project.” Report No. 24386, Washington, DC.

Yamano, Takashi, Harold Alderman, and Luc Christiaensen. 2005.”Child growth, shocks, and food aid in rural Ethiopia.” *American Journal of Agricultural Economics*, 87(2):273-288.