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On *Shaky* Ground: The Effects of Earthquakes on Household Income and Poverty[♦]

Javier E. Baez*
Indhira V. Santos**

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[♦] Document prepared for the ISDR/RBLAC Research Project on Disaster Risk and Poverty. This document is part of the Latin American contribution to the Global Assessment Report on Disaster Risk Reduction, and the Regional Report on Disaster Risk and Poverty in Latin America. The terms *natural disaster* and *climate-related events* will be used interchangeably, understanding that socioeconomic conditions play a role to explain the intensity and consequences of such phenomena. Thus, no event is strictly or exclusively natural.

[*] The World Bank and IZA ** Bruegel.

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"On *Shaky* Ground: The Effects of Earthquakes on Household Income and Poverty"

Javier E. Baez
World Bank and IZA

Indhira V. Santos
Bruegel

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Draft Paper

The devastating consequences of large natural disasters on socioeconomic systems are evident to all. Yet, little is really known about the magnitude of such negative effects on human development. For several reasons, El Salvador --the smallest country in Central America—is very susceptible to the effects of repeated and severe natural hazards. We use two strong earthquakes that struck El Salvador in early 2001 together with longitudinal data in a quasi-experimental fashion. Our strategy exploits the exogeneity implicit in the intensity of the geological events which is defined by their seismic parameters, the geographic coordinates of the dwellings and the predominant soil types of the villages. We find that the combined effect of both earthquakes is associated with a reduction in household income per capita of one third of the pre-shock average for households in the upper half of the ground shaking distribution There is also an increase in the depth and severity of poverty, although less significant in statistical sense. The results also highlight that the pervasive effects of natural disasters are likely to persist in the medium- and long-term. Overall, our findings do not appear to be driven by differential trends at pre-shock time, econometric specifications and methods, and sample attrition. Furthermore, we argue that the results are still informative when the empirical design is confronted with the issues of measurement error in the indicator of treatment intensity or aggregated equilibrium effects.

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1. Introduction

The world has witnessed an increase in the frequency and severity of natural disasters in the last two decades. Such prevalence of natural hazards has disrupted social and economic systems in a variety of ways. The adverse impacts range from human casualties, epidemics, disabilities, dislocations and direct damages on critical infrastructure and physical capital to potential losses in income, drops in consumption and reductions in human capital accumulation. In contrast, inflows of resources channeled through national and international reconstruction efforts in the aftermath of extreme natural events can increase and improve the stock of public and private capital and revive several dimensions of human welfare –even when compared to their pre-disaster levels. Furthermore, and in line with findings from standard neoclassical models, regions have often experienced strong and sustained economic growth after being struck by a large natural disaster.

At first, based on common observation, the combined effects of large disasters are expected to hinder development in the short-term and probably to persist –at least to some extent– in the long-term. Yet, establishing whether communities are worse off or better off as result of extreme natural events is above all a subject that can only be resolved empirically. But while the occurrence of a given natural disaster is largely exogenous, the impact that it has on the population is not. The deprivation that characterizes the lives of the poor –and their attainable choices– exacerbates the potential effects of natural disasters. It is for those families living along rivers or in steep slopes, in housing with inappropriate walls or roof and with fragile health and low education that these events represent the biggest risk. Likewise, the occurrence of natural disasters intensify these deficiencies by destroying crops and livestock, reducing incomes and consumption, and forcing households to liquidate assets and take steps that may curtail current and future human capital accumulation.

In addition to this two-way causal story, other potential issues can confound any association between human welfare and the vulnerability to natural disasters: varied institutional capacity, location of settlements, economic cycles and individual choices (e.g. migratory responses to shocks), among many others. Besides, the lack of proper data makes it hard to undertake solid strategies and robust micro-econometric methods. Therefore, disentangling the causal impacts of natural disasters on human development is rather a complex empirical task. In this paper, we attempt to overcome these concerns by exploiting two seismic events that hit El Salvador in 2001 in a quasi-experimental fashion.

El Salvador is by area the smallest country in Central America but its economy –measured by the GDP– is the third in importance in the region after Costa Rica and Guatemala. Despite noticeable progress in past years, El Salvador was one the poorest countries in Latin America at the time of the quakes, with nearly 31% (update) of the population under extreme poverty in 2000. This degree of poverty was compounded by limitations in critical infrastructure, partial access to social services, low levels of schooling and profound informality in the labor market, especially in rural areas of the country. Yet, two factors have marked the recent economic and social Salvadorian history: civil conflicts and natural disasters. Despite the fact that the war officially ended at the beginning of the 1990's, the country remains very susceptible to the effects of repeated and severe natural events.

The vulnerability of El Salvador to natural hazards is explained by several factors. First, the country has the highest population density among all the countries in Central America. Second, several major population settlements are located along six active volcanoes and in areas highly exposed to geological hazards such as the earthquake-prone Ring of Fire. In fact, El Salvador has been struck by a major quake, on average, once every ten years during the last century. Third, the country is located in the sub-tropical hurricane area and, thus, is subjected to both Atlantic and Pacific storms. The floods triggered by these storms are at times followed by extended dry periods with significantly below average precipitation.

Two strong earthquakes and a number of smaller follow-ups struck El Salvador in early 2001. These earthquakes and related landslides produced a death toll of more than 1,200 people, affected nearly 300,000 dwellings (about 32% of the existing housing stock) and caused US$1.6 billion in direct and indirect damages (12% of GDP in 2000).[1] Our empirical analysis is aimed at identifying and quantifying the net impacts of these geological shocks on household income and

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[1] Economic Commission for Latin America and the Caribbean (CEPAL, 2001a).

poverty as well as exploring their possible consequences for long term human and economic welfare. We also test some of the channels of transmission to provide some insights into the mechanisms at play. Overall, identification is attained essentially from two specific features of these shocks: (a) the quasi-exogenous location of the earthquakes and, (b) the quasi-exogenous variation in treatment intensity derived from the degree of ground shaking and depth of the earthquakes. We implement this strategy with pre- and post-shock data from four rounds of longitudinal surveys collected in rural areas of El Salvador (approximately 700 households) and data on the geological parameters of the earthquakes to construct measures of ground shaking, i.e. intensity.

We find that the combined effect of both quakes is associated with a reduction of $1,760 *colones* in household income per capita –one third of the pre-shock average– for households in the upper half of the ground shaking distribution. Back-of-the-envelope calculations suggest that this decline in rural incomes roughly amount to the gains of economic growth that these households achieved during the prosperous decade of the 1990's. Although the results do not show a statistical significant increase in the poverty headcount ratios among highly affected households, other measures more likely to capture the impoverishing effects of the two disasters such as the poverty gap indicate that there was an increase in the depth of poverty. We also show that these findings are not driven by external issues not related directly with the impacts of the earthquakes such as differential trends between experimental groups at pre-shock time, econometric specification and methods or sample attrition. Furthermore, we argue that the results are still informative when the empirical design is confronted with the issues of measurement error in the indicator of treatment intensity or aggregated equilibrium effects.

The fall in income seems to be explained by ….. (complete this with the mechanisms).

These results together with previous findings highlight that while natural disasters have a pervasive impact on poverty in the short term, the most dangerous effects are those that reveal themselves only in the medium to long term. Children in households highly exposed to the 2001 earthquakes in rural El Salvador became differentially less likely to attend school as the probability of enrollment decreased by 6 percentage points, a fall of 7% (Santos, 2007). The evidence for El Salvador indicates, therefore, that sufficiently large natural disasters are likely to have a long term and inter-generational impact on poverty, unless public policy plays both a prevention and mitigation role.

The remainder of the paper is organized as follows. The next section summarizes the existing empirical evidence that investigates the influence of natural shocks on socio-economic conditions, gives background information on El Salvador at the pre-shock time and describes the earthquakes of interest for this study. The third section presents and discusses the data, the identification strategy and findings of the natural experiment arising from the earthquakes as well as a series of robustness checks. Next, we examine some of the channels through which the effects were transmitted and provide interpretation for our results. Finally, section five concludes, focusing on the implications of the findings for the literature on risk and household welfare, natural disasters and public policy.

2. Background

2.1. Relevant Literature

Not surprisingly, the rising prevalence and severity of natural disasters has increasingly caught the attention of scholars in a variety of fields. Yet, the empirical side of the literature that examines the potential causal impoverishing effects of these events for specific segments of the population is rather scant. The main reason is probably that disentangling these impacts in a credible way has long proved challenging. This task requires not only datasets that span many object categories but also identification strategies that exploit suitable variation in exposure (or intensity) to natural disasters. Often, both are hard to obtain.

What is empirically known to date in regard to the link between natural disasters and poverty emerges basically from two strands in the literature. First, there is the dominant approach which has examined the effects of these events on country-level variables such as GDP, GDP growth, indebtedness, inequality and damages to the environment (Charveriat, 2000; IADB, 2000, CEPAL, 2001). Overall, this literature has highlighted the pervasive impacts of exposure to natural shocks on these aggregate measures in short- and middle-run, in particular the heavy toll in terms of the share of the GDP. Studies of this type have gathered information to document that, for instance, the damages of the floods of Guyana (2005) and Bangladesh (2004) added up to almost 58% and 12% of their annual GDP, whereas the losses arising from the earthquake in Pakistan (2005) and the tsunami in Sri Lanka (2004) accounted for 5% and 7% of their GDP, respectively (International Strategy for Disaster Reduction, ISDR, 2008). As for Latin America, Charveriat (2000) estimated that the annual average cost of natural disasters in the region for the period 1970-1999 was between $700 million and $3.3 billion (put this number in context). Similarly, other works that have used different metrics to assess the impacts have also stressed the costs in terms of lives, people's disability and injuries and livelihoods affected. All agree that the impacts are enormous and they are unequally distributed, with the poor and most vulnerable carrying most of the burden of the costs.

The second approach comes from a parallel and growing interest in the literature on microeconomic development to investigate the human welfare consequences of shocks, either natural (e.g. climate-related disasters) or man-made (e.g. economic downturns, conflicts). This body of research has explored the impacts of these phenomena on many different but related household and/or individual level responses: the ability of households to smooth consumption (Deaton, 1992; Paxson, 1992; Townsend, 1994 & 1995; Jalan et al., 1999, Morduch, 2002; Skoufias, 2002), the production and investment behavior of farmers (Biswanger et al., 1993; Rosenzweig et al. 1993, Fafchamps et al., 1998; Kazianga et al., 2006), labor supply adjustments (Cunningham, 2001; World Bank, 2003), child labor (Beegle et al, 2003; Vakis, et al., 2004), school attendance (Jacoby et al., 1997; De Janvry et al., 2004), nutrition and health outcomes (Foster, 1995; Jensen, 2000; Hoddinott et al., 2000 & 2001), and migration (Jalan et al., 1999). Overall, these studies have long stressed the negative effects of these events on welfare, in particular for poor, credit constrained and uninsured households.

Yet, just a few papers focus specifically on the susceptibility of different dimensions of human well-being to major disasters. For instance, Foster (1995) shows that the growth of children in landless and credit constrained households was severely affected by very destructive floods that struck rural Bangladesh in 1988. Ureta (2005) finds a worsening in school retention and progression in some areas of Nicaragua that were hit by Mitch, a category five hurricane that hit the country in 1998; a deterioration in the nutrition status of young children and an increase in the prevalence of child labor associated to this hurricane was also identified by Baez, et al. (2007), even three years after the phenomenon occurred. As for the effects geological risks, in previous work Santos (2007) found that the 2001 earthquakes in El Salvador reduced school attendance and changed the allocation of children's time towards more work outside of the household –and for longer hours. To the extent that a lower accumulation of human capital roughly means a lower future income, this evidence suggests that natural disasters can even have long-lasting impacts on poverty rates through the inter-generational transmission of these effects.

Three additional general features characterize the majority of the literature on the subject and help illustrate the contributions of our work. First, most of the papers have looked at shocks –or proxies of them– that produce transitory fluctuations in income. Therefore, with few exceptions, existing work has ignored that large and aggregate disasters such as hurricanes, floods and earthquakes have also wider effects on household assets and community resources. Consequently, they can underestimate the magnitude of the impacts, attribute the effects to drops in income solely or ignore their stronger persistence in the middle and long run. More precise knowledge about these interactions and dynamics is crucial for the design of disaster aid policies. Second, most of the findings from works that look exclusively at natural disasters rely on reduced form estimates –mainly for data reasons– but do not provide insights into the mechanisms of transmission. Finally, even though most of these studies have assessed the effects of shocks on the proximate determinants of poverty, none –to the best of our knowledge—has directly tested the possible impoverishing consequences of these events, especially for the Latin American context. We attempt to do so in the next sections.

2.2 El Salvador before the Shock

The end of the civil war in 1991 brought an inflection point for the future socioeconomic progress of El Salvador. Immediately after, a number of structural economic reforms were enacted with the aim of achieving macro-economic stability, introducing the foundations for free markets and integrating the economy to global markets. Following these reforms, the economy expanded at an annual rate of 6 percent on average during the first half of the 1990's, much faster than previous years. Growth rates declined between the mid 1990's until 2001, in part due to a coffee crisis (a major source of income for a large fraction of rural households), a strong hurricane and other domestic economic shocks, but they still remained well above their pre-war levels. In all, the political, social and economic transition of the 1990's allowed the country to achieve substantial social and economic progress through higher incomes, education levels, coverage of basic services (e.g. water and electricity), and better health outcomes (e.g. life expectancy and infant mortality) and nutrition.

This success was accompanied by a remarkable reduction in poverty before the earthquakes. The proportion of people below the poverty line fell from 64% in 1991 to 39% by 2000, whereas the corresponding measure of people in extreme poverty declined by 15 percentage points during the same period –from 31% to 16% (World Bank, 2004). By 2000, El Salvador had a per capita income of US$2,326 (constant 2000 US$), higher than neighboring Guatemala, Honduras and Nicaragua's. Yet, these achievements were not homogenously distributed between urban and rural parts of the country. Poverty was considerably higher in the latter, where over half of the people were poor by 2000 and about 25% lived under extreme poverty, almost twice the average ratio of urban centers. Similarly, there was substantial variation in poverty decline at the state level, with some departments such as Cuscatlan, San Miguel, Morazan and San Salvador having much less success on this front.

This economic and social transformation has been accompanied –and probably debilitated– by a long history of natural disasters. The country is geographically positioned in an area subjected to a large variety of hazards such as earthquakes, droughts, hurricanes, floods, volcanic eruptions and mudslides. The prevalence of geological disasters is a good case in point. El Salvador is located on the Pacific's Ring of Fire –an area of regular seismic events and volcanic activity– and has been confronted with a major earthquake on average once every ten years throughout the last century. Three major seismic shocks hit the country between mid 1980's and early 2000's. The geological risks are further compounded by relatively frequent volcanic eruptions. Its location in the sub-tropical hurricane area also makes El Salvador highly exposed to storms and cyclones originated in the Pacific and the Atlantic. During the five years before the earthquakes studied in this paper, the country was hit by two powerful hurricanes: Cesar-Douglas in 1996 and Mitch in 1998. In addition to the enormous amounts of precipitation dropped by these events, yearly floods and mudslides are often triggered by erratic periods of heavy rains. El Salvador has also dealt with extensive periods of rainfall well below average precipitation like the drought that affected large areas of subsistence crops and arable land between 1998 and 2000 and became the worst drought to hit Central America in recent years.

El Salvador's vulnerability to natural hazards is further compounded by a combination of existing social and economic factors. First, in addition to its high population density, numerous urban and rural settlements are located in areas with particularly high risks of volcanic activity, earthquakes and hurricanes.[2] Unsurprisingly, the human and economic costs that arise when natural disasters strike are relatively higher than in neighboring countries. Second, and despite its recent economic advance, still many social challenges prevail. Low levels of education and income, limited access to basic social services, unsafe settlements, low-quality housing and precarious infrastructure increase the vulnerability of some individuals, especially the poor. Third, a big part of the country relies on agro-economic activities to derive their incomes, which are vastly dependent on natural conditions and thus, highly volatile. Finally, the country lacks reliable and integral systems of risk identification and disaster preparedness that could reduce its vulnerability considerably. Therefore, it is against this scenario of economic growth, prevalent natural hazards and variation in vulnerability that we test whether the two strong earthquakes of 2001 worsened the standards of living of those mostly affected by these shocks.

2.3 The Earthquakes of 2001

On January 13, 2001, just after 11:30 am many Salvadorians were shaken by a major earthquake of magnitude 7.7 in the Richter scale and a number of subsequent follow-ups. The second phenomenon, which compounded the negative effects of the January event, struck on February 13 and had a magnitude of 6.6 in the Richter scale. Figure 1 shows the location of the

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[2] With approximately 330 inhabitants/km^2, El Salvador is the most densely-populated country in Central America and the second in Latin America after Puerto Rico.

epicenters of both earthquakes. In the January event, the most affected departments were Usulután, La Paz and San Vicente, but the whole country was affected to some extent. The February earthquake, in contrast, generated damages in a smaller area. The most damages were concentrated in the departments of La Paz, San Vicente, San Salvador and Cuscatlán, although the effects of the January event were accentuated in the neighboring regions.

The series of earthquakes and related landslides had a combined death toll of more than 1200 people, affected an estimated 300,000 dwellings (approximately 32% of the existing housing stock in the country) and caused US$1.6 billion in direct and indirect damages (12% of GDP in 2000). The total losses produced by the earthquakes were equivalent to the economic growth that El Salvador had accumulated during the four years before the events (UNDP Human Development Report, El Salvador, 2001). Table 1 presents information by economic sector on the total value of the direct and indirect damages due to both earthquakes.

(creo que falta un poco aca)

3. Empirical Analysis

3.1 The data

We use panel data from the BASIS El Salvador Rural Household Surveys, comprised of four biennial questionnaires with approximately 700 households and covering between 1996 and 2002. These surveys were organized and conducted by the Salvadorian Foundation for Economic and Social Development (FUSADES by its Spanish acronym) with the support of the World Bank. The BASIS surveys did a good job in following households that moved within El Salvador, especially since 1998.[3] In 1996, 628 families were interviewed, while in the 1998 round, 494 households of those included in the first round (1996) were re-interviewed. In addition, in 1998 – in order to make the sample nationally representative once again– 25 families similar to those who left the sample and other households were added for a sample size of 623 families. After 1998 attrition was very low. In 2000, only 4.7% of the 1998 households left the sample, while

[3] When the survey started in 1996, it was not planned to have other waves in the future with the same households and, as a result, there is a larger attrition between 1996 and 1998 (21.3%) than between the following years.

between 2000 and 2002 only 24 out of 696 household dropped out (3.4%).[4] In general, there are 451 households that took part in the four waves. In this study, we primarily make use of the last two rounds of the survey, namely 2000 (year before the earthquakes) and 2002 (year after the shock) to identify the impacts of the earthquakes on household incomes and poverty.

Like most of the household-level surveys conducted in developing countries, the BASIS collect detailed information –only in rural areas– on household and individual demographics, employment, household income, assets, savings and other related data corresponding to the preceding calendar year. In addition to that, the 2000 dataset includes the geographic coordinates for each dwelling in the sample which we use in our identification strategy. In turn, the fourth round (fielded in 2002) also has detailed information on the impact of the earthquakes at the household level (in terms of income, assets, health, etc.), as well as module with the actions undertaken to cope with the consequences of the shocks.[5]

The panel data for 2000 and 2002 covers 14 departments and 162 municipalities and 653 rural households. Selected descriptive statistics of the households in the sample for 2002 (the pre-disaster year) are summarized in Table 2.[6] Families in the sample, as is often the case in rural areas of developing countries, are poor and vastly dependent on agriculture. The median annual income per capita of the households is $3,444 colones or US$394 and in 2000, 34% of the households were living in extreme poverty as they were not able to afford a basic basket of food, while 17% more lived in relative poverty as they could afford one but not two baskets of food for each one of its members. 70% of households have at least one member working in the agricultural sector and, on average, more than one quarter of households' income depends on agriculture, which suggests that there was a non-trivial degree of income diversification among the households in the sample. Remittances also account for an important source of income, with 28% of the households receiving remittances that represented three quarters of their total income.

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[4] These 24 households – 14 which would have been in the treatment group, as examined with 1998 and 2000 data, do not systematically differ from the other households in their group in terms of household and individual characteristics expected to be associated with our outcomes of interest.

[5] Further information from the BASIS survey is available at http://www-agecon.ag.ohio-state.edu/programs/RuralFinance/Basis.htm

[6] All monetary values are expressed in 1996 *colones*.

Households have nearly 6 members and the head is poorly educated, with less than five years of schooling on average. In addition, less than a quarter of the households have any savings and only half report ever having any type of credit –formal or informal. This means that, if faced with a large negative shock like a natural disaster, many of these households have very limited capacity to smooth consumption in the aftermath of such an event through capital markets. The ability of their dwellings to withstand natural hazards is also fairly limited, and the construction materials most often used –adobe and *bahereque*– are ill-prepared for strong winds, flooding or strong ground shaking. Similarly, only 44% of households have a private source of water and 68% have electricity.

In short, the longitudinal nature of the BASIS dataset, together with the richness of information in terms of the socio-economic and demographic characteristics of the households, make this survey well-suited for investigating the impact of the 2001 earthquakes on incomes and poverty. In the next subsection, we describe our empirical methodology and how we exploit the data available to provide a causal story of the microeconomic effects of the quakes in El Salvador.

3.2 Identification

The main objective of this paper is to isolate the causal effect of the 2001 seismic events on rural household incomes and poverty in the short-term.[7] Although ideal, it is impossible for obvious reasons to achieve this goal with a strategy that relies on a fully experimental randomization. Instead, we attain identification through the exogeneity implicit in the intensity of the shocks which is defined by the parameters of the earthquakes, the geographic coordinates of the dwellings and the predominant soil types on which the villages were located. These variables are combined in a way that allows us to construct measures of the ground shaking (i.e.

[7] Although from a welfare standpoint, households are more interested in consumption than in income, the BASIS dataset only contains information in the latter. However, in an environment like that of rural El Salvador, where credit and insurance markets are highly imperfect, income could be taken to represent a good proxy for consumption.

intensity) experienced by each household and, thus, determine the experimental groups in our study. [8]

Both the January and February quakes were well recorded by three accelerograph networks in El Salvador and peak ground acceleration (PGA) data are available for 31 stations throughout the country (Cepeda, et.al, 2001). PGA indicates the ground strong motions –the shaking– to which a location is exposed and depends mainly on the characteristics (i.e. parameters) of the seism (magnitude, depth, duration, spectral distribution of the movements), distance to the epicenter, the quality of the construction and the response of the local soil (soft terrains amplify the shaking). PGA values –measured as a percentage of gravity acceleration– between 0.25 and 0.45 are associated with earthquakes that are "destructive" (i.e. partial collapse in substantial buildings and great damage in poorly constructed ones); 0.45 – 0.60 with events that are "ruinous" (i.e. buildings shifted off foundations and considerable damage to even specially designed structures); 0.60 to 0.80 with "disastrous" quakes (i.e. some well built wooden structures destroyed; most masonry and frame structures destroyed with foundation); 0.80 to 0.90 with "very disastrous" events (i.e. few, if any masonry structures remain standing) and above 0.90 with "total damage" (UCGS, 2007).

To construct the indicator of the shock, we first regress the strong ground motions of the stations on their distance to the quake's rupture and the station's soil type. The resulting attenuation relationship for each earthquake, together with the geographic coordinates for each household prior to the shocks, is used to estimate the shaking that each household was subject to during the 2001 earthquakes. This yields an indicator that is defined to be in the (0, 1) interval and ranges between __ and __ in our sample. The measures constructed are used in two ways. In a first specification we exploit the variation in earthquake intensity to identify the marginal effect of ground shaking on the outcomes of interest. Second, we define two groups based on the household's relative position in treatment index distribution. According to this, we define a household to be part of the "high intensity" group if it is among the upper half of households in the sample exposed to the hardest shaking as measured by the sum of the earthquakes ground motions. The "low intensity" experimental group is defined likewise based on the bottom half

[8] For a more detailed description of this measure, see Santos, I. (2007), where this methodology was first developed.

portion of the distribution. On the basis of this, out research design is not using "clean" and "immune" counterfactuals that were completely unaffected by the shock as the source of identification but rather comparison groups derived from variation in exposure to the power of the events.[9] This has important implications for the interpretation of the results and the messages extracted for policy action.

Of the 653 panel households present in both 2000 and 2002, 328 form the "high intensity" experimental group, which we call treatment group from hereon. On average, households in the treatment group experienced a peak ground acceleration of 0.7 *g* (70% of the acceleration of gravity), compared to 0.32 *g* in the control. Table 1 presents the summary statistics of key variables, broken down by treatment status. There are no significant differences between the households hardest hit by the quakes and those in the comparison group in terms of most key socio-economic indicators such as median household income per capita, age, schooling and gender of the head of household, wealth indicators or access to credit.

This comparison, however, shows that those households exposed to more intense ground shaking have a lower probability of having savings and a migrant relative. To the extent that these characteristics influence the effect of the shock in our outcomes of interest, results could be biased. The observed pre-shock differences, however, disappear once one includes geographical controls. The earthquakes mostly affected Central and Oriental regions, and therefore western departments in the Occidental region are not represented in our treatment group. Since departments in El Salvador are quite heterogeneous, this translates into differences in some characteristics of the treatment and comparison groups.

In short, controlling for the geographic composition of our sample, there are no observable pre-shock differences between those households exposed to the shock and those in the comparison group. This result suggests that the latter can be considered a suitable counterfactual of the "high-intensity" group based on the balance of most covariates examined. In the multivariate analysis that follows, as described below, we control for the pre-shock

[9] This is more the rule rather than the exception for studies of this type. Since good and credible comparison groups for households affected by large and aggregated shocks are difficult to find, variation in intensity is in practice the most common –and often– only source of identification available.

characteristics mentioned previously and include municipality fixed effects as well as department and year interaction effects.

3.3 Empirical Specification

The empirical strategy discussed above is implemented with a double-difference (DID) analysis and seeks to investigate the impact of the 2001 earthquakes on households' income and poverty in rural El Salvador. Since variation in the outcome variables between 2000 and 2002 can be due to other factors not related to the seismic shocks, we include additional controls related to household initial socio-demographic and economic characteristics. In addition, these controls allow us to take into account that some of the pre-shock differences in the sample –mainly geographic– could give rise to different underlying trends biasing the results. We use linear probability DID models for the dichotomous outcomes of interest –mainly extreme and relative poverty- and OLS and fixed effects DID models for estimating the response of household income to the earthquakes. The main specification takes the following form:

$$Y_{imt} = \alpha + \varpi_m + \beta_1 X_{it=0} + \beta_2 t_t + \beta_2 T + \beta_3 (t_t \ x \ T) + \beta_4 (T \ x \ Z_{it=0}) + \varepsilon_{imt} \qquad (1)$$

The unit of observation is household *i* in municipality *m* in year *t* (1 if 2002, 0 otherwise). *T* identifies the treatment and comparison groups and, as noted before, is defined as a binary index (1 if treatment, 0 otherwise) or as continuous intensity measure that varies between 0 and 1. *Y* represents each of the outcomes of interest. All regressions include municipality fixed effects, ϖ_m, and pre-shock socio-demographic controls $X_{it=0}$: head of household's education, age and gender; household size, dwelling's wall materials, distance to closest school and paved road, crops cultivated and type of soil where the dwelling is located. Other controls include dummies for whether the household owns business, works in agriculture, has animals, owns land, has electricity, has indoor plumbing or private well, receives public aid, has credit, has savings, has a migrant relative, receives inter-household transfers. The coefficient of interest is β_3, which captures the specific average variation in the outcomes of treated households between 2000 and

2002 with respect to the controls. Standard errors are robust and clustered at the municipality level.

$Z_{it=0}$ is a sub-set of vector X with household characteristics for which we estimate interaction effects. In particular, we include departmental and year interactions to account for differential geographic trends in the outcomes of interest and departmental and shock interactions to control for possible differential impacts of the shock across departments. Additionally, the most complete specification includes other interaction terms in order to check for differential effects of the earthquakes depending on household composition, crop-grown, initial wealth and pre-shock access to other risk coping mechanisms such as credit and remittances. Lastly, ε_{imt} is a assumed to be mean-zero error term. The results of these empirical models are presented in the next section.

3.4 Results

Income and Poverty

We initially focus on quantifying the aggregated effect of the two geological shocks on household income per capita.[10] The economic growth experienced in El Salvador since the 1990s, (briefly documented in Section 2.2) means that there were rapid reductions in poverty and an overall improvement in living standards during this period. This situation is no different for the rural households in our sample. Between 2000 and 2002, average household income per capita increased from $5,449 to $6,957 colones in real terms, while poverty rates fell from 33.8% to 26.6% in the case of relative poverty and from 16.8% to 16.2% for extreme poverty.

Despite that the treatment and comparison groups start from similar levels, the growth in average incomes was larger for the households less affected by the shock, making the effects of

[10] Our measure of household income is constructed by adding: 1) net agricultural income from agricultural production (using the market price of all production if consumed or sold), animals (using the market price of animals sold, derivates), salaries received for agriculture work, and other income (rent from land, tools, etc.) - minus the cost of the inputs used, salaries and other related costs such as land rent; 2) net non-agricultural income from own business, salaries in non-agro jobs and other income such as housing or car rent, interest or pensions; 3) inter-household and public transfers from inside and outside of El Salvador.

the earthquakes already apparent in the raw data. Simple DID models (with no covariates) indicate that the earthquakes are associated with a reduction of $1,760 *colones* in household income per capita or one third of the pre-shock average for the whole sample (specification (i) in Table 2). We also incorporate these exercises into a multivariate analysis. The magnitude and statistical significance of the effect is maintained, with the most conservative estimate – specification (iii) that includes multiple interaction terms– associating the earthquakes with a $1,709 *colones* fall in annual household income per capita. Interestingly, the negative average effect of the seismic events rises by 19 percent ($325 *colones*) when public transfers (likely endogenous) are excluded from the income calculations.

Our results so far have shown that the geological events resulted, on average, in a substantial loss of income for treated households relative to comparison households. Yet, these impacts appear to vary across the income distribution. Building on the seemingly exogenous variation in treatment intensity presented above, we constructed non-parametric distributions of household income per capita for treatment and control groups at the pre- and post-shock times (Figure 2). For our purposes, the main insight from these graphs is that, whereas the distributions overlap almost completely before the earthquakes hit El Salvador, there is a clear departure between the two in the period after the events. This shift left the group of treated households worse-off vis-à-vis their counterparts in the comparison group, which is particularly evident for those with after-shock incomes (annual per capita) up to $8,000 *colones*. However, it is important to note, that the "worsening" of the income distribution is only relative to the potential level, as the income prospects have improved significantly for both groups during the period under study.

We next move to investigate the impacts of the earthquakes on poverty. The distributional analysis discussed above hints at an increase in the prevalence of poverty among the most affected households. In fact, as shown in Table 2, the direction of the estimates suggests that more people in this group fell below the poverty lines, especially for the measure of relative deprivation. However, they are not significant in statistical sense. Part of the reason may be explained by the limited power of our empirical models to capture a visually apparent but marginal increase in poverty due to a relatively low number of observations (656 after-shock observations), in particular around the poverty thresholds. Related to this, the other plausible interpretation is that the earthquakes had a minor impact on poverty but overall affected considerably the standards of living of a group of low-middle- and middle-income rural households in El Salvador. Indeed, as the kernel densities show, most of the worsening in incomes is suffered by household gathered above the poverty lines and around the median income household. [meter los resultados que usan las otras medidas de pobreza y el indicador continuo]

Potential Long-Term Effects

Up to now we have documented an instant reduction in rural income associated with the intensity of the earthquakes. The next natural question is to examine whether such impacts could persist in the longer horizon and are transmitted across generations. However, since 2002 is the last year available in the BASIS dataset, one need to focus on the possible impact of the earthquakes on household assets (physical and human) to get an indication of the medium and long-term effects. As it will be illustrated below, we argue that the pervasive effects of the natural disasters are likely to extend beyond the immediate effects presented above. Indeed, some simple statistics suggest that they could have a permanent effect on people's budget through the loss of productive assets, the diversion of investment resources towards current consumption and a reduction in investments in human capital.

We initially approach this subject by examining the consequences of the shock on productive resources and other physical assets, both through the direct damaging effects of the quakes and the responses of households to cope with their impacts (e.g. liquidation of assets). The BASIS questionnaire collects information on the asset losses suffered by households, including housing and other buildings, land, home furniture and appliances, agricultural and non-agricultural machineries and tools, inventories and productive animals (Table 5). Nearly two thirds of the households in the sample suffered asset losses. Conditional on having experienced a loss, the median value of the total losses was $1,840 *colones* or 9% of the pre-shock median household income. As expected, households in the treatment group experienced more severe damages. The proportion of households declaring asset losses is higher in the treatment (70%) than in the control group (56%). The median value of the losses suffered is twice as high in the experimental group ($2,400 versus $1,440 *colones* among the control households). The destruction caused by the earthquakes is also reflected in the damages suffered by the existing infrastructure, in particular housing. With 56% of the dwellings built out of materials with low resistance to seisms (e.g. adobe and bahereque), it is not surprising that one third of households in our sample report experiencing severe damage to their dwelling, including the case of its total destruction or when it was rendered inhabitable.

In the aftermath of the shock, households carried out a series of actions in order to maintain their level of consumption and finance reconstruction activities. Some of these responses imply that households liquidated critical means of production. For instance, 9.3% of households had to sell productive assets –animals or land– and 1.07% report having sold other assets. Similarly, a large fraction of households had to use their savings (20.5%) or borrow money (14.2%). Even though the latter is in theory an optimal response to smooth consumption, what the data seem to indicate is that part of these resources were not aimed at balancing out transitory spending and saving but increase the accumulation of future assets. For example, 7.5% of households cite having stopped or cancelled investments in physical capital and 23.7% having saved less as strategies to deal with the consequences of the quakes.

Finally, and perhaps more importantly, the two geological events had negative impacts on human capital accumulation in children and, therefore, on future income prospects of the affected population–and possibly of the rest of the economy. With limited access to credit and insurance markets, it seems plausible that the income and asset shock illustrated above force households to withdraw children from schools (Basu, 1999; Jensen, 2000; Baez & Santos, 2007). Indeed, going to school is not cheap in El Salvador. Data from the BASIS survey for 2000 reveals that rural households with children in El Salvador spend on average $754 *colones* per year on school expenses (including uniforms, books, tuition, transportation and food), equivalent to one third of the median household income.[11] After the shock, 4% of rural households with children in the BASIS dataset report that the earthquakes left them with no money to send children to school.

For a more rigorous take on this issue, and drawing on results from Santos (2007), we focus on the impact of the shaking of the earthquakes on children's school enrollment as a proxy for the future accumulation of human capital.[12] Still using the BASIS dataset, we limit our sample to children aged between 6 and 15, and follow the same design exploited so far. Results are summarized in Table 7. At baseline 83.6% of children in the treatment households and 77.3% of control children were enrolled in school. While the rate seems to have increased for both groups, the change is much more marked among children in the comparison areas, increasing by about 5 percentage points. When moving from a simple DID to a multivariate model, the estimated effect of the earthquakes on enrollment not only stays almost intact to the inclusion of household-level covariates but it is also strengthened when departmental and year interaction effects are added (significant at the 5 percent level).

3.5 Robustness Analysis

A number of factors associated with the nature of the shocks and our research design can threaten the internal validity of this study. In what follows we either test or intuitively discuss the robustness of the causal relationships from the empirical models to these issues. We start by assessing the exogeneity of the implicit quasi-experiment that defines the treatment and comparison groups. Essentially, the validity of our instrument emerges from the exogenous nature implicit in the determinants of the treatment intensity: earthquakes' magnitude, distance to the epicenters and geological conditions of local soils. Furthermore, such orthogonality has been tested indirectly throughout the paper when comparing the sensitivity of the parameters between the simple DID and the extended models with the inclusion of covariates. Largely consistent with results from the test of balance in pre-shock covariates, the coefficients of interest

[11] The official annual national household survey reveals that, among children in rural areas who should be enrolled in school but are not, 20% did not go to classes because they needed to work, 16.8% of the cases were attributed to household economic difficulties while 17.1% responded that schooling was too expensive.

[12] Citar trabajo de Vakis sobre la alta probabilidad de que los ninos no vuelvan a la escuela

remain mostly unchanged across models. Then, by design, our strategy would be contestable by time-varying and unobservables –or unmeasured– factors that are correlated with the intensity of ground shaking. These correlations seem very implausible.

Next, we test the underlying assumption of our models in the sense that any differential changes in the outcomes between treatment and comparison groups are attributed exclusively to the intensity of the quakes and not to other pre-existing factors. This source of bias is investigated directly with two waves of pre-shock longitudinal data from the BASIS project collected in 1998 and 2000, the latter being the baseline information used in the main empirical models. Given that the seismic events hit the country in 2001, we run a placebo test for the period 1998-2000 for which basically all households become part of the control group. We test the hypothesis of no "treatment effect" during the pre-shock interval, namely that the treatment indicator (either the binary or continuous definition) is not statistically different from zero. Indeed, the results of this exercise indicate the findings presented above were not driven by any underlying group-specific trends (Table xx).

Seeking to assess the sensitivity of the results to the linearity assumed in the main regressions, the econometric models were re-estimated using non-parametric double-difference methods (PSMDD). Several kernel techniques are used to match treatment households with households from less affected areas on the basis of the propensity score. The score itself is constructed with the parameters obtained from a logistic regression of the treatment status on a number of pre-shock municipality and household variables. Bootstrapped standard errors from PSMDD models are obtained from 250 replications. Overall, the quantitative findings of the paper as well as their statistical significance are largely replicated by these non-parametric models.

Another potential subject of concern is attrition. Inferences regarding the causal effect of the earthquakes could be biased in the event that the decisions or the reasons to leave the sample are attributed to the strength of the geological events. But more importantly, if the underlying factors explaining these decisions/reasons are systematically correlated with the definition of our experimental groups and, accordingly, affect the composition of these groups between the pre- and after-shock time. We argue that attrition in this study is largely exogenous to the definition of the shock. It was pointed out at the beginning of the document that the BASIS project was very successful at recontacting households in the follow-up surveys. Indeed, for period 2000-2002 in particular, just 3.4% of the households (24 out of 696) were untracked. In spite of the low number of leavers, two additional simple statistical exercises were undertaken to further examine this issue. First, and notwithstanding the low variation in the outcome variable, we run regressions of the attrition status on treatment intensity, conditional on pre-shock covariates. The results show that the magnitude of the ground shaking does not predict attrition in our sample (Table xx). Second, we compare observable key baseline characteristics of households that were and were not re-interviewed in 2000 and do not find any substantial differences. Furthermore, the various treatment effect parameters estimated with household fixed-effect models and regressions that include the 24 untracked households are almost identical. The consistent message from this series of results is that our design is highly robust to the issue of sample attrition.

Finally, we discuss two other subjects of concern that, although of different nature, are expected to produce a similar bias. The first one is measurement error in the indicator of treatment. It is true that we carefully constructed a measure that incorporates the most important parameters of the quakes determining the seismic magnitude experienced by each household. Yet, it is probable that our measure of the shock misses other factors that also shape the severity of the earthquakes. For example, the propagation of seismic waves is to some extent determined by the complex combination of local geological and geomorphological characteristics. Although we attempted to account for these local conditions –as well as for other determinants, the information used and in particulat the way in which these complex relationships were modeled means that the treatment indicator is still an approximation of the real intensity of the earthquakes. This noise implies that the shock indicator is probably measured with error and, thus, the parameter would suffer from a attenuation bias.

The second issue is related to the definition of the comparison group, i.e. "low intensity". By construction we assume that, after controlling for pre-shock observables and time-invariant group-specific characteristics, the only difference between them and those in the "high intensity" group is the magnitude of the shock. Yet, households in areas with lower treatment intensity can also confront the country-wide impacts of the earthquakes (as the treatment group does) such as the effects of disrupted infraestructure on the access to markets or the consequences of an economic slowdown on employment and prices. If so, the comparison group is also worse off through these channels and less "immune" as originally though. Again, this would bias the results downwards. However, although it is is certainly difficult to rule out this matter or the problem of measurement error, both issues do not eliminate the information behind our causal history since the parameters can still be interpreted as lower bound estimates of the true impacts resulting from the two earthquakes.

5. Interpretation

[TO BE COMPLETED]

Recycled for this section:

stress that those households exposed more severely to the shock also saw their income suffer the largest setbacks.

Over 30% of the households report having being impacted by the quakes in the form of a decrease in income from agriculture or own business, although the only income source among the most affected households that appears to have suffer an outright reversal of fortunes is that related to productive animals as average income actually fell in real terms by 50%. Furthermore, in terms of job opportunities outside the own farm or business, 2% of households report having a household member who lost his/her job.

It is important to highlight at this point of the discussion that, even though in terms of welfare, households ultimately care about the level of consumption more than their level of income, the latter is still very indicative given the limited functionality of credit markets. Yet, when households are hit by a natural disaster or affected by a large shock of another nature that reduces their income and/or affects their assets, they can draw on different resources to limit a fall in consumption. The role of inter-household transfers, labor supply, diversification or migration, for example, is well documented in the literature.

It is not in the scope of this paper to analyze the causal effect of the earthquakes on the different coping mechanisms. However, some basic indicators point at the fact that these alternative sources of income and consumption only played a limited role. Households affected by the shock did receive more public transfers and made use of their savings, for example, but, when asked, they still replied that their consumption had to decrease. In fact, 26.8% of households cite a fall in food consumption as one of the main consequences of the earthquakes and 17.92% report a fall in consumption of non-food or education items. Other effects are also likely to reduce future consumption (Table 4). In short, the 2001 earthquakes, through a loss of income and assets, are likely to have led to a fall in current and future consumption.

6. Conclusions

The devastating consequences of large natural disasters on socioeconomic systems are evident to all. Yet, little is really known about the magnitude of such negative effects. This paper estimates the impact of two strong earthquakes in El Salvador on rural household income and poverty and sheds some light into their persistence in the middle- and long-run. Methodologically, it addresses various underlying confounding problems by exploiting plausibly exogenous variation in the intensity of these geological events caused by the combination of their seismic parameters, types of soils and the geographic coordinates of the dwellings. Reduced-form results show that the quakes led to a decline of one third in the average baseline household income per capita among "highly treated" households relative to their counterfactuals. Associations between the earthquakes and the levels of poverty also emerge from our empirical exercises but they lack enough statistical power. Furthermore, we find suggestive evidence that these geological shocks can have negative effects on the potential earning capacity of current and future generations through reductions in physical and human capital accumulation.

These findings, together, point towards natural disasters having long-lasting negative consequences on poverty and the overall economic development of affected populations. For policy makers, this means that mitigation policies should combine a number of instruments to shield several dimensions of human development at different points in time. First, priority should be placed on investments in critical infrastructure and information systems that protect individuals from the direct physical damages caused by large and powerful natural hazards. Second, present and future incomes, consumption and human capital accumulation processes are largely at risk in the aftermath of these disasters. On one hand, these impacts are caused by the direct damaging effects of natural events and, as such, require rapid and effective humanitarian relief. On the other hand, these negative effects are exacerbated by common households' pervasive coping responses such as withdrawing children from schools and liquidating critical productive assets. Furthermore, if poorer households are in fact more like to take children out of school in face of a shock, this result has important implications for future poverty incidence and persistence. This calls for programs with social relief measures such as scalable, flexible and well-targeted safety nets that respond quickly to the characteristics and magnitude of each event.

Finally, these challenges also create a critical role for policy action to reduce the use of inefficient ex-ante risk management strategies at the household level well before the realization of new destructive disasters. Even though all these instruments together may not provide full isolation from the harmful effects of natural shocks, they are likely to make any household's socioeconomic well-being less determined by its closeness to random destructive events. So far, such proximity still plays a big detrimental role as evidence from this paper seems to suggest.

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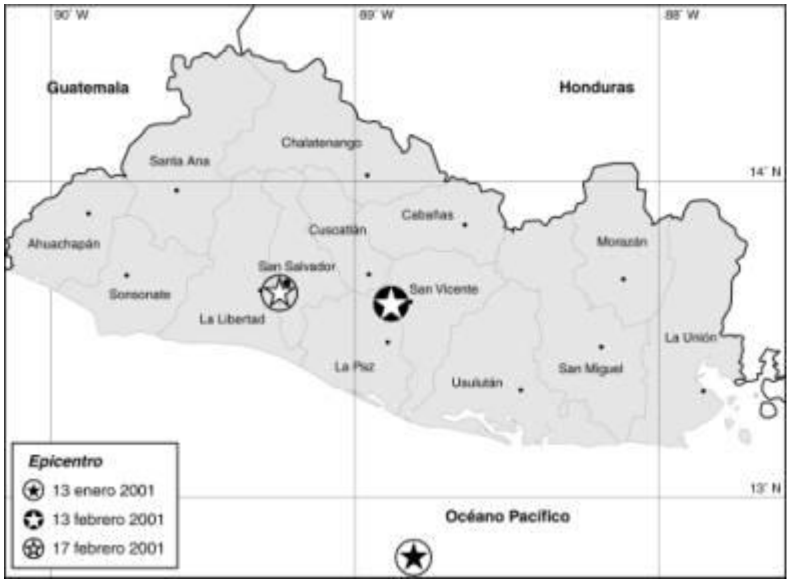
Figure 1. Departmental Map of El Salvador and
Epicenters of the 2001 Earthquakes



Source: PAHO, (2002), "Cronicas de Desastres. Terremotos en El Salvador, 2001".

Table 1. Pre-shock Rural Households' Characteristics by Treatment Status

Variable	Total	Treatment (Quakes=1)	Control (Quakes=0)	Difference
	Rural Households			
Household size	5.98	6.09	5.87	0.22
	[0.102]	[0.144]	[0.145]	[0.205]
Age of household head (in years)	52.55	52.57	52.52	-0.05
	[0.553]	[0.790]	[0.775]	[1.107]
Schooling head of household (in years)	4.93	4.92	4.94	-0.018
	[0.221]	[0.313]	[0.311]	[0.442]
Household headed by woman	0.14	0.12	0.15	-0.03
	[0.014]	[0.018]	[0.020]	[0.027]
Single-headed household	0.19	0.17	0.2	-0.03
	[0.015]	[0.021]	[0.022]	[0.030]
Annual income per capita (colones)	5,449.21	5,300.77	5,599.02	-298.25
	[241.833]	[349.414]	[334.616]	[483.795]
Household in extreme poverty	0.34	0.36	0.32	0.04
	[0.019]	[0.026]	[0.026]	[0.037]
Household in relative poverty	0.17	0.15	0.18	-0.03
	[0.0147]	[0.020]	[0.022]	[0.029]
Households has electricity	0.68	0.66	0.70	-0.04
	[0.018]	[0.026]	[0.025]	[0.036]
Household has indoor plumbing or private well	0.44	0.44	0.44	0.00
	[0.019]	[0.027]	[0.027]	[0.038]
Type of walls				
Concrete	0.36	0.39	0.34	0.05
	[0.018]	[0.027]	[0.026]	[0.038]
Adobe/Bahareque	0.56	0.55	0.57	-0.02
	[0.019]	[0.027]	[0.027]	[0.039]
Households has own business	0.29	0.31	0.27	0.04
	[0.017]	[0.026]	[0.024]	[0.036]
Household works on agricultural activities	0.66	0.69	0.63	0.06
	[0.019]	[0.026]	[0.027]	[0.037]
Household has savings	0.24	0.21	0.27	-0.06 *
	[0.017]	[0.023]	[0.025]	[0.033]
Amount of savings (colones)	988.07	887.59	1,089.47	-201.88
	[161.967]	[220.039]	[238.093]	[324.200]
Household has credit	0.16	0.18	0.14	0.04
	[0.014]	[0.021]	[0.019]	[0.029]
Household has migrant relative	0.41	0.37	0.44	-0.11 **
	[0.019]	[0.027]	[0.027]	[0.038]
Annual net inter-household transfers received (colones)	3,222.22	2,963.00	3,483.83	-520.83
	[361.941]	[511.244]	[512.862]	[724.153]
Geographic location				
Occidental region	0.26	0.00	0.52	-0.52 ***
	[0.017]	[0.000]	[0.027]	[0.028]
Central region	0.44	0.64	0.23	0.48 ***
	[0.019]	[0.026]	[0.024]	[0.035]
Oriental region	0.30	0.36	0.24	0.12 ***
	[0.018]	[0.027]	[0.024]	[0.036]
Minutes to closest highway	33.67	33.37	33.97	-0.60
	[1.405]	[1.853]	[2.112]	[3.814]
Minutes to closest primary school	12.01	12.21	11.79	0.42
	[0.442]	[0.644]	[0.604]	[0.884]
Number of households	653	328	325	

Notes. Robust standard errors presented in square brackets. ***, (**) and [*] stand for significance at the 1%, (5%) and [10%] level, respectively. See text for definitions of treatment and control households. All monetary values are in 1996 colones.

Table 2. Short-Run Impact of the 2001 Earthquakes on Household Income and Poverty

Sample: Rural Households in El Salvador

Outcome	Pre-shock mean		Reduced Form Estimates: D-D: Treatment=1, Control=0			D-D: Continuous treatment indicator			N
	Treatment	Control	(i)	(ii)	(iii)	(i)	(ii)	(iii)	
Income									
Annual household income per capita (colones)	5,300.77	5,599.02	-1,759.67 **	-1,763.18 **	-1,708.58 **	-8,346.09 **	-8,367.09 **	-8,112.30 *	1,306
	[349.414]	[334.616]	[773.745]	[828.645]	[854.625]	[3,951.53]	[4,260.82]	[4,342.85]	
Annual household income per capita, excluding public transfers (colones)	4,874.12	5,504.65	-2,052.45 **	-2,074.94 **	-2,033.139**	-9,683.82 **	-9,868.08 **	-9,673.79 **	1,306
	[387.460]	[333.911]	[837.900]	[895.060]	[912.479]	[4,740.98]	[5,069.86]	[5,087.63]	
Poverty									
Probability of being in extreme poverty	0.357	0.320	0.004	0.003	0.008	0.278	0.275	0.306	1,306
	[0.0265]	[0.0259]	[0.041]	[0.044]	[0.045]	[0.255]	[0.272]	[0.278]	
Probability of being in relative poverty	0.152	0.185	0.0246	0.027	0.016	-0.106	-0.092	-0.141	1,306
	[0.020]	[0.022]	[0.036]	[0.039]	[0.039]	[0.262]	[0.282]	[0.285]	
Poverty Gap									1,306
Household and individual characteristics?			no	yes	yes	no	yes	yes	
Municipality fixed effects?			no	yes	yes	no	yes	yes	
Interaction effects?			no	no	yes	no	no	yes	

Notes. Robust standard errors, clustered at the municipality level, presented in square brackets. ***, (**) and [*] stand for significance at the 1%, (5%) and [10%] level, respectively. Household characteristics include head of household's education, age and gender; number of members in the household, dwelling's wall materials, distance to closest school, crops cultivated and type of soil where the dwelling is located. Other controls include dummies for whether the household owns business, works in agriculture, has animals, owns land, has electricity, has indoor plumbing or private well, receives public aid, has credit, has savings, has a migrant relative, receives inter-household transfers. Interaction effects refer to interactions between the shock indicator and the explanatory variables as well as department and year interactions. See text for definitions of treatment and control households and before and after years.

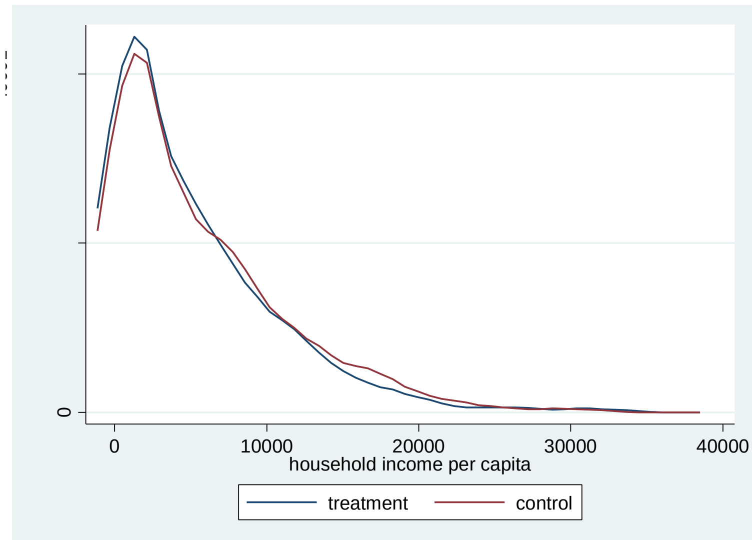
Table 3. Consequences of 2001 earthquakes
BASIS Dataset, Rural Households

Consequence	% of households
Reduction in food consumption	26.80%
Had to stop sending children to school	3.37%
Reduction in consumption other items (no food or education)	17.92%
Stopped or cancelled investments in physical capital	7.50%
Saved less	23.74%
Other	7.66%

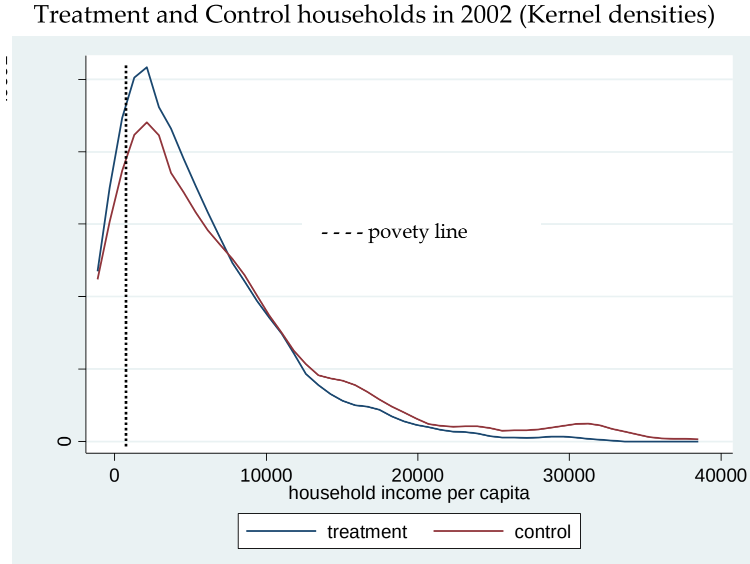
Source: BASIS Dataset, 2002 and own calculations

Figure 2. Distributional Changes in Household Income per Capita

Treatment and Control households in 2000 (Kernel densities)



Treatment and Control households in 2002 (Kernel densities)



Source: BASIS Dataset, 2002 and own calculations

Table 4. Asset Losses due to 2001 earthquakes
BASIS Dataset, Rural Households

Asset Category	% of households	Median value of losses, colones *
Housing		
Small housing damages	28.94%	480.00
Severe housing damages	15.01%	2400.00
Dwelling destroyed	17.15%	4800.00
Other assets		
Other buildings and land	6.58%	1600.00
Furniture and appliances	13.94%	800.00
Farm machinery and tools	0.46%	360.00
Non-farm machinery and tools	1.07%	800.00
Inventory and storaged grains	3.72%	400.00
Productive animals	0.92%	1040.00
Other	1.38%	440.00
Any asset	**63.25%**	**1840.000**

Notes: * Average value of losses, conditional on having suffered a loss on the corresponding asset class

Table 5. Actions taken by households to deal with the effects of the 2001 earthquakes
BASIS Dataset, Rural Households

Action	% of households
Used savings	20.52%
Sold animals or land	9.34%
Sold other assets	1.07%
Borrowed from bank or other institution	3.37%
Borrowed from friends or family	10.87%
Received aid from non-family	24.66%
Increased labor supply	0.61%
A member of the houshold migrated	0.46%
Other	2.91%

Source: BASIS Dataset, 2002 and own calculations

Table 6. Short-Run Impact of the 2001 Earthquakes on School Enrollment, Simple and Extended DID models

	Sample: Children Rural Households in El Salvador					
	Pre-shock mean		Reduced Form Estimates			
Outcome	Treatment	Control	(i)	(ii)	(iii)	N
School enrollment	0.836	0.773	-0.048 *	-0.053 *	-0.061	2,151
	[0.015]	[0.019]	[0.030]	[0.029]	[0.030]	
Household and individual characteristics?			no	yes	yes	
Municipality fixed effects?			no	yes	yes	
Interaction effects?			no	no	yes	

Notes. Robust standard errors, clustered at the municipality level, presented in square brackets. ***, (**) and [*] stand for significance at the 1%, (5%) and [10%] level, respectively. Household and individual characteristics include child's age and gender; head of household's education, age and gender; number of members in the household, dwelling's wall materials, distance to closest school, crops cultivated and type of soil where the dwelling is located. Other controls include dummies for whether the household owns business, works in agriculture, has animals, owns land, has electricity, has indoor plumbing or private well, receives public aid, has credit, has savings, has a migrant relative, receives inter-household transfers. Interaction effects refer to interactions between the shock indicator and the explanatory variables as well as department and year interactions. See text for definitions of treatment and control households and before and after years. The sample includes only children aged 6-15.

Table 7. Matching Estimates of the Short-Run Impact of the 2001 Earthquakes on Income and Poverty

	Type of kernel [a]				
Outcome	NN(1) bw = 0.01	NN(10) bw = 0.01	G bw = 0.01	E bw = 0.01	*N*
Income					
Annual household income per capita (colones)	- 2,379.70 *	- 1,974.02 ***	- 1,910.66 ***	- 2,126.08 ***	653
	[1,317.557]	[856.235]	[798.555]	[917.318]	
Annual household income per capita, excluding public transfers (colones)	- 2,798.87 **	- 2,276.08 ***	- 2,240.30 ***	- 2,451.44 ***	653
	[1,285.67]	[869.257]	[880.508]	[902.077]	
Poverty					
Probability of being in extreme poverty	-0.037	0.005	-0.001	-0.012	653
	[0.054]	[0.0421]	[0.040]	[0.043]	
Probability of being in relative poverty	0.012	0.029	0.035	0.044	653
	[0.052]	[0.037]	[0.037]	[0.038]	
Poverty Gap					653

Notes: Bootstrapped standard errors presented in square brackets were obtained from 500 replications. ***, (**) and [*] stand for significance at the 1%, (5%) and [10%] level, respectively. The units of observation are households and were matched on the propensity score from a logistic regression on presence in the treatment region. Pre-shock covariates in the logistic regression include head of household's education, age and gender; number of members in the household, dwelling's wall materials, distance to closest school, crops cultivated, type of soil where the dwelling is located, dummies for whether the household owns business, works in agriculture, has animals, owns land, has electricity, has indoor plumbing or private well, receives public aid, has credit, has savings, has a migrant relative, receives inter-household transfers. See text for definitions of treatment and control households and before and after years.

[a] NN(10) = 10 nearest neighbors; E = Epanechnikov; LL = local linear; bw = bandwith; CS = common support.

Table 8. Pre-shock difference-in-difference models of Income and Poverty, 1998-2000

	Sample: Rural Households in El Salvador					
	Pre-shock mean		Reduced Form Estimates			
Outcome	**Treatment**	**Control**	**(i)**	**(ii)**	**(iii)**	**N**
Income						
Annual household income per capita (colones)	3,127.22	3,904.14	365.69	370.36	445.56	1,116
	[517.859]	[267.685]	[800.675]	[898.510]	[953.824]	
Annual household income per capita, excluding public transfers (colones)	3,077.84	3,844.53	247.90	252.67	324.23	1,116
	[267.893]	[518.523]	[791.056]	[887.433]	[942.370]	
Household and individual characteristics?			no	yes	yes	
Municipality fixed effects?			no	yes	yes	
Interaction effects?			no	no	yes	

Notes. Robust standard errors, clustered at the municipality level, presented in square brackets. ***, (**) and [*] stand for significance at the 1%, (5%) and [10%] level, respectively. Household characteristics include head of household's education, age and gender; number of members in the household, dwelling's wall materials, distance to closest school, crops cultivated and type of soil where the dwelling is located. Other controls include dummies for whether the household owns business, works in agriculture, has animals, owns land, has electricity, has indoor plumbing or private well, receives public aid, has credit, has savings, has a migrant relative, receives inter-household transfers. Interaction effects refer to interactions between the shock indicator and the explanatory variables as well as department and year interactions. See text for definitions of treatment and control households and before and after years used for the placebo test.