

# Earthquakes and terrorism: the long lasting effect of seismic shocks

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- In the last few years there has been a plethora of analyses relating shocks, mostly natural disasters and climatology (rainfall, temperature, windstorm, etc), to economic outcomes, democratization, political transitions or violent conflicts.
- The exogenous nature of these events helps in the identification of its effects on a given spatial area. In some other occasions these variables are used as instruments to analyze the transmission mechanism of other relevant variables, primarily income.
- This literature has evolved towards the use of panel data or the choice of increasingly smaller geographical areas.
- In addition, recent papers examine not only the short run impact of these idiosyncratic shocks but also the long run consequences.

- Recent literature on climate shocks (abnormal temperatures, extreme rainfall episodes, drought, etc.) and violence
- Alternative transmission mechanism:
  - Dell (2012): draught severity and differences in the intensity of insurgency across Mexican regions determined the extension of a land institutions called "el ejido"
  - Hornbeck and Naiud (2014) show that the 1927 Mississippi flood produce large and persisten out-migration that lead to increase capital intensity in agricultural activities in flooded areas
  - Hornbeck (2012) analyzes the long run impact of dust storms in the US during the 30's

- Brancati (2007) shows, using cross-country data, that earthquakes increase the likelihood of conflict
- Berrebi and Ostwald (2011) use data for 167 countries and find a strong positive effect of disaster related deaths on subsequent terrorism incidence
- Anbarci et al. (2013) claim that earthquakes open a window of opportunity for political transition
- Belloc et al. (2013) claim that earthquakes decrease the probability of shifts from the feudal regime to communal institutions and, through institutional inertia, affected growth in the long run

- Channels of the relationship:
  - Negative climate shocks/natural disasters reduce tax revenues and, therefore, the ability of governments to repress terrorist acts
  - The destruction of infrastructures caused by an earthquake will benefit terrorists since it reduces state capacity
  - Social infrastructure to support terrorists can foster terrorism even in the presence of good physical infrastructures

- With very few exceptions like the recent work by Enders et al. (2011) and Piazza (2011), previous studies have analyzed international terrorism. Earlier research on the quantitative study of transnational terrorism includes the work of Sandler, Tschirhart and Cauley (1983), Im, Cauley and Sandler (1987), Enders, Parise and Sandler (1992) and Enders and Sandler (1993, 1999), among others. Recent work on terrorism includes Krueger and Laitin (2007), Krueger and Maleckova (2003), Piazza (2006), Abadie (2006) and Keefer and Loayza (2007).
- An important reason for their focus on international terrorism is data availability.

# Our paper: Contributions

- In this paper we present evidence of the relationship between earthquakes and terrorism.
- This paper makes at least two contributions in the literature of terrorism.
- First, we construct a novel and comprehensive dataset that separates domestic terrorism from international terrorism for a long period of time:
  - International terrorism represents only a small part of all terrorist events. In principle, the causes of domestic and international terrorism may be quite different.
  - Given that many studies at cross country level use only international events to infer on the general determinants of terrorism, this paper helps in better understanding its differential determinants.
  - We distinguish domestic versus international terrorist events using a new dataset that provide information on 80.000 terrorist events (domestic and international) from 1970 to 2007.

# Our paper: Contributions

- Second, in this paper we conduct a geographically detailed empirical analysis at the sub-national level using all the countries in the world over the period 1992-2007. Our units of observation are one degree by one degree cells resulting from superimposing a grid on the map of the world.
  - The grid approach, or the use of very geographically disaggregated unit of analysis, is by now, a frequent strategy in economic research. Recent examples include Alesina, Giuliano and Nunn (2013), Harari and La Ferrara (2013) or Michalopoulos and Papaioannou (2013).
  - Since conflicts, in particular terrorist events, are concentrated in very specific parts of each country, we believe that it is crucial to study the determinants of domestic terrorism at the sub-national level.
  - For the case of terrorism it is even more important since terrorist events are geographically concentrated



- “Patterns of Global Terrorism”, prepared by the State Department of US.
- ITERATE (International Terrorism: Attributes of Terrorism Events), constructed by Mickolus, Edwards. (1980, 1982) and Mickolus Edwards, Todd Sandler, and Jean M. Murdock.1989).Enders and Sandler (2000).
- Memorial Institute of Prevention of Terrorism (MIPT). This dataset provides information on international terrorism from 1972 to 2006.

- Abadie (2006) explains, the studies that use data on transnational terrorism either from Patterns of Global Terrorism or other sources, “suffer, in principle from some important shortcomings.
- International terrorism represents only a small fraction of terrorist activity. For example for the year 2003, we had 1536 events of domestic terrorism, but only 240 events of international terrorism”.
- As Abadie also argued, the causes of international terrorism may be different from the causes of domestic terrorism, and therefore the policy implications could be very different. In particular Abadie (2006) uses the World Market Research Center’s Global Terrorism Index (WMRC-GTI).
- The WMRC-GTI assesses the risk of terrorism in 186 countries and against these countries’ interests abroad for the period 2003/4. This was an advantage since the data on terrorist events available up to this time was considering only the transnational cases.

- The GTD dataset is the first one which provides information on all terrorist events of all countries in the world for a long period of time (1970-2007), but without distinguishing which ones are domestic or international Total: 80.000 events
- This gives us an opportunity to separate distinguish between domestic and international terrorist acts
- This data is now maintained and provided by The National Consortium for the Study of Terrorism and Responses to Terrorism (START). START is a U.S. Department of Homeland Security Center of Excellence, based at the University of Maryland, College Park.

- The Global Terrorism Database (GTD) is an open-source database including information on terrorist events around the world from 1970 through 2007.
- Information in the GTD is drawn entirely from publicly available, open-source materials. These include electronic news archives, existing data sets, secondary source materials such as books and journals, and legal documents.
- All information contained in the GTD reflects what is reported in those sources. The database developers attempt, to the best of their abilities, to corroborate each piece of information among multiple independent open sources.

- The first phase of data for the GTD (GTD1: 1970-1997) was collected by the Pinkerton Global Intelligence Service (PGIS)—a private security agency. Cases that occurred between 1998 and 2007 were identified and coded by the Center for Terrorism and Intelligence Studies (CETIS), in partnership with START. (National Consortium for the study of terrorism and responses to terrorism).
- In addition to data originally collected by PGIS and CETIS, other archives of terrorism incidents have also been incorporated, including: the Conflict Archive on the Internet; the Australian Turkish Media Group, Armenian Terrorism: The Past, Present, the Prospects, by Francis Hyland; the National Abortion Federation; and "Further Submissions and Responses by the ANC to Questions Raised by the Commission for Truth and Reconciliation 12 May 1997."

- Our objective is, first, to distinguish these two types of events.
  - Under domestic terrorism we include the events where the country of origin of the perpetrator group is the same as the target country or target nationalities.
  - Under International terrorism we include the cases where the country of origin of the perpetrator group is different from the target country or nationalities.

# Data: Terrorism - domestic versus international

- Enders et al. (2011) use several steps to distinguish these two types:
  - 1 In the first step they excludes some observations:
    - “Begin by excluding observations that do not meet the following three GTD inclusion criteria: (i) the attack is perpetrated for a political, socioeconomic, or religious motive; (ii) the attack is intended to coerce, intimidate, or send a message to a wider audience than the immediate victim(s); and (iii) the attack is beyond the boundaries set by international humanitarian law.
    - This means that if all the three criterions are not met, the event is excluded.
    - Moreover following Enders et al (2011), we purge all terrorist incidents that are defined by the ‘Doubt Terrorism Proper’ determination.

- 2 The second step is to construct a Definition of transnational events. This has five sub-steps:
- If the venue country is different from the country of nationality for one or more victims, then the attack is clearly a transnational terrorist incident.
  - Terrorist attacks against diplomatic staff, their families, and property are transnational in nature, as are attacks against nongovernmental organizations (NGOs), which are multinational entities.
  - terrorist attacks against US entities that occurred outside the USA are classified as transnational terrorist events.
  - A terrorist act that occurs outside of the USA and that involves US fatalities or injuries is classified as transnational.
  - Any such incidents that involve the diversion of an airplane or resolution in another country, so that two or more countries are involved, are transnational terrorist events.



- 3 Dummy uncertain: Uncertain events: missing or unknown information regarding nationality, target type, target entity, US fatalities, injuries, hostages, ransom demanded or paid
- 4 Dummy domestic\_new: Domestic are those non transnational

## Data: Domestic versus international - our definition

- We use the first step to clean the cases, following Enders et al. (2011)
- For our definition it is crucial to know the country of origin of the perpetrator group of all terrorist events.
- GTD data provide the name of the perpetrator group. We look at the terrorist groups profile to identify their origin.
- In order to do this we use different sources. One of the sources is the Terrorist Organization Profiles (TOPS), encyclopedias and Government sources, newspapers, and other online sources.

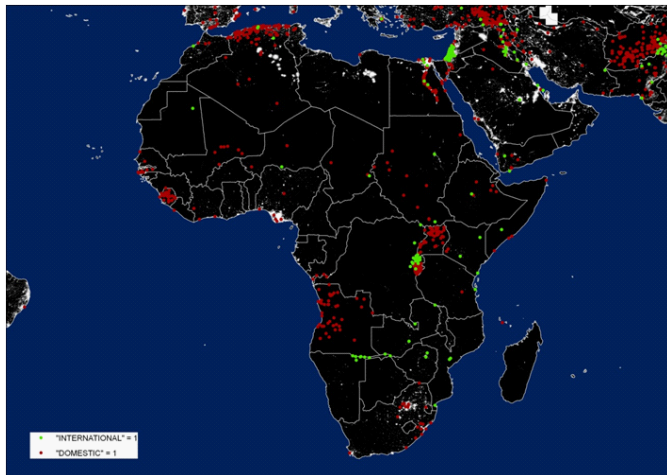
# Data: Terrorisms - Geographic location of events

- We geographically locate all the terrorist events in maps in order to see under which cell-country of the world grid they occurred.
- We started working with a dataset that reported 81.799 terrorist attacks.
- We collapsed those event in 26.624 places
- This dataset is the first one that has geographically located all terrorist events. Moreover we are able to separate between domestic and international following our own definition, and the version in Enders et al.'s.

- Since good data on income per capita are difficult to find at the grid/cell level, we follow Henderson, Storeygard and Weil (2011) and use luminosity at night as a proxy for development.
- The satellite night light data are available from the National Oceanic and Atmospheric Administration.
- These data has been used recently by Rohner, Thoenig and Zilibotti (2011) and Michalopoulos and Papaioannou (2012)

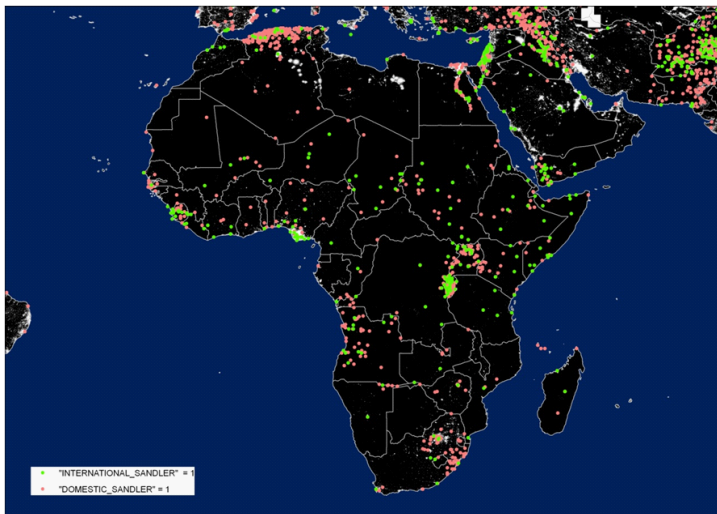
# Example

- Africa: our definition



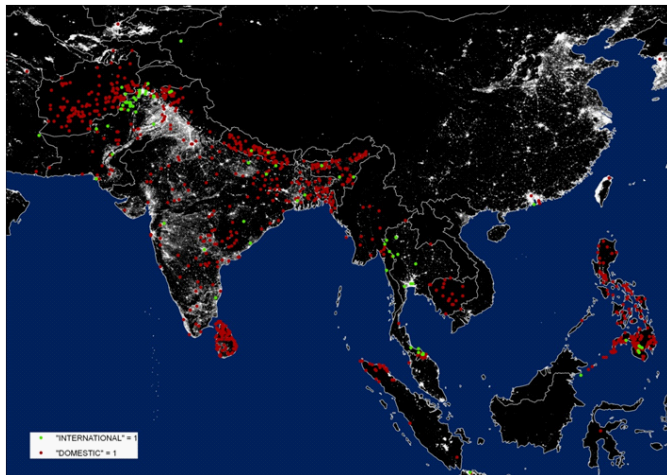
# Example

- Africa: Enders' definitions



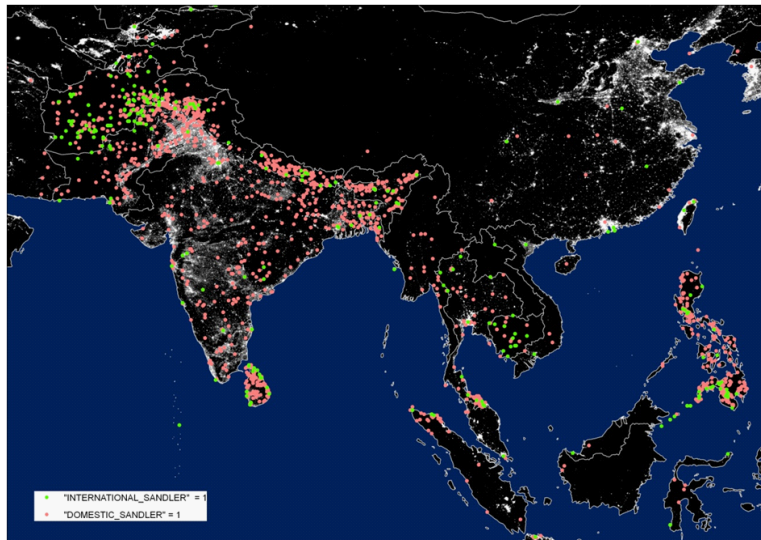
# Example

- Asia: our definition



# Example

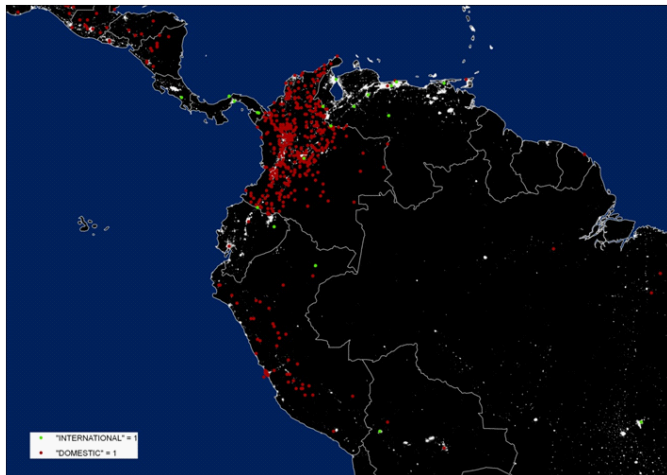
- Asia: Enders' definition





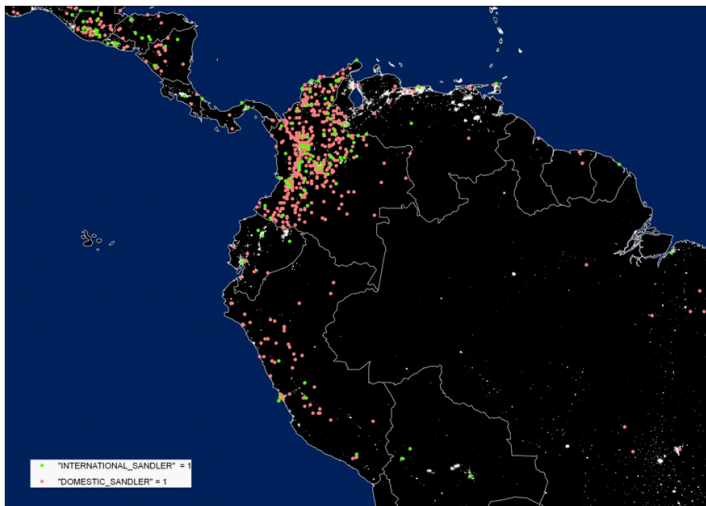
# Example

- Zoom in Latin America: our definition



# Example

- Zoom in Latin America: Enders' definition



- We use data from Significant Worldwide Earthquakes (2150 B.C. - 1994 A.D.) from NGDC (NOAA's National Geophysical Data Center). Data source is <http://www.ngdc.noaa.gov/>.
- Contains information on earthquakes from 2150 B.C. to the present.

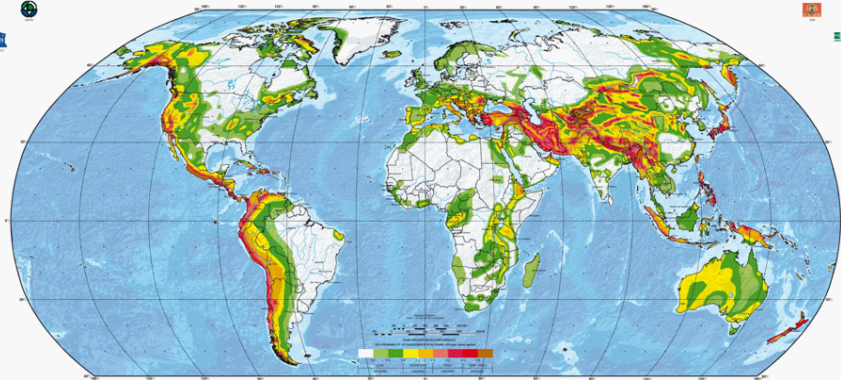
# Data: Earthquakes and risk of earthquakes

- One important concern is that the effect of earthquake could capture the effect of the risk of earthquake. In order to address this important concern we control for risk of earthquakes.
- We use the information from the Global Seismic hazard Map, produced by the The Global Seismic Hazard Assessment Program (GSHAP)
- Seismic hazard is defined as the probable level of ground shaking associated with the recurrence of earthquakes. This measure is exogenous to the level of development. The GSHP distinguish seismic hazard from seismic risk:
  - “The assessment of seismic hazard is the first step in the evaluation of seismic risk, obtained by combining the seismic hazard with vulnerability factors (type, value and age of buildings and infrastructures, population density, land use, date and time of the day). Frequent, large earthquakes in remote areas result in high seismic hazard but pose no risk; on the contrary, moderate earthquakes in densely populated areas entail small hazard but high risk”.

# Data: Risk of earthquakes

## GLOBAL SEISMIC HAZARD MAP

Produced by the Global Seismic Hazard Assessment Program (GSHAP):  
a demonstration project of the UN/International Decade of Natural Disaster Reduction, conducted by the International Lithosphere Program:  
Global map assembled by D. Giardini, S. Grünthal, K. Shedlock, and P. Zhang:  
1999



- The hazard level is divided into 8 potential levels:
- The lowest hazard is the white with hazard values below 0.2,
- The second lowest is hazards between 0.2 and 0.4.
- The bins are defined as follows: 0.4-0.8, 0.8-1.6, 1.6-2.4, 2-4-3.2, 3.2-4, 4-4.8,  $>4.8$
- The levels between 0 and 0.8 are considered of low hazard, between 0.8 and 2.4 are moderate hazard areas, the ones between 2.4 and 4 suppose a high hazard, and the ones with values higher than 4 imply a very high hazard

## Data: Control variables

- Yale University Geographically Base Economic Dataset (G-econ): Population, distance to the sea, distance to lake, distance to river, share\_mines. We take the 120 squared km grid. Since some grids cross country boundaries, we end up with 27,445 country-grid cells (hereafter simply "grid cells") spread across the world.
- Climate Research Unit Average Climatology high-resolution data sets (denoted CRU CL 2.0): precipitation and temperature. We calculate averages at "grid cell" from .
- Roughness, elevation and quality of the soil (% of fertile soil): we calculate averages at "grid cell" from the raw data from Nunn and Puga (2012)
- Distance to the capital of each "grid cell": our own calculation
- Number of ethnic groups at each "grid cell" calculated suing GREG dataset

- To estimate the effect of grid-cell specific earthquakes on Terrorism, we relate the dummy for terrorism grid cell  $j$  of country  $i$ , (that has value 1 if the cell-country unit suffers at least one domestic terrorist event between 1994 and 2007), with a dummy that has value 1 if the cell-country unit had suffered any earthquake in the past.
- Among the 27,445 grid cell, 1861 suffer at least one earthquake, and 987 suffer at least one terrorist attack.
- The destructive local effects of earthquakes are well-know as long as its lasting effects on the local economy.



- Basic specification

$$P_{ji} = \mu_i + \beta EARTHQ_{ji} + \delta T\_EARTHQ_{ji} + \sum \gamma_k x_{kji} + \epsilon_{ji}$$

- where  $P$  is a dummy variable that takes value 1 if there has been a terrorist attack in the period under consideration. For robustness purposes we also consider the proportion of years with terrorist attacks
- The controls  $x$  include distance to the coast, average elevation of terrain, roughness, temperature, precipitation, distance to the capital and seismic hazard
- Standard errors are clustered at the country level

Table 1  
Earthquakes and Domestic Terrorism

	(1) terrorism	(2) terrorism	(3) terrorism	(4) terrorism	(5) terrorism	(6) terrorism	(7) terrorism
Earthquake	0.160*** (0.036)	0.101*** (0.022)	0.098*** (0.021)	0.098*** (0.021)	0.092*** (0.021)	0.090*** (0.021)	0.096*** (0.021)
Distance to the sea			-0.012** (0.006)	-0.012** (0.006)	-0.012** (0.006)	-0.011** (0.006)	-0.012** (0.006)
Climate and geographic variables			yes	yes	yes	yes	yes
Distance to capital				-0.004*** (0.001)	-0.004** (0.002)	-0.004** (0.002)	-0.004** (0.001)
Seismic_hazard					0.005 (0.004)		
Seismic hazard dummies						yes	
Seismic hazard dum							0.027 (0.021)
Country dummies		yes	yes	yes	yes	yes	yes
Observations	27,445	27,445	20,522	20,515	20,515	20,515	20,515
R-squared	0.047	0.269	0.268	0.268	0.269	0.270	0.269

**Note:** Standard errors clustered by country in parentheses. The asterisks refer to the former: \*\*\* p<0.01, \*\* p<0.05, \* p<0.10.

- Table 1: the estimation shows that the probability of a terrorist attack increases around 10 percentage point if the cell suffered an earthquake in the past
- Robust analysis:
  - Table 2: Years since the last earthquake - the longer the time since the last earthquake, the lower is the impact on the probability of a terrorist attack
  - Table 3: Definition of terrorism - the basic results are robust to other measures of terrorist attacks (fraction of years with terrorist attacks or number of cases) and to the definition of domestic terrorism of Enders
  - Table 4: The basic result is robust to the inclusion of additional controls although the size of the impact is smaller than before

Table 4  
Earthquakes and Domestic Terrorism: robust analysis

	(1) Terrorism	(2) Terrorism	(3) Terrorism	(4) Terrorism
Earthquake	0.069*** (0.020)	0.069*** (0.020)	0.068*** (0.019)	0.066*** (0.019)
Distance to the sea	0.005 (0.005)	0.005 (0.005)	-0.000 (0.006)	-0.003 (0.008)
Climate and geographic variables	yes	yes	yes	yes
Distance to capital	0.001 (0.001)	0.001 (0.001)	0.002 (0.001)	0.001 (0.002)
Seismic_hazard	0.004 (0.003)	0.004 (0.003)	0.004 (0.003)	0.003 (0.003)
Ln pop dens	0.022*** (0.005)	0.022*** (0.005)	0.024*** (0.005)	0.025*** (0.005)
Number of ethnic groups		0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
Sharemin			0.065 (0.064)	0.066 (0.065)
Other geaographic (land quality, distance lake and river)				yes
Country dummies	yes	yes	yes	yes
Observations	20,460	20,460	17,245	17,179
R-squared	0.290	0.290	0.287	0.288

**Note:** Standard errors clustered by country in parentheses. The asterisks refer to the former: \*\*\* p<0.01, \*\* p<0.05, \* p<0.10.

- What is the role of income? Table 5 shows:
  - The probability of terrorist acts increases with lightnigh<sup>t</sup>.
  - Areas with a high level of development compared with the rest of the country, conditional on all the other geographical controls, had experience earthquakes in the past. The evidence shows that the physical destruction and the social disruption associated with natural disasters tends to spur innovation, entrepreneurship and creativity. A few recent examples are new techniques for buildings' construction (Haiti), new materials for water pipelines (New Zealand, Southern California), a quick switch to paperless administration, a fast adoption of new technologies (Haiti), a creative wave (Chile, New Zealand) and even innovation in healthcare models (New Zealand).

Table 5  
Earthquakes and Domestic Terrorism  
and regional development

	(1) Terrorism	(2) Lnightlight 92-93	(3) Terrorism IV
Earthquake		0.459*** (0.100)	
Lnightlight 92-93	0.002* (0.001)		0.143*** (0.051)
All controls from column 4 of table 4	yes	yes	Yes
Country dummies	yes	yes	yes
Observations	17,179	17,179	17,179
R-squared	0.284	0.517	

**Note:** Standard errors clustered by country in parentheses. The asterisks refer to the former: \*\*\* p<0.01, \*\* p<0.05, \* p<0.10.

- What is the role of income? Table 5 continues:
  - Under the assumption that earthquakes shocks affect terrorist events only through income (level of development), we can estimate the effect of income on terrorism using an instrumental variable approach. The estimates show that income, measured as night light, has a positive effect on terrorism
- If we consider only earthquakes that happened more than 100 years ago we still find an effect on nightlight

- One could argue that earthquakes increases political instability due to the negative popularity shocks and therefore affect terrorist events through this channel.
  - First: Our analysis is at sub-national level, we should not worry about this. We also have a country fixed effect
  - Second: the instability phenomena have an immediate impact, while we are considering earthquakes over the past
- However we should worry about local mechanisms: trust in local institutions. religiousness, etc. We try to address some of these concerns using the Afrobarometer data.
- First, we show that the main results hold using only the African sample. Table 6.
- Second (not shown) there is no effect of earthquakes on trust.



**Table 6**  
**Earthquakes and Domestic Terrorism: evidence from Africa**

	(1) Terrorism	(2) Terrorism	(3) Lnightnight 92-93	(4) Terrorism IV
	c4, T4	c1, T5	c2, T5	c4,T5
Earthquake	0.133** (0.060)		0.555* (0.313)	
Lnightlight 92-93		0.005*** (0.002)		0.240 (0.173)
All controls from column 4 of table 4	yes	yes	yes	Yes
Country dummies	yes	yes	yes	yes
Sample	Africa	Africa	Africa	Africa
Observations	3,339	3,339	3,339	3,339
R-squared	0.275	0.271	0.416	

**Note:** Standard errors clustered by country in parentheses. The asterisks refer to the former: \*\*\* p<0.01, \*\* p<0.05, \* p<0.10.

- We analyze the persistent effect of earthquakes on terrorism
- Areas with a high level of development compared with the rest of the country, conditional on all the other geographical controls, had experience earthquakes in the past.
- The evidence suggest that the physical destruction and the social disruption associated with natural disasters tends to spur innovation, entrepreneurship and creativity