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Short and Long Run Effects of Earthquakes on Household Welfare in Indonesia

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ABSTRACT

This paper studies the impact of earthquakes on household welfare in Indonesia. Using large-scale longitudinal household surveys for the period 1993-2007 together with data from a US Geological Survey catalog of earthquakes, we seek to evaluate if the consequences of earthquakes extend beyond the immediate event into the medium and long-term and what are the mechanisms driving the long-term effects of earthquakes. We accomodate a panel fixed-effects model to account for the facts that the welfare outcomes are measured at the household level while the experience of an earthquake is measured at the individual level and that the composition of households changes across rounds. The results suggest that households who experienced a large earthquake in Indonesia, after going through short-term welfare losses, were able to recover in the medium-run, and even exhibit welfare gains in the long-run. In addition, the stocks of productive assets, notably in farm businesses, are in average reconstituted and even increased in the medium-run. This suggests that reconstruction strategies after large earthquakes allow and/or provide incentives to small business holders to reconstitute and increase their investments.

Keywords: natural disasters; long-term effects; recovery; household welfare; small businesses.

JEL codes: I30, L26, O10, Q54.

1. INTRODUCTION

Natural disasters occur when extreme natural phenomena, like earthquakes, storms or droughts, cause deaths or serious human suffering and extensive material and economic damage. The frequency of natural disasters reported worldwide has been increasing in recent years (Stroemberg, 2007; UNISDR, 2009). Measuring the economic costs of those events and understanding households' behavioral responses for coping with them can help designing public interventions for reducing their potential costs. However, if the work examining their welfare consequences is growing, as stated by Cavallo and Noy (2009), "compared to the vast amount of research in natural sciences and other social sciences devoted to increase the ability to predict disasters and prepare them, the economic research on natural disasters and their consequences remains fairly limited" and there are identified limitations and gaps of knowledge in the existing literature.

One of the most glaring scantiness common across most of the related literature on the effects of natural disasters on household welfare, and recurrently pointed out (see, for example, Christiansen and Subbarao, 2005; Thomas et al., 2010; Baez et al., 2010) is the lack of appropriate data. Indeed, much of the evidence relies on imperfect measures of natural hazards. In this sense, many studies exploit measures of shocks based on individual reports, derived from household questionnaires where respondents are asked if they experienced different types of shocks (droughts, storms, earthquakes,…) over a certain period of time. Such self-reported data on shocks are subject to measurement error due to recall problems, a fact that could bias the estimated effects of shocks (towards zero if the measurement error is random, upwards or downwards otherwise). Self-reported data may also be subject to reporting bias if different groups of individuals (those who live in a certain area, those of a certain socio-economic background, …) systematically respond to the shock questionnaires differently. To avoid these problems, some studies have been able to use primary databases (from weather stations, satellite observations, …), but still too often construct their objective measures of natural disasters at rather highly aggregated levels (for example, studies on droughts often use rainfall data obtained from a limited number of weather stations and impute the observed weather patterns to areas that may not necessarily share the same climatic conditions).

In terms of the spotted lacks of knowledge in the understanding of the effects of natural hazards on household welfare, Thomas et al. (2010) point out that there are still uncertainties about the magnitudes of the welfare loss, its heterogeneity across groups and its persistence over time. Much of the literature examining the ways in which households deal with sudden disaster events in developing countries has focused on short-run implications, and has ignored the long-run consequences.[1] Some recent studies that look at the long-term outcomes (consumption, human capital,…) from serious shocks find substantial effects, but these are based on a handful of data sets and settings and more evidence is needed to be able to generalize the importance of these effects (Dercon, 2008). These studies focusing on the long-term effects of shocks at the micro-level encounter additional demands in terms of data quality, since ideally sufficiently long panel data with low attrition rates are needed to avoid the multiple selection biases that could be at play, if individuals that drop from the sample over time are not random. But such data are again rarely available, given the difficulties to track a sufficiently large group of individuals over time.

The objective of this paper is to examine the effects of large earthquakes on household welfare in Indonesia, and to investigate some mechanisms driving those. Using high-quality large-scale longitudinal household surveys for Indonesia during the period 1993-2007, as well as both self-reported and objective measures of earthquakes, we first seek to evaluate if the effects of earthquakes on household welfare, as measured by per capita consumption, extend beyond the immediate event into the medium and long term and if heterogeneities across different population groups, notably inhabitants of rural and urban areas, are observed. We second examine the effects of earthquakes on a range of household economic outcomes, including labor and non-labor incomes, and non-business and business assets for investigating the channels driving the welfare effects. In order to do so, we accomodate a panel fixed-effects model to account for the facts that the welfare outcomes are measured at the household level while the experience of an earthquake is measured at the individual level and that the composition of households changes across rounds.

The choice of Indonesia as our case study is not without reason. Indonesia, the world's fourth most populous country, is located at the intersection of several tectonic plates and as a result, has to contend with one of the most frequent and powerful seismic activities in the world. Focusing on earthquakes among the different natural disaster suffered by households is also particularly pertinent, since they may cause severe human and economic damages and are a great burden on the national budget. In addition, if the concussion of the earth is no new thing, the same cause does not necessarily imply the same effects, at least not over time, across households and at different intensity levels. A better understanding of such heterogeneities may help government in the design and targeting of relief policy programs.

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1 With the exception of several studies of the long-run effects of famines (e.g. Chen and Zhou, 2007) and a couple of studies of weather shocks (notably Maccini and Yang, 2009).

Our aim is to make several contributions to the literature on natural disasters and household welfare effects. First, this study benefits from the availability of a very long term panel database (1993-2007) that is known to have rarely low attrition rates, which is crucial for examining the long-run impacts of natural disasters. The use of the Indonesian Family Life Survey allows us to look at the short and long-term consequences of earthquakes, minimizing the possibility of different selection biases that could be at play.

A second contribution has to do with the fact that earthquakes affect both urban and rural settings and we are able to provide evidence on both. Papers focusing on natural disasters have very often used weather data (such as rainfall measurement) and have usually restricted their analysis to rural areas. As a consequence, economic behavior of households or firms in urban settings has not received sufficient attention.

Surprisingly, our results indicate that households who experienced a large earthquake in Indonesia, after going through short-term welfare losses, were able to recover in the medium-run, and even exhibit welfare gains in the long-run. Although the short-run effects appear to be more significant in the rural sample, the long-run gains are found in both the rural and urban samples.

A third contribution is to examine some potential mechanisms driving those long-run positive effects of natural disasters. We find evidence of short and medium-run decreases in the stocks of non-business assets, including financial assets, suggesting some self-insurance is at play. Subtancial social assistance transfers are also received, notably in the rural sample. We then find evidence that the stock of productive assets, notably in farm businesses, is reconstituted and even increased in the medium-run. This could suggest that reconstruction strategies, and in particular, reconstruction aid, allow and/or provide incentives to small business holders to reconstitute and increase their investments.

Methodologically, our paper is one of the few studies to consider both objective measures of earthquake incidence (and intensity) and self-reported variables on natural disasters' occurrence (and costs), to assess the impacts of natural disasters on household welfare. The implementation of these two approaches allows us to investigate the direction and magnitude of biases incurred in by using self-reported measures, which are the ones usually made exploited in socioeconomic studies. We find evidence of substancial endogenous reporting bias when self-declared measures of earthquake experience instead of objective measures.

This paper is organized as follows. Section 2 presents the data sources and variables used. Section 3 presents descriptive statistics on earthquake incidence and intensity and compares objective and subjective information on shocks. Section 4 describes the methodology used for assessing the effects of earthquakes on household welfare. Section 5 includes an analysis of our findings. Section 6 concludes.

2. DATA SOURCES

In this paper we link data from two different sources: our first dataset consists on panel household surveys data for Indonesia including socio-economic characteristics of individuals as well as self-reported information on shocks experienced by households; our second dataset is a geological survey including detailed information and measures of earthquake incidence and intensity. Both datasets and the merging procedure we apply are described below.

2.1. *Panel household surveys data*

Household level microdata were gathered from the four full waves of the Indonesia Family Life Survey (IFLS), a large-scale longitudinal household survey that collects information on the lives of individuals, their households and family members, and the communities in which they live. The first wave was conducted in 1993 (IFLS1), and full follow-ups took place in 1997 (IFLS2), 2000 (IFLS3), and 2007 (IFLS4). A total of 7,224 households were interviewed in IFLS1, representing about 83% of the Indonesian population living in 13 of the nation's 26 provinces.[2] Subsequent waves attempted to reinterview these households and households to which previous household members had moved. The total number of households interviewed, including the split-off households, was 7,698 in IFLS2, 10,435 in IFLS3 and 13,535 (with 43,649 individuals) in IFLS4. Because substantial effort was done to track the movers, attrition rates in IFLS surveys is remarkably low. Overall, 87.6% of households that participated in IFLS1 are interviewed in each of the subsequent three waves.[3] In terms of individuals within households and for cost reasons, not all were interviewed in 1993 (in particular, not all children were included). However, from 1997 onwards, individuals aged 26 and more in 1993 and all their children were tracked, and in 2000 and 2007 tracking was complete for all members of 1993 households.

From IFLS surveys, self-reported information on exposure to shocks and information on a set of households economic outcomes was used. Concerning the specific IFLS section on shock exposure, households were asked if they faced any economic shock or hardship during the past five years, such as

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2 The 1993 sample was elaborated by randomly selecting 321 villages from the 1993 National economic Survey (SUSENAS), spread among 13 Indonesian provinces, in particular, four provinces from Sumatra (North Sumatra, West Sumatra, South Sumatra, and Lampung), all of Java and four from the remaining islands (Bali, West Nusa Tenggara, South Kalimantan, and South Sulawesi).

3 For more detailed discussions on IFLS attrition rates, see Strauss et al. (2009) and Thomas et al. (2010).

a death of a household member, a natural disaster, a price shock or a drought. Note that up to 2007, recall information on natural disasters experienced by the household in the previous five years was collected, but without clearly distinguishing which type of natural disaster had taken place. In 2007, detailed information about separate types of natural disasters (earthquakes, tsunami, floods, muslides) and their consequences has been made available. In this survey, households have been asked to evaluate losses from each type of disaster, such as assets destroyed, expenses on medical injuries and funerals, response migration, and assistance received.

The outcomes variables considered in this paper include measures of: real monthly per capita household (total, food and non-food) consumption[4]; non-business assets (incl. housing and land, other buildings, movable, and financial assets); monthly labor (wage and self-employment) incomes; monthly social assistance transfers (total, subsidized food, and other transfers); farm-business assets (incl. land, buildings, and movable assets); and non-farm business assets (same categories). For most variables, we use indicator variables for non-zero value (participation), and also the observed value; all those values are in real terms using deflators that incorporate inflation and spatial variations in prices.

In order to measure exposure to earthquakes, we recover the migration histories, at the subdistrict level, for all individuals in our survey, since 1985. The information on migration was obtained from two different sources in the survey: the tracking modules with information on the household's location in 1993, 1997, 1998, 2000 and 2007, and the specific (adult) individuals' migration modules with information on residence at birth, at age 12, and all moves after age 12 (with dates and place).[5] IFLS respondents provide information on their places of residence since birth in the first 1993 round or in subsequent rounds, in case they enter the panel, and since the previous round at which they were observed in case they are re-interviewed; we extract all past subdistricts of residence. For children's migrations, after checking that their care-taker was preeminently the mother throughout the survey, we imputed the migration histories of their mothers (or, exceptionally fathers or other care-takers, when mothers were missing from the household). Once we have constructed migration histories, two measures of exposure to an earthquake have been distinguished: short-run exposure (individuals declare to have been exposed to an earthquake during current and past survey years) and medium-run exposure to earthquakes (during the four previous years).

2.2. *Earthquakes data*

4 Spatial and time deflator obtained from Firman Witoelar, in 2007 Jakarta prices.

5 The construction of migration patterns has been greatly facilitated by the 2007 IFLS4 survey, which attempted to re-interview all 7,224 households interviewed in IFLS1, plus all of the newly formed households (split-offs) that first appeared in 1997, 1998 and 2000.

Our second source of data is the Centennial Earthquake Catalog (Engdahl and Villaseñor, 2002), which contains objective measures of earthquakes occurences and allows to estimate the local earth tremors they caused and that were felt by individuals in the IFLS panel survey.[6]

The Centennial catalog is a compilation of records of large earthquakes, obtained from seismographic instruments located around the world, that is made available by the U.S. Geological Survey. It has been assembled by combining existing catalogs and harmonizing the magnitude and location measures. For the period 1965-present, the Centennial catalog records earthquakes with a magnitude higher than 5.5 and is complete up that threshold. The Catalogue registers, for each seismic event, the date and exact time, epicenter's location, focal depth, magnitude (measure and scale)[7], as well as details on the source catalog, recording technique and instruments. From the Catalogue, we selected all earthquakes that occurred since 1985 in the region surrounding Indonesia (geographic latitudes between -12 and +12 degrees and longitudes between 80 and 150 degrees); there are 1111 such earthquakes.

We exploit this data to measure the strength of ground motion that was locally felt by the households in the IFLS panel, and the subsequent amount of damage they were likely to suffer. A common geological measure of local hazard that earthquakes cause is peak ground acceleration (PGA), or the maximum acceleration that is experienced by a physical body, e.g. a building, on the ground during the course of the earthquake motion. PGA is considered as a good measure of hazard to short buildings, up to about seven floors.[8]

Though local measures of the ground motions induced by earthquakes are available only for selected locations where stand seismographic stations, the mapping of the felt ground shaking and potential damage can be imputed from the characteristics of earthquakes and the local geography. Seismologists and structure engineers have developed models, called attenuation relations, for predicting the local

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6 We thank Professor Raul Madariaga (ENS) for helpful discussion and for directing us to this source of data.

7 Magnitudes are global measures of the size of earthquakes and are measured in terms of energy released by earthquakes in the Centennial catalog, usually using moment magnitude (Mw) scales (Hanks and Kanamori, 1979). The local magnitude scale (ML), also known as the Richter scale (Richter, 1935), tends to underestimate the strength of large earthquakes, so that the scale saturates above a threshold of around 7. Other older scales that appear in the catalog, such as the surface wave (Ms) or the body wave (mB) magnitudes (Gutenberg 1945) also saturate at different levels. The Mw scale does not saturate, and is thus considered as the most reliable measure of magnitudes. It is the common scale for measuring the size of medium to large earthquakes. Note that recent seismologists' research work revealed some limitations of the Mw scale for moment estimation at small magnitudes (see the discussion in Scordilis, 2006). Thus, other magnitude scales may be used for smaller (and more numerous) earthquakes, notably the unified magnitude (mb) based on Gutenberg and Richter (1956) local recordings of trace amplitudes. The Mw scale can then be calibrated to the older local magnitude scales.

8 The physical constraints put on those buildings during an earth tremor have been found to be strongly correlated with PGA. For taller buildings, peak ground velocity (PGV), the first integration of PGA, is viewed as a better measure of hazard.

intensity of ground shaking caused by a given earthquake; these models serve notably for mapping seismic hazards. Attenuation relations are obtained by specifying a functional form, e.g. with PGA being a log-linear function of distance to the source fault among other terms, and estimating the parameters using data for past earthquakes. Specific attenuation relations have been proposed for estimating ground motions for different regions, types of earthquakes, and distance ranges. The specific attenuation relation applied in this paper was derived by Zhao et al. (2006) using data from earthquakes in Japan.[9] The Zhao et al. attenuation relation, predicting the local record j for seismic event i, is the following (equation (1) p.901 in Zhao et al., 2006):

$$\log PGA_{ij} = aM_{wi} + bx_{ij} - \log_e(r_{ij}) + e(h - h_c)\delta_h + F_R + S_L + S_S + S_{SL}\log_e(x_{ij}) + C_k + u_{ij} + v_i \quad (1)$$

with $r_{ij} = x_{ij} + c\exp(dM_{wi})$ and where PGA is expressed in terms of g (the constant measuring the acceleration due to gravity, with value of 980 cm/second squared)); M_{wi} is moment magnitude (measured in dyn.cm[10]); $x_{i,j}$ is the source distance[11] (in kilometers); h is the focal depth (in kilometers, capped at 125 km); h_c is a depth constant (taking the value of 15 km); δ_h is a dummy variable that equals 0 for $h < h_c$ and 1 for $h \geq h_c$ (implying that the depth term only takes effect for depths larger than a certain level; F_R is a reverse fault parameter that applies to some crustal events, S_L parameter applies to interface events, and S_S and S_{SL} to subduction slab events.[12] C_k, for k=1,...,4, is a parameter for the type of local soils distinguishing rocks, hard soil, medium soil, and soft soil[13]; the

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9 This attenuation relation was chosen as it allows predicting ground motion for a variety of earthquake types, including subduction, crustal onshore, or deep intraplate earthquakes. It was also designed to predict ground motion at close-in distances, where damage is likely to be more significant. Note that though some attenuation relations have been developped using data from earthquakes that occurred in Indonesia, those have limitations and in particular are limited to a subset of earthquakes or distances; for instance Megawati and Pan (2010) propose an attenuation relation, derived from data on earthquakes in Sumatra, that is valid only for subduction events and at large distances. We thank Stephan Harmsen (USGS) for his advice on this choice.

10 A dyn is a unit of force and 1 dyn = 1 g·cm/s².

11 Source distance is either the shortest distance to the rupture zone or hypocentral distance. We use the later as we don't have fault models for the earthquakes under study and using those would be computationally untractable. For information, the hypocenter of an earthquake is the position where the source fault began to rupture. It is located at the focal depth below the epicenter.

12 All the earthquakes in our dataset are classified by type using information on focal depth and whether their epicenter is located on- or off-shore: crustal earthquakes are events onshore with depth lower than 25 kilometers, interface events are offshore and with depth lower than 50 kilometers, and slab events have depth larger than 50 kilometers offshore or 25 kilometers onshore (one would ideally consider the fault mechanism with interface events having a reverse mechanism and slab events a normal one). We thank again Stephan Harmsen for his help in identifying earthquake types.

13 The type of soil matters for determining local damages, as in particular soft soils tend to amplify those. Specific geographic environments such as ridges and hills also enter in the process. However, since we don't

error term of this random effects model contains an event specific effect v_i and an intra-event recording error $u_{i,j}$. The estimated values of the Zhao et al. model parameters are: $a = 1.101$, $b = -0.00564$, $c = 0.0055$, $d = 1.080$, $e = 0.01412$, $S_R = 0.251$, $S_L = 0$, $S_S = 2.607$, $S_{SL} = -0.528$, $C_H = 0.293$, $C_3 = 1.355$.

This attenuation formula allows estimating the PGA induced by any earthquake in our selected dataset and for any subdistrict surveyed by the IFLS; subdistricts typically are small areas, rarely larger than 20 kilometers of diameter, and we take one set of geographic coordinates for each of those. Source distance x is easily obtained from the latitudes and longitudes of the subdistrict ("kecamatan") and earthquake hypocenter locations. For each earthquake, we thus recover a mapping of the induced ground shaking felt in the IFLS subdistricts, with a measure of PGA for each subdistrict.

PGA measures can then be approximately converted to potential damages using the Modified Mercalli intensity scale: a well-known conversion rule (based on observations, reports of damages and perceived shaking) which has ten intensity levels, and where the upper six levels correspond to local ground motions with PGAs large enough to cause damage. Level 5 intensity level has PGAs between 3.9 and 9.2 percent of g (% g), and can cause very light damage, level 6 (PGAs between 9.2 and 18 % g) light damage, level 7 (PGAs between 18 and 34 % g) moderate damage, level 8 (PGAs between 34 and 65 % g) moderate to heavy damage, level 9 (PGAs between 65 and 124 % g) heavy damage, and level 10 or more (PGAs larger than 124 % g) very heavy damage. For each subdistrict in the IFLS panel surveys, we thus recover the PGAs that were experienced each year and the corresponding number in the Modified Mercalli intensity scale.

2.3. *Merged dataset*

The last step is to merge the earthquake subdistrict-level information with IFLS individuals. For each individual in the panel, we recover his history of exposure to ground shakings using the information from the specific subdistricts where the individual was living each year (migration histories are therefore taken into account) and the occurrence of ground shakings in those specific subdistricts and those years. Note that we compiled longitudes and latitudes for subdistricts that appear in any of the four waves of the household surveys. If an individual migrated to any other place, the associated geo-data and exposure to ground shakings for those areas could not be calculated. In any case, the share of such

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have detailed information on local environments nor on soils for Indonesia, we assume medium soils ($k = 3$) for our predictions.

individuals remains very limited.[14]

3. EARTHQUAKE INCIDENCE AND INTENSITY

Indonesia being one of the most seismically active regions in the world, large magnitude earthquakes occur frequently, in particular in the areas where the IFLS survey respondents live. Table 1 gives the list of earthquakes (and the information that is reported in the Centennial catalog) which caused earth tremors of intensity 7 or more felt in IFLS subdistrits. From this table we can already see that a relevant number of potentially damaging seismic events occur in the regions and period of the IFLS panel survey. There were 25 such earthquakes since 1985. Similarly there were respectively 105, 48, 15, and 6 earthquakes that caused ground motions of intensity level higher than 5, 6, 8, and 9. As expected, moderate intensity earthquakes are more common than highly devastating ones. The earthquakes that implied the strongest Modified Mercalli intensity levels experienced by our IFLS sample occurred on October 9, 1985 (magnitude M6.4), September 28, 1998 (M6.6), May 25, 2001 (M6.3), May 26, 2006 (M6.3 – this is the Yogyakarta and Central Java earthquake with killed 5,700 people, injured 40,000 and caused damages estimated at 3.1 billion USD), December 1st, 2006 (M6.3), and March 6, 2007 (M6.3).[15]

Table 2 gives the number of individuals in our survey that were touched by these large earthquakes. There is no single year without at least some individuals affected by earthquakes of intensity 5 or more. The years with higher earthquake incidence, in terms of individuals affected, correspond are 1985, 1998, 2001, and 2007, when more than 10,000 individuals in our sample were touched. But the years with the largest numbers of individuals exposed to earth tremors of intensity level 7 or more, are 1985, 1998, 2001, 2005, 2006 and 2007, when more than 500 individuals experienced such high intensity ground motions.

Table 3 presents self-reported information on earthquake incidence for all IFLS survey waves. In particular, the table presents the proportion of individuals that declare a household/business loss due to an earthquake[16], specifying the year in which the event took place. From this table we can see that

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14 Note that one must be careful not to impute in the survey year exposure to earth tremors that occurred after the households were interviewed, so that we consider only the earthquakes that happened during the first semester (all surveys were fielded during the second semester); we may however miss a few earth tremors affecting some panel households in late 1997 and 2007.

15 Note that the Centennial catalog may report larger magnitude earthquakes -for instance on March 28, 2005 (M8.6), September 12, 2009 (M8.5), that translate into less intense ground shakings from the moment they occur further away from ILFS households' location of residence.

16 Earthquakes not only produce ground shaking and movement along a fault, with the direct consequences this can produce on individuals (deaths or injuries) and building structures. They are also a relevant cause of

individuals systematically report fewer events as time goes by in all IFLS survey years.[17] Indeed, when we are able to obtain self-reported data for the same year in two surveys proportions are systematically larger in the survey that took place in a year closer to the event (for example for year 1997, 38.91% report an event in IFLS2 –at date t- and only 20.74% in IFLS3- at date t-3). This table shows clear evidence on how individuals tend to forget the past, which implies that self-reported data on events is subject to recall bias.

Table 4 compares our objective data on earthquakes with self-reported information on earthquake incidence and damages suffered (deaths, injuries, relocations and/or financial losses). The information presented concerns: (i) the proportion of individuals living in a subdistrict touched by an earthquake; (ii) the proportion of individuals self-reporting an earthquake in the period 2002-2007; and (iii) the proportion of individuals reporting severe damages (altogether and distinguishing between type of damage) from an earthquake in the period 2002-2007. Percentages are presented separately for urban and rural areas and by levels of ground shaking intensity felt in the subdistrict. We see that earthquakes of moderate intensity (less than level 5) are rather common (across districts and over time) and therefore affect higher proportions of the population (70% in urban areas and 63% in rural zones). At the other side of the distribution, highly devastating earthquakes, more rare, still touch around 12% of the urban and 8% of the rural population over a 5 years period. Individuals' perception of an earthquake clearly depends on the magnitude of the event. The proportion of individuals self-reporting an earthquake among those living in affected subdistricts, climbs from less than 5% for both urban and urban areas when considering moderate earthquakes (less than level 5) to around 40% in rural areas and around 60% in urban zones when looking at events of level 7 or more. A similar increasing pattern with earthquake intensity is observed in the proportion of individuals reporting severe damages. Note that urban proportions more than double rural ones at almost all intensity levels when we look at reporting damages. If we dig into the different types of damage that individuals report both in urban and rural areas, the most common damages are always losses of non-business assets (for example, for the highest intensity earthquakes, 32% among urban individuals and 12% among rural ones declare losses), followed by short-term displacements (31% and 11%), and by house damage (20% and 8%).

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floods (due to ruptures on dams or leeves along a river or to tsunamis and seiches) and fires (if for example, earthquakes break gas or power lines). Until 2007, the IFLS survey asked about earthquake, fire or other natural disaster events in a single question. In 2007, the survey allowed distinguishing between different types of natural disasters, and therefore, specific information on earthquakes is shown for that year.

17 2006 seems to be an exception, since the proportion of individuals declaring to have suffered an earthquake is higher than the one declared in 2007, but from our objective earthquake information we can see that 2006 was a year with one of the most devastating earthquakes experienced in Indonesia. 1993 seems to be another exception, but this seems to be more a subject of measurement error, since data are not comparable across IFLS surveys.

From Table 4 we can extract three main conclusions: first, individuals' perception of an earthquake increases with the intensity of the event (and so will the quality of self-reporting data). Second, earthquakes affect both urban and rural areas, and seem to generate higher immediate costs (higher proportion of individuals reporting losses) in urbanized areas. Third, the most important damage concerns asset and housing losses. Displacements are also important consequences of earthquakes, but in general last less than 6 months.

4. EMPIRICAL STRATEGY

4.1. Econometric model

To identify the short and medium-run welfare effects of earthquakes in Indonesia, we employ a fixed-effects panel econometric model. For this application, we need to accommodate the usual fixed-effects model to account for the facts that the welfare outcomes are measured at the household level while the experience of an earthquake is measured at the individual level and that the composition of households changes from one round of the panel to another. Abstracting for the moment from the longitudinal dimension, the underlying individual-level model that would be estimated if welfare outcomes were measured at the individual level writes:

$$y_{ij} = \alpha + \beta T_{ij} + \epsilon_{ij} \tag{2}$$

where y_{ij} is the welfare outcome of individual i of household j, T_{ij} a measure of the experience of an earthquake, and ϵ_{ij} a residual. The issue is that only an average $\bar{y}_j$ of the welfare outcomes at the household level is observed (e.g. the consumption expenditures aggregate is at the household level), so that one would need to estimate the averaged model:

$$\bar{y}_j = \alpha + \beta \bar{T}_j + \bar{\epsilon}_j \tag{3}$$

where $\bar{T}_j$ would be a household-level measure of treatment, i.e. experience of an earthquake. Using an individual-level treatment would lead to a misspecification bias, as can be seen by replacing individual-level by household-level welfare in equation (2):

$$\bar{y}_j = \alpha + \beta T_{ij} + (\bar{y}_j - y_{ij}) + \epsilon_{ij} = \alpha + \beta T_{ij} + u_{ij} \tag{4}$$

where one would need to control for the deviations of individual outcomes to the household level averages $\bar{y}_j - y_{ij}$; given that these deviations are unobserved and potentially correlated with treatment T_{ij}, the residual u_{ij} would not be independent from T_{ij} and the estimate of β would be biased in this specification. Thus, in a cross-section setting, only the household-level averaged model (3) would provide consistent estimates of the effects of earthquakes experience.

However, in a longitudinal setting, individuals can exit from households and join others, so that household-level fixed effects are not relevant, and one needs to incorporate individual fixed effects in a household-level averaged model. Consider thus the panel model. The underlying individual-level model writes:

$$y_{ijt} = \alpha + \beta T_{ijt} + \lambda_i + \epsilon_{ijt} \tag{5}$$

where the welfare outcome, the experience of an earthquake treatment and the residuals vary with time, and λ_i are individual fixed effects. The household-level model is obtained by taking the average and accounting for the fact that individuals can belong to different households at different dates:

$$\bar{y}_{jt} = \alpha + \beta \bar{T}_{jt} + \sum_{k \in K_{jt}} p_{tk} \lambda_k + \bar{\epsilon}_{jt} \tag{6}$$

where K_{jt} denotes the set of individuals k who belong to household j at date t. Because of these changes in household composition, the individual fixed effects need to be weighted by the shares p_{tk} of each individual represent of the number of household members (i.e. one divided by household size).

Now many household members, e.g. many couples, will remain together at all rounds of the panel. For those household members that are always observed together, individual fixed effects cannot be identified and can be replaced by fixed effects for the groupings of associated members. The weights p_{tk} will then consist on the shares of the number of household members represented by the individuals in the grouping at each date. The model we estimate thus writes:

$$\bar{y}_{jt} = \alpha + \beta \bar{T}_{jt} + \sum_{g \in G_{jt}} p_{tg} \lambda_g + \bar{\epsilon}_{jt} \tag{7}$$

where G_{jt} denotes the set of groupings of individuals (observed together) g who belong to household j at date t. In this model, treatment is defined at the household level and indicates whether any household member experienced an earthquake during a given of time preceding the date observation (e.g. in the past two years).

This model can be estimated as long as the number of fixed effects and other independent variables is smaller than the number of observations. With four rounds of data and a number of individuals remaining together across the different waves, this constraint happens to be satisfied.[18] The identification assumption is then the one usually formulated in fixed effects panel estimations. The fixed effects for groupings of individuals will control for time-invariant unobserved heterogeneity: the effects are identified using the longitudinal between variations by comparing the outcomes of households with the same members at dates after experiencing an earthquake and at other dates when they do not endure any earthquake. The main identifying assumption is that the experience of an earthquake is independent from the changes in unobserved determinants of welfare outcomes. The fact that the occurrences of earthquakes are to a large extent unpredictable makes it highly plausible.

The concerns with the endogeneity associated with the decision regarding the place of residence and migrations are limited for individuals who do not move over large distances (the fixed effects will capture the heterogeneity in residences between individuals), and to further safeguard identification from endogeneity associated with long distance migrations, we include in addition some fixed effects for the province of residence. We also control for several observable characteristics of household head (his gender, age, and education).

4.2. Specification of the estimates

The model above is estimated on an unbalanced panel of households with individuals aged 25 to 54, and fixed effects are included for the individuals in this age range or groupings of individuals who remain together across rounds. We exclude the observations of individuals in provinces where almost no one was affected by a large earthquake (of intensity of 5 or more). Besides, we consider separately two samples of individuals that are observed first in urban and rural areas respectively in the panel. The rural sample is thus made of households with individuals that lived in rural areas at their first observation (they can have moved afterwards to some urban areas), and the urban sample of households with individuals first observed in an urban area. The respective sizes of the two samples are respectively about 16,100 observations for the rural one and 15,500 for the urban one.

We estimate the effects of the experience of an earthquake first on per capita consumption expenditures, and second on the set of outcomes presented above: labor and social assistance incomes, the value of non-business, farm and non farm-business assets. Our dependent variables are the logarithms of those outcomes. Two set of treatment variables measure the experience of an earthquake. First, we use objective measures of the experience of an earthquake of intensity above a given level (5, 6,

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[18] The estimation of the model is still computationally intensive as several thousands of fixed effects must be estimated.

or 7) during the current or previous year (capturing a short-run effect of earthquake incidence); between two to five years before the year survey (capturing a medium-run effect), and between 6 to 15 years before the survey year (capturing a long-run effect). Second, we use subjective reports of the experience of an earthquake for the same short-run and medium-run reference periods (the nature of the question asked in the IFLS survey does not allow to measure the long-run effect in a comparable manner). Household level treatment indicates whether any household member did experience or report an earthquake.

5. RESULTS

5.1. *Estimating the effects of earthquakes on hh welfare using different measures of exposure to earthquakes*

We begin by examining the effects of earthquakes on household welfare at different time horizons. The outcome we consider for monitoring welfare is total per capita consumption, and, in addition to total consumption, we consider separately food and non-food consumption.

In addition to the substantive point above, we seek to adresss two methodological issues, by first testing for the presence of bias in the estimates obtained using subjective reports rather than objective measures of the experience of earthquakes, and second by examining the extent to which the effects of earthquakes on household welfare vary with their intensity. For taking those issues, we compare estimates of the effects of earthquakes on consumption obtained using different measures of exposure, including subjective reports and observed experiences of tremors of intensity 6+ and 7+.

Table 5 gives the estimates of the effects of earthquakes on per capita consumption expenditure, using self-reported measures of earthquake experiences together with objective measures, based on migration histories and sismological data, of the experience of earth tremors of intensity 6 or more and 7 or more, both in our rural and urban samples.

The main findings are the following. First, the estimates obtained using objective measures show negative short-run effects of earthquakes experience on household per capita consumption, with large decreases in total (by 10%) and non-food consumption (13%) for the rural sample, and smaller point estimates (resp. 4 to 7% decreases) and statistically non-significant effects for the urban sample. However those negative effects disappear in the medium run, and, in the long run, our estimates show positive effects of earthquake experience on per capita consumption, with substantial increases in both food and non-food consumption in both the rural (by 9-10%) and urban (7-10% statistically significant only for non-food consumption) samples.

Second, although the differences are not statistically significant, point estimates suggest that higher intensity earthquakes have larger negative effects in the short-run on consumption and also larger positive effects in the long-run.

Third, we find some inconsistencies between the estimates obtained using subjective and objective measures of earthquakes experience: differently from the ones with the objective measures, the estimates obtained with subjective measures show large positive medium-run effects. This is likely due to reporting bias, with better-off households possibly being more likely to report earthquakes.

To summarize the evidence in Table 5, households exhibit some resiliency with short-run welfare losses but recovery in medium-run and even positive long-run effects of earthquakes on their consumption. This pattern is more marked in the rural sample but the positive long run effects are apparent also in the urban sample. Methodologically, we find some consistency in the estimates obtained using earthquake measures with different intensities but not when using subjective measures; we take this as evidence of subjective reporting bias.

5.2. *Decomposing the impacts of earthquakes on household economic outcomes*

We now conduct a detailed analysis of the effects of earthquakes on household economic outcomes. We seek to learn on the mechanisms through which households are impacted, and those by which they are able to recover. Of particular interest are: a) the extent of immediate losses associated with the destruction of housing/building and movable non-business and business assets; b) coping strategies in particular reliance on self-insurance, notably by the mobilization of financial assets or sales of some assets (including land), or receipt of social assistance, and whether those behaviors allow households to reconstitute some of their losses, notably their stock of productive businesses assets; and c) disruption and recovery of the local economy, due notably to aid flows, and their effects on labor earnings.

We are particularly interested in the dynamics of business assets and labor incomes to examine whether demand-side effects of the recovery of local economy, in addition to household coping behaviors (e.g. self-insurance) and social assistance, can explain the positive long-run effects on consumption that we observed in the previous subsection.

For this purpose we use exclusively the objective measure of experience of an earthquake of intensity 6 or more, and estimate the effects of earthquake on the household outcomes: a) food and non-food consumption; b) non-business assets: house and land, other buildings, financial, movable (measured by dummy variables – except for movable – and log of monthly value); c) farm and non-farm business assets: house and land, other buildings, movable (dummies and log of monthly value); d) food and cash transfers non-labor incomes (dummies); and e) wage and self-employment labor incomes (dummy and log of monthly value).

We begin by examining in more details the effects on welfare. Table 6 gives the estimates of the effects of earthquakes on both food and non-food per capita consumption expenditure. The negative short-run effects are higher and more significant for non-food consumption and for the rural sample: households seem to cut mostly their non-food expenditure, i.e. the ones that can be reduced. There are positive but not statistically significant medium-run effects for the urban sample, and the positive long-run effects are consistent across two samples and for both food and non-food consumption (though not signif on food for urban): the long-run welfare gains are thus confirmed.

We now turn to business and non-business assets to investigate losses, the ability of households to reconstitute their assets, and self-insurance.

Table 7 gives the estimates of the effects of earthquakes on non-business assets (it uses outcomes in values, and Table 7bis uses indicator variables). In the short-run, we find negative effects on the ownership and value of housing and land assets and very large negative effects on the ownership and value of financial assets which suggest that households mobilize those assets for a self-insurance motive. In the medium-run, the negative effects on the value of movable assets could be associated with the reduced non-food consumption or indicate some sales of non-business assets. In the long-run, we find positive but not statistically significant point estimates for most long-run assets stocks (higher for the rural sample).

Table 8 gives the estimates of the effects of earthquakes on the value of farm-business assets (Table 8bis uses indicator variables). It shows negative short-run effects on building ownership and values (the point estimates are negative but statistically insignificant for other assets) in the rural sample, indicating substancial short-run losses in farm businesses. Now, there are positive medium-run effects on ownership and value of movable assets (positive point estimates also on land and building but not statistically significant) both in rural and urban sample, suggesting that productive assets are reconstituted in the medium-run. There are large positive but not statistically insignificant long-run effects on most farm business assets.

Table 9 gives the estimates of the effects of earthquakes on the value of non-farm business assets (Table 9bis uses indicator variables). We find some negative point estimates for the short and medium-run effects on building and land, but most estimates are not statistically significant. We also find some negative long-run effects statistically significant for the value of buildings in urban sample. The recovery of businesses thus seems not as good in the urban sector, when compared to the rural one.

Table 10 gives the estimates of the effects on the receipt of social assistance transfers. There are large positive short and medium-run effects in both rural and urban sample, mostly through subsidized food assistance: food social assistance is important in the short and medium-run. In the long-run, some negative effects on other transfers in rural sample provide another indication of the long-run welfare improvements.

Table 11 gives the estimates of the effects on the value of labor incomes (Table 11bis uses indicator variables). We find negative but insignificant point estimates for short-run effects, notably on wage income in rural sample and self-employment incomes in the urban sample. However, there are very strong positive medium-run effects on self-employment incomes, suggesting either that aid and reconstruction create business opportunities. Those demand-side benefits should complement supply ones (self-insurance and social assistance) and could explain the recovery of households' businesses. In the long-run, some positive point estimates remain, for self-employment in rural sample and both wage/self-employment income in urban one, but those are not statistically significant (possibly due to some heterogeneities in the effects of older and more recent earthquakes).

In summary, we find evidence of households coping behaviours, with decreases in the stocks of non-business assets (including financial assets) in the short and medium-run, suggesting some self-insurance is at play, and subtantial social assistance transfers. We also observe that the stock of productive assets, notably in farm businesses, is reconstituted and even increased in the medium-run; this suggests that reconstruction aid allows and/or provide incentives to small business holders to reconstitute and increase their investments.

6. CONCLUSION

Using high-quality large-scale longitudinal household surveys for Indonesia during the period 1993-2007, as well as both self-reported and objective measures of earthquakes, we examine the effects of large earthquakes on household welfare in Indonesia, and investigate some mechanisms driving those.

We first seek to evaluate if the effects of earthquakes on household welfare, as measured by per capita consumption, extend beyond the immediate event into the medium and long term and if heterogeneities across different population groups, notably inhabitants of rural and urban areas, are observed. Surprisingly, our results indicate that households who experienced a large earthquake in Indonesia, after going through short-term welfare losses, were able to recover in the medium-run, and even exhibit welfare gains in the long-run. Although the short-run effects appear to be more significant in the rural sample, the long-run gains are found in both the rural and urban samples. Methodologically, we find evidence of substancial endogenous reporting bias when self-declared measures of earthquake experience instead of objective measures.

We then examine the effects of earthquakes on a range of household economic outcomes, and find evidence of short and medium-run decreases in the stocks of non-business assets, including financial assets, suggesting some self-insurance is at play, and subtancial social assistance transfers are also received, notably in the rural sample. We also observe that the stock of productive assets, notably in farm businesses, is reconstituted and even increased in the medium-run. This suggests that reconstruction aid allows and/or provide incentives to small business holders to reconstitute and increase their investments.

This work is in progress and more evidence is to be gathered to deepen the analysis of mechanisms. More evidence on the changes in infrastructures and their relations with the outcomes of small businesses and welfare gains should in particular allow testing the extent to which reconstruction induces local development and explains the long-run welfare gains we observed.

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Table 1: list of earthquakes causing local earth tremors of intensity 7+ felt by the IFLS sample

day	month	Year	depth	magnitude	type	latitude	longitude	onshore	type
24	2	1985	53	5.8	Ms	-2.083	119.772	1	slab
1	3	1985	23.5	6.4	Ms	-2.045	119.632	1	crustal
2	3	1985	45.1	6.7	Ms	-1.936	119.716	1	slab
9	10	1985	156	6.4	Ms	-6.743	107.006	1	slab
25	4	1987	7.7	6.4	Ms	2.409	98.906	1	crustal
28	4	1987	4.4	5.5	Ms	2.069	99.016	1	crustal
8	4	1988	111.2	5.5	Ms	-8.858	117.399	1	slab
9	6	1992	73.9	6	Ms	-8.457	111.021	0	slab
15	2	1994	19.8	6.9	Ms	-5.007	104.251	1	crustal
6	10	1995	35.6	6.7	Ms	-2.009	101.447	1	slab
17	6	1996	590.9	7.9	Ms	-7.146	122.512	0	slab
7	7	1997	27.9	5.9	Mw	.999	97.476	1	slab
28	9	1997	13	5.9	Mw	-3.782	119.655	1	crustal
28	9	1998	146.4	6.6	Mw	-8.182	112.337	1	slab
14	8	1999	98.1	6.4	Mw	-5.913	104.622	1	slab
11	11	1999	213.4	6	Ms	1.244	100.22	1	slab
25	5	2001	140	6.3	Mw	-7.85	110.04	1	slab
1	1	2004	43.5	5.8	Mw	-8.4	115.71	1	slab
30	6	2004	91	6.2	Mw	.68	124.69	0	slab
23	1	2005	44.1	6.2	Mw	-1.28	119.84	1	slab
28	3	2005	33.7	8.6	Mw	2.05	97.06	0	interface
26	5	2006	19.7	6.3	Mw	-7.96	110.34	1	crustal
1	12	2006	204	6.3	Mw	3.39	99.09	1	slab
6	3	2007	24.1	6.3	Mw	-.5	100.52	1	crustal
8	8	2007	290	7.5	Mw	-5.91	107.67	0	slab

Table 2: Numbers of individuals in the sample affected by earth tremors, by year and ground shaking intensity

year	I5	I6	I7	I8	I9	I10
1985	4359	1178	6321	939	70	170
1986	2	0	0	0	0	0
1987	2097	176	8	0	0	0
1988	910	901	207	4	0	0
1989	2	0	0	0	0	0
1990	359	0	0	0	0	0
1991	2122	1017	0	0	0	0
1992	4319	939	3	0	0	0
1993	916	0	0	0	0	0
1994	3660	215	0	0	0	0
1995	5650	198	0	329	0	0
1996	3442	1298	239	0	0	0
1997	1374	320	189	9	0	0
1998	6959	3573	683	1498	330	0
1999	3867	582	165	9	0	0
2000	2035	5	0	0	0	0
2001	6586	3370	1329	612	180	4
2002	1576	2	0	0	0	0
2003	3196	8	0	0	0	0
2004	3324	1628	150	473	0	0
2005	2994	594	30	0	0	0
2006	3054	1547	2742	617	179	81
2007	5809	3523	3240	5613	108	0

Table 3: Self-reported earthquake incidence, by IFLS survey year

% reporting a natural disaster at year	1993 (IFLS1)	1997 (IFLS2)	2000 (IFLS3)	2007 (IFLS4)
t	39.48	38.91	27.75	23.28
t-1	22.00	16.24	24.75	64.06
t-2	17.36	12.37	21.17	10.85
t-3	10.82	9.66	20.74	0.85
t-4	8.20	16.75	3.72	0.53
t-5	1.55	6.06	1.86	0.43

Note: For the three first IFLS surveys, proportions concern the incidence and timing of household and/or business loss due to earthquake, fire or other natural disaster. For year 2007, we are able to provide disaggregated proportions only for earthquakes.

Table 4. Intensity levels (I) experienced and reports of earthquakes and losses

Intensity levels:	**Less than level 5**	**Level 5**	**Level 6**	**Level 7 or more**
Individuals living in urban areas:				
% objectively touched	70.61	11.70	5.12	12.57
% reporting an earthquake	0.024	0.242	0.417	0.590
% reporting severe damages (death / injury / financial loss / relocation) from an earthquake	0.001	0.031	0.192	0.356
% reporting deaths	0,0%	0,0%	0,0%	1,1%
% reporting injuries	0,0%	0,0%	0,5%	3,2%
% reporting displacements	0,1%	2,0%	14,2%	31,3%
% reporting displacements of more than 6 months	0,0%	0,0%	2,1%	6,3%
% reporting house damaged	0,1%	0,0%	12,2%	20,7%
% reporting house heavily damaged	0,1%	0,0%	2,2%	4,8%
% reporting loss of business assets	0,0%	0,1%	3,4%	8,4%
% reporting loss of non business assets	0,1%	1,7%	15,8%	31,9%
Individuals living in rural areas:				
% objectively touched	63.61	19.21	8.91	8.28
% reporting an earthquake	0.038	0.256	0.388	0.428
% reporting severe damages (death / injury / financial loss / relocation) from an earthquake	0.002	0.043	0.080	0.148
% reporting deaths	0,0%	0,0%	0,3%	0,6%
% reporting injuries	0,0%	0,2%	0,5%	1,3%
% reporting displacements	0,0%	1,8%	4,8%	11,5%
% reporting displacements of more than 6 months	0,0%	0,3%	0,8%	3,3%
% reporting house damaged	0,0%	2,0%	4,2%	8,8%
% reporting house heavily damaged	0,0%	0,5%	3,0%	2,4%
% reporting loss of business assets	0,0%	0,2%	1,7%	2,5%
% reporting loss of non business assets	0,1%	3,6%	5,8%	12,4%

Table 5: Effects of the experience of an earthquake on per capita consumption expenditures

	RURAL SAMPLE			URBAN SAMPLE		
	Level 6 or more	Level 7 or more		Level 6 or more	Level 7 or more	
Earthquake experienced in years t to t-1	-0.0980**	-0.0966**		-0.0401	-0.0565*	
	(0.045)	(0.047)		(0.052)	(0.027)	
Earthquake experienced in years t-2 to t-5	-0.0139	-0.0069		0.0537	0.0530*	
	(0.038)	(0.043)		(0.044)	(0.027)	
Earthquake experienced in years t-6 to t-15	0.0984***	0.1170**		0.0888**	0.0660**	
	(0.037)	(0.043)		(0.039)	(0.023)	
Self-reported earthquake in years t to t-1			-0.0468			0.0616
			(0.108)			(0.084)
Self-reported earthquake in years t-2 to t-5			0.2222**			0.1169*
			(0.127)			(0.106)
Number of Obs	15837	15762	15207	15013	14750	14148
R-squared	0.808	0.816	0.810	0.872	0.878	0.875

Note : Standard errors (in parentheses) are robust to heteroskedasticity. All regressions include time and groupings of individuals fixed effects. Additional controls include the province of residence and several characteristics of the household head (gender, age and eductation). *** significant at 1%; ** significant at 5%; * significant at 10%.

Table 6: Effects on per capita household consumption: food and non-food.

	RURAL SAMPLE		URBAN SAMPLE	
	Food consumption	Non-food consumption	Food consumption	Non-food consumption
I6+ Earthquake experienced in years t to t-1	-0.0528	-0.1340**	-0.0570	-0.0698
	(0.046)	(0.060)	(0.053)	(0.063)
I6+ Earthquake experienced in years t-2 to t-5	-0.0396	0.0159	0.0098	0.0895
	(0.040)	(0.050)	(0.045)	(0.059)
I6+ Earthquake experienced in years t-6 to t-15	0.0999**	0.0904*	0.0729	0.0914*
	(0.039)	(0.048)	(0.045)	(0.049)
Number of Obs	15889	15892	15129	15108
R-squared	0.774	0.802	0.820	0.868

Note : Standard errors (in parentheses) are robust to heteroskedasticity. All regressions include time and groupings of individuals fixed effects. Additional controls include the province of residence and several characteristics of the household head (gender, age and eductation). *** significant at 1%; ** significant at 5%; * significant at 10%.

Table 7: Effects on the value (in logs) of non-business assets: house and land; other buildings; financial assets; movable assets.

	RURAL SAMPLE				URBAN SAMPLE			
	ouse and nd	her buildings	ovable assets	ancial assets	House and land	Other buildings	Movable assets	Financial assets
I6+ Earthquake experienced in years t to t-1	-0.9305*	0.0305	-0.0263	-0.7918*	-0.5234	-0.0438	-0.1965	-1.1498**
	(0.564)	(0.416)	(0.183)	(0.414)	(0.584)	(0.595)	(0.166)	(0.574)
I6+ Earthquake experienced in years t-2 to t-5	0.5567	-0.2007	-0.4398**	0.2339	0.5786	0.2110	-0.1216	0.8282
	(0.477)	(0.306)	(0.183)	(0.359)	(0.545)	(0.535)	(0.191)	(0.552)
I6+ Earthquake experienced in years t-6 to t-15	0.4827	0.3757	0.0733	0.1968	-0.4159	0.4002	0.1269	0.0305
	(0.470)	(0.349)	(0.160)	(0.342)	(0.442)	(0.510)	(0.153)	(0.475)
Number of Obs	15812	15928	15955	15946	15061	15217	15278	15237
R-squared	0.660	0.803	0.793	0.747	0.707	0.825	0.812	0.757

Table 7bis: Effects on the ownership of non-business assets: house and land; other buildings; financial assets; movable assets.

	RURAL SAMPLE			URBAN SAMPLE		
	House and land	Other buildings	Financial assets	House and land	Other buildings	Financial assets
I6+ Earthquake experienced in years t to t-1	-0.0705*	0.0017	-0.0639**	-0.0397	0.0042	-0.0770*
	(0.039)	(0.025)	(0.031)	(0.038)	(0.035)	(0.041)
I6+ Earthquake experienced in years t-2 to t-5	0.0324	-0.0087	0.0187	0.0478	0.0057	0.0647
	(0.032)	(0.019)	(0.028)	(0.036)	(0.032)	(0.040)
I6+ Earthquake experienced in years t-6 to t-15	0.0303	0.0174	0.0109	-0.0170	0.0123	0.0060
	(0.033)	(0.021)	(0.026)	(0.029)	(0.030)	(0.034)
Number of Obs	15812	15928	15946	15061	15217	15237
R-squared	0.661	0.790	0.721	0.704	0.813	0.735

Note : Standard errors (in parentheses) are robust to heteroskedasticity. All regressions include time and groupings of individuals fixed effects. Additional controls include the province of residence and several characteristics of the household head (gender, age and eductation).
*** significant at 1%; ** significant at 5%; * significant at 10%.

Table 8: Effects on the value (in logs) of farm-business assets: house and land; other buildings; financial assets; movable assets.

	RURAL SAMPLE			URBAN SAMPLE		
	House and land	Other buildings	Movable assets	House and land	Other buildings	Movable assets
I6+ Earthquake experienced in years t to t-1	-0.1632	-0.8033**	-0.0642			
	(0.495)	(0.333)	(0.395)			
I6+ Earthquake experienced in years t-2 to t-5	0.1782	0.2589	0.7588**			
	(0.438)	(0.322)	(0.370)			
I6+ Earthquake experienced in years t-6 to t-15	0.2322	0.1687	0.3790			
	(0.437)	(0.307)	(0.350)			
Number of Obs	15885	15908	15956			
R-squared	0.833	0.710	0.825			

Table 8bis: Effects on the ownership of farm-business assets: house and land; other buildings; financial assets; movable assets.

	RURAL SAMPLE			URBAN SAMPLE		
	House and land	Other buildings	Movable assets	House and land	Other buildings	Movable assets
I6+ Earthquake experienced in years t to t-1	-0.0123	-0.0628**	0.0022	0.0107	0.0119	0.0164
	(0.030)	(0.026)	(0.030)	(0.023)	(0.017)	(0.024)
I6+ Earthquake experienced in years t-2 to t-5	0.0149	0.0258	0.0570**	0.0021	0.0330*	0.0463*
	(0.026)	(0.025)	(0.027)	(0.024)	(0.019)	(0.028)
I6+ Earthquake experienced in years t-6 to t-15	0.0136	0.0111	0.0230	0.0067	0.0162	0.0173
	(0.026)	(0.024)	(0.027)	(0.017)	(0.012)	(0.017)
Number of Obs	15885	15908	15956	15263	15267	15279
R-squared	0.827	0.710	0.817	0.788	0.689	0.811

Note : Standard errors (in parentheses) are robust to heteroskedasticity. All regressions include time and groupings of individuals fixed effects. Additional controls include the province of residence and several characteristics of the household head (gender, age and eductation). *** significant at 1%; ** significant at 5%; * significant at 10%.

Table 9: Effects on the value (in logs) of non-farm-business assets: house and land; other buildings; movable assets.

	RURAL SAMPLE			URBAN SAMPLE		
	House and land	Other buildings	Movable assets	House and land	Other buildings	Movable assets
I6+ Earthquake experienced in years t to t-1	-0.0339	-0.3323	0.0965	-0.4055	-0.4091	0.4417
	(0.283)	(0.307)	(0.466)	(0.377)	(0.474)	(0.551)
I6+ Earthquake experienced in years t-2 to t-5	0.1664	-0.0355	0.2877	0.0327	-0.3340	0.6480
	(0.250)	(0.283)	(0.385)	(0.384)	(0.446)	(0.539)
I6+ Earthquake experienced in years t-6 to t-15	0.1139	-0.1543	0.4364	-0.4128	-0.6965*	-0.0320
	(0.225)	(0.260)	(0.391)	(0.325)	(0.399)	(0.460)
Number of Obs	15927	15931	15956	15223	15200	15279
R-squared	0.695	0.743	0.774	0.719	0.759	0.793

Table 9bis: Effects on the ownership of non-farm business assets: house and land; other buildings; movable assets.

	RURAL SAMPLE			URBAN SAMPLE		
	House and land	Other buildings	Movable assets	House and land	Other buildings	Movable assets
I6+ Earthquake experienced in years t to t-1	-0.0018	-0.0200	0.0087	-0.0247	-0.0312	0.0231
	(0.018)	(0.020)	(0.034)	(0.023)	(0.031)	(0.039)
I6+ Earthquake experienced in years t-2 to t-5	0.0097	-0.0005	0.0202	0.0039	-0.0194	0.0388
	(0.015)	(0.018)	(0.027)	(0.024)	(0.029)	(0.038)
I6+ Earthquake experienced in years t-6 to t-15	0.0062	-0.0118	0.0290	-0.0249	-0.0489*	0.0009
	(0.014)	(0.017)	(0.029)	(0.019)	(0.025)	(0.032)
Number of Obs	15927	15931	15956	15223	15200	15279
R-squared	0.697	0.748	0.763	0.718	0.757	0.782

Note : Standard errors (in parentheses) are robust to heteroskedasticity. All regressions include time and groupings of individuals fixed effects. Additional controls include the province of residence and several characteristics of the household head (gender, age and eductation). *** significant at 1%; ** significant at 5%; * significant at 10%.

Table 10: Effects of the receipt of social assistance transfers

	RURAL SAMPLE			URBAN SAMPLE		
	any assistance	subsidized food assistance	other assistance (incl. cash)	any assistance	subsidized food assistance	other assistance (incl. cash)
I6+ Earthquake experienced in years t to t-1	0.0983***	0.0946***	-0.0174	-0.0316	0.0148	-0.0764*
	(0.034)	(0.034)	(0.021)	(0.064)	(0.063)	(0.042)
I6+ Earthquake experienced in years t-2 to t-5	0.2283***	0.2073***	0.0225	0.0798	0.0972	0.0018
	(0.033)	(0.033)	(0.020)	(0.084)	(0.080)	(0.055)
I6+ Earthquake experienced in years t-6 to t-15	-0.0275	-0.0240	-0.0368**	-0.0530	-0.0233	-0.0132
	(0.027)	(0.027)	(0.017)	(0.058)	(0.057)	(0.038)
Number of Obs	9015	9015	9015	8663	8663	8663
R-squared	0.863	0.860	0.835	0.878	0.872	0.819

Note : Standard errors (in parentheses) are robust to heteroskedasticity. All regressions include time and groupings of individuals fixed effects. Additional controls include the province of residence and several characteristics of the household head (gender, age and eductation). *** significant at 1%; ** significant at 5%; * significant at 10%.

Table 11: Effects on the value (in logs) of labor income: wages and self-employment income.

	RURAL SAMPLE		URBAN SAMPLE	
	Wages	Self-Employment income	Wages	Self-Employment income
I6+ Earthquake experienced in years t to t-1	-0.2810	-0.0047	-0.1460	0.0506
	(0.375)	(0.339)	(0.423)	(0.414)
I6+ Earthquake experienced in years t-2 to t-5	0.1289	0.5180*	0.6864*	0.0306
	(0.307)	(0.287)	(0.403)	(0.377)
I6+ Earthquake experienced in years t-6 to t-15	-0.0172	0.3080	0.1046	0.3394
	(0.316)	(0.286)	(0.363)	(0.350)
Number of Obs	16090	16090	15516	15516
R-squared	0.798	0.826	0.801	0.839

Table 11bis: Effects on the ownership of labor income: wages and self-employment income.

	RURAL SAMPLE		URBAN SAMPLE	
	Wages	Self-Employment income	Wages	Self-Employment income
I6+ Earthquake experienced in years t to t-1	-0.0138	0.0099	0.0028	-0.0183
	(0.034)	(0.032)	(0.036)	(0.037)
I6+ Earthquake experienced in years t-2 to t-5	0.0178	0.0528*	-0.0059	0.0497
	(0.028)	(0.028)	(0.034)	(0.037)
I6+ Earthquake experienced in years t-6 to t-15	-0.0013	0.0251	0.0233	0.0022
	(0.029)	(0.027)	(0.030)	(0.032)
Number of Obs	16090	16090	15516	15516
R-squared	0.776	0.791	0.809	0.788

Note : Standard errors (in parentheses) are robust to heteroskedasticity. All regressions include time and groupings of individuals fixed effects. Additional controls include the province of residence and several characteristics of the household head (gender, age and eductation). *** significant at 1%; ** significant at 5%; * significant at 10%.