Chapter 7

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CHAPTER 7
Natural Disaster and Human Capital Accumulation: The Case of the Great Sichuan Earthquake in China*

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In this paper, we employ original micro data collected from students and schools affected by the Great Sichuan Earthquake in 2008 to uncover the impacts of the earthquake on the broad human capital of students, i.e., their cognitive and non-cognitive outcomes. Two main findings emerge from our empirical analysis. First, the household-level shocks due to the earthquake worsen a child's psychosocial outcomes as well as family environment uniformly. Second, classroom relocations due to the earthquake mitigate depression, enhance self-esteem, improve family environment, and improve Chinese test scores. These effects may reflect positive peer effects through the earthquake-affected students' unexpected exposure to students and facilities in better schools. Since non-cognitive skills may be more malleable than cognitive skills at later ages, the government must play an important role in facilitating human capital accumulation in a broader sense effectively by amending the non-cognitive skills of children affected by a natural disaster directly or indirectly.

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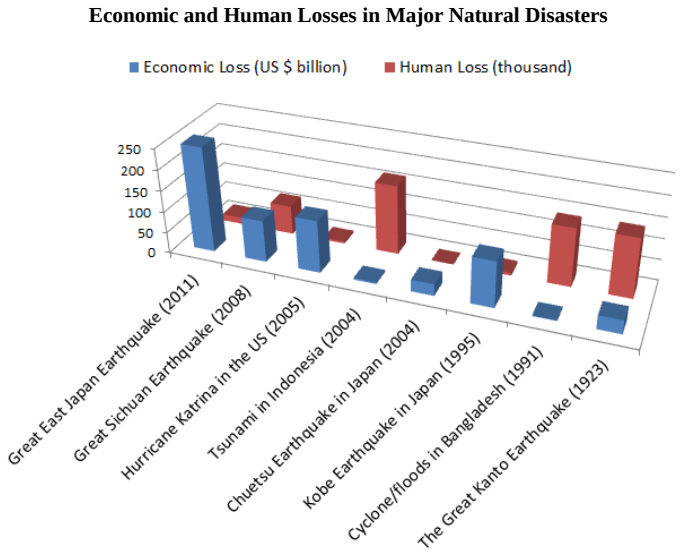
1. Introduction

On the afternoon of May 12th, 2008, Wenchuan County of China's Sichuan Province was hit by a devastating earthquake measuring 7.9 on the Richter scale (USGS, 2012). The epicentre of the earthquake was 80 kilometers from Chengdu, the capital of Sichuan, home to more than 14 million people. The earthquake resulted in confirmed losses of more than 69,000 lives and economic losses exceeding RMB 845 billion. As can be seen in Figure 7.1, the scale of the losses means that the earthquake is one of the largest economic disasters ever recorded in human history (Park and Wang, 2012; Sawada, 2013). Yet, there are only few studies that document how the earthquake affected individual households in the disaster-affected areas (Park and Wang, 2009, 2012; Shi *et al*., 2012; Huang *et al*., 2011). Particularly, it is largely unknown how such a traumatic shock affects the psychosocial situations as well as cognitive achievements of children in schools.

Figure 7.1: Economic and Human Losses in Major Natural Disasters



Source: Sawada (2007), USGS (2012), and Cabinet Office (2011).

The purpose of this paper is to bridge this gap in the literature. We explore the exogenous variations in earthquake outbreak and students' relocations to uncover the psychosocial as well as cognitive impacts of earthquakes on children. In addition to surveys in Wenchuan County, we study Mao County, a nearby county with a lower level of damage, to identify the causal impacts

of the earthquake. Right after the earthquake, all the schools in Wenchuan County and the surrounding areas were closed, with no exams given for the semester. In July 2008, the Wenchuan County education bureau decided to send all the students to other places to continue their studies. By August 2008, most of the students had been relocated to other cities or counties not seriously affected by the Sichuan earthquake as well as other provinces including Guangdong, Shanxi, Shandong, Beijing, and Fujian. In January 2009, the schools had their own exams for the fall semester, and in July 2009, the school year end exams were organised for all the students by the county education bureau. After the school year end exams were over in late July 2009, the students returned to Wenchuan County. In September 2009, the students started their studies in their new schools in Wenchuan County.

Using this unique natural experimental situation, we study how the experience of being temporarily relocated to new schools after the earthquake influenced the educational and life outcomes of students from Wenchuan County. Most of the middle school and high school students in Wenchuan County were relocated to schools in the Guangdong, Shanxi, or other regions of Sichuan. The preliminary results from the analysis of students and school survey data show that many parents felt that the school environment and grade attainment of their children improved after the temporary relocation to new schools (Park and Wang, 2009). This suggests that such temporary relocation may have played a positive role in the students' development, perhaps through the better environmental factors or positive peer effects resulting from the interaction of students, teachers, and principals with their counterparts in the host schools in more developed regions. In addition, the randomness in the assignment of schools to different host schools creates an exogenous variation in the quality of the host schools, providing an unusual research opportunity to evaluate how the different aspects of the relocation experience and characteristics of the host schools influence the development of students. Using carefully organised student-, teacher-, and school-level surveys, we examine the impacts of the earthquake. The results of the study will have valuable implications for designing public intervention policies to rehabilitate children during educational as well as psychological problems caused by natural disasters.

This paper is organised as follows: The next section reviews the existing studies on the impacts of natural disasters. In the third section, we describe our research design for the school surveys in Sichuan province, followed by data description in the fourth section. The fifth section gives the econometric framework and estimation results, followed by our concluding remarks in the final section.

2. Literature Review

A major natural disaster causes the immediate loss of hundreds of thousands of lives, and it has been found that hydro-meteorological natural disasters such as cyclones, floods, and droughts are increasing in number (e.g., Cavallo and Noy, 2009; Kellenberg and Mobarak, 2011; Strömberg, 2007). Both the developed and developing countries are continuing to be hit by high-profile natural disasters such as the 2011 devastating earthquake, tsunami, and nuclear radiation crisis in Japan; the Indian Ocean tsunami; Hurricane Katrina; and earthquakes in central Chile, Haiti, the Sichuan province of China, northern Pakistan, and the Hanshin area of Japan. These natural disasters not only cause the loss of human lives but also destroy the survivors' livelihoods. It is known that the poor in the developing countries are particularly vulnerable to natural disasters (World Bank and United Nations, 2010).

While there are a number of studies on the macroeconomic impacts of natural disasters (for example, Kahn, 2005; Freeman *et al*., 2003; Noy, 2009; Barro, 2009; Strömberg, 2007; Skidmore and Toya, 2007; Raddaz, 2007; and Yang, 2008), there are relatively few microeconomic studies (Kunreuther *et al*., 1978; Carter *et al*., 2007; Skoufias, 2003; Morris and Wodon, 2003; Kohara *et al*., 2006; Gitter and Barham, 2007; Sawada, 2007; Sawada, *et al*., 2009; de Mel *et al*., 2012; Halliday, 2006, 2012; Frankenberg *et al*., 2008; Nakata *et al*., 2010; Frankenberg *et al*., 2011; Shoji, 2010; Takasaki, 2011; Sawada, 2013). These micro studies examine the individual- or household-level ex post facto coping strategies against disasters, because disasters happen unexpectedly, causing serious negative impacts on household welfare. Since the formal insurance mechanisms against losses caused by natural disasters are weak

(Cummins, 2006), most individuals often adopt inappropriate responses against natural disasters, often sacrificing physical and/or human capital investments. Sawada (2013) and Sawada and Shimizutani (2008, 2011) show that credit market access plays an important role in weathering the damage caused by disasters in developed countries. Yet, the poor in the developing counties are likely to be excluded from effective credit access to cope with damage caused by natural disasters. Theoretically, under binding borrowing constraints, a household has an incentive to reallocate its resources intertemporally to cope with unexpected negative shocks by cutting back on physical and human capital investments.

Of course, there are several studies based on micro data from developing countries focusing on the impacts of exogenous shocks on human capital investments (Jacoby and Skoufious, 1997; Garg and Morduch, 1998; Jensen, 2000; Thomas *et al*., 2004; Beegle *et al*., 2006; Fitzsimons, 2007; Sawada and Lokshin, 2009; Duryea *et al*., 2007). For example, Foster (1995) found that the negative income shocks due to price shocks translate into the low growth of children under credit market imperfections. Moreover, Kochar (1999) found that such negative shocks increase the labour force participation of parents. Behrman (1988) found that the nutrition of girls is affected more than that of boys in the lean season. Similarly, Behrman and Deolalikar (1988) reported that price changes affect the consumption level of girls more than that of boys. As a consequence, Rose (1999) found that girls suffer disproportionately from adverse shocks, evaluated by mortality rate. Using micro data from Ethiopia, Dercon and Krishnan (2000) found that women in these households, who engage in risk-sharing, bear the brunt of adverse shocks, while examining the ability of individual members of households to keep the consumption smooth over time. Using a Pakistan panel data set, Alderman and Gertler (1997) found that the income elasticities of demand for medical expenditure are uniformly larger for females than for males.

Yet, these existing studies investigate the usual exogenous income shocks, and almost no paper exists that investigates how extreme shocks arising from natural disasters affect human capital investments. This paper tries to bridge this gap in the literature by examining the impacts of the Great Sichuan Earthquake on the cognitive and non-cognitive outcomes of children affected by the earthquake.

3. Research Design

As part of the *Kin Mirai Kadai Kaiketsu Jigyo* project of the Hitotsubashi University, headed by Professor Makoto Saito, we conducted our study in the Wenchuan County as well as the Mao County, a nearby county with a lower level of damage, in December 2009. We conducted our study of primary schools, middle schools, and high schools in Wenchuan County and middle schools and high schools in Mao County. To be more precise, the following four types of respondent groups are included in our study:

First, the "(present) schools," that is, the schools existing when the research was carried out. The headmaster or a staff member who knows well the overall affairs of the researched school (A) is required to fill in the forms. Each school submits one set of the "Questionnaire for (present) schools" forms.

Second, the "schools before the earthquake," that is, all the schools that existed before the earthquake. A staff member who knows well the overall affairs of the former schools is required to fill in the forms. If school (A) includes students from three former schools B1, B2, and B3, the situation about all the three former schools needs to be submitted in separate forms. Hence, there will be three sets of the "Questionnaire for schools before the earthquake" forms.

Third, all the teachers in charge of any subject in the researched schools are required to fill in the forms. Specifically, the teachers in charge of the lectures from Grade 3 to Grade 6 in the targeted primary schools need to fill in the forms, while with regard to middle schools and high schools, all the teachers in charge of the subjects of all the grades need to fill in the forms. Each teacher submits one set of the "Questionnaire for teachers" forms.

Finally, all the students in the selected classes are required to fill in the forms. Each student submits one set of the "Questionnaire for students" forms.

With the financial support from the Economic Research Institute for ASEAN and East Asia (ERIA), the research team updated our original microdata collected from students and schools affected by the great Sichuan earthquake

in 2009. We collected high school entrance exam record for all middle school students and college entrance exam record for all high school students we surveyed in 2009. All the new data collection was done in March 2014. Using this unique natural experimental situation tracked by our unique surveys, this research will study how the experience of being exposed to the earthquake affects human capital accumulation.

3.1. Sampling Procedure

The school sample for the research on education in earthquake-hit areas includes all the primary schools, middle schools, and high schools in Wenchuan County, except for the special children educational schools and schools in the Wolong Special District, as well as the middle schools and high schools in Mao County. All the schools in the sample are required to fill in the school questionnaires. From the school samples, all the teachers in charge of subjects from Grade 3 to Grade 6 in primary schools and any subject in the middle schools and high schools are included in our teacher samples. As for the student survey, the most important component of this study, the sampling object is selected from every school of the sample: 50% of all the classes in each grade are randomly selected. All the students in the selected classes comprise the student samples. The sampling approach we adopt to select the target classes is the "Simple Equidistant Random Sampling" method.[1] Using this method, we sample each grade in each school to select the classes. All the students in each selected class are students in the sample.

[1] Specifically, (1) arrange all the classes from Class 1 to Class n in Grade G with the number of students in each class; (2) multiply the total number of students in Grade G with a random number to get the product, say 98; (3) from the cumulative number of students in the classes, check which class the 98th student belongs to. If the student belongs to Class C, Class C is the first class selected in Grade G; (4) because 50% of the classes in each grade are selected, meaning that the distance between the neighboring classes in the sample is 2, using Class C, add or subtract the distance to get the other classes into the sample.

3.2. Survey Implementation

Our field surveys are conducted by three professors from the Renmin University of China and the Sichuan University, as leaders, and 18 PhD and MA students from the two universities. Before the field research, a training session was conducted on December 5th, 2009. The staff members in charge of the project gave training to all the investigators. The main issues included, first, training on the contents of the questionnaires for students, teachers, and schools in order to enable the investigators answer the questions that arise when actually having to fill in the questionnaires and second, training on how to guide the process of investigation in order to assist the investigators arrange a reasonable investigation process, control the speed, and avoid flaws.

The field research was conducted from December 6 to December 10, 2009. All the members were divided into two groups to carry out the research in Wenchuan County and Mao County simultaneously. The actual survey procedure is described as follows: First, the staff in charge of all the schools and teachers in charge of all the selected classes were assembled, and the details of the survey and training on the main points of the research were given. Second, the questionnaires for the schools and teachers were distributed to the staff in charge of each school, and special notifications were given when handing out the forms. The questionnaires for the schools and teachers were filled in by the concerned persons, and were then gathered back in each school and handed over to our investigators. The investigators checked the submitted questionnaires and returned the forms that miss any relevant information or that were obviously flawed, requiring that such forms be redone; Third, the questionnaires for the students are distributed to the teachers in charge of each class, and special notifications were given when handing out the forms. Each teacher in charge of a class generally spent the time of one class to explain all the questions, and then guided the students to fill in the forms from the beginning to the end. The investigators gave technical instructions to aid the process, and finally checked the gathered questionnaires one by one.

Collection of high school and college entrance exam records for all the sample students were administered by the county education bureau of Wenchuan and Mao County.

4. Data

Following this sampling approach, we selected 90 classes in Wenchuan County and 37 in Mao County. We estimated the sample to include 4,291 students from Wenchuan County and 1,663 from Mao County, totaling 5,954 students. The students belonged to 12 primary schools, 2 middle schools, and 2 high schools in Wenchuan County and 3 middle schools and 1 high school in Mao County. After a week of field research, we finally gathered the samples comprising 5,482 students and 980 teachers from 20 schools in Wenchuan County and Mao County. The exact figures are given in Table 7.1.

Table 7.1: Number of Respondents in Our Study

County	School type	Students	Teachers	Present schools	Schools before the earthquake
Wenchuan	Primary School	1219	288	12	16
	Middle School	626	86	2	3
	High School	2159	253	2	3
Mao	Middle School	733	252	3	7
	High School	745	101	1	1
Total		5482	980	20	30

The actual number of students in the samples is less than the expected total of 5,954. There are mainly two reasons for this discrepancy: First, the number of students that the education bureau of the two counties gave us was different from the actual number of students in the classes we visited. The number reported by the education bureau was higher, so there was a statistical error. Second, some students were absent on the day we visited the classes, so we could not include them in the investigation. The number of these students is approximately 2% of the whole sample size, which is the factor that we could not control.

4.1. Natural Experiments

To identify the causal impacts of the earthquake on the psychosocial and cognitive outcomes of children, we have two sources of exogenous variations—or serendipitous "natural experiments"—which we investigate in this paper. First, the physical and human losses caused by the earthquake are treated as unforeseen exogenous shocks. In order to utilise this natural experiment, we conduct an additional survey of Mao County, a nearby county with a lower level of damage, to identify the causal impacts of the earthquake by comparing Mao and Wenchuan counties. Tables 7.2 and 7.3 compare the household and school damage, respectively, in the two counties. Table 7.2 shows that the intensities of home damage and negative job impacts are greater in Wenchuan County than in Mao County. Yet, surprisingly, the proportion of households whose income and consumption declined is slightly smaller in Wenchuan County than in Mao County. This probably reflects the fact that Wenchuan County received disproportionate amounts of external support after the earthquake. Table 7.3 shows the school and classroom damage in the two counties. Obviously, the intensity of damage is much larger in Wenchuan County than in Mao County. Also, Table 7.4 summarises the variables on damage and environmental changes that we use in this study.

Table 7.2: Household-Level Damage (In Percentage)

	Houses collapsed	HH member unemployed	Income declined	Food consumption declined
Wenchuan	26.77	25.34	75.03	45.04
Mao	16.14	10.06	82.63	47.55

Table 7.3: School and Classroom Damage(In Percentage)

	Serious damage of first floor	Serious damage of equipment	Serious human injury or loss at the school
Wenchuan	9.52	90.91	9.09
Mao	0	62.50	0

Table 7.4: Variables on Damage and Environmental Changes

Damage to households and individuals
Member(s) killed or injured
Member(s) became unemployed
Damage at school level
Serious human injury or loss at the school
Serious physical damage to the school
Environmental changes of education
Teacher and student environment change in temporary school
Teacher and student environment change in new school
Moved outside of county
Broad peer effects
(Outside Wenshuan) Teachers' interaction and communication with local school and community
(Outside Wenshuan) Donation from government and society
(Outside Wenshuan) Students' interaction and communication with local school and community
(Outside Wenshuan) Treatment of local government and volunteers

Another source of natural experiment is the peculiar decisions regarding school allocation in Wenchuan County after the earthquake. Of all the earthquake regions, only Wenchuan County decided to allocate most of the students outside the county after the earthquake. The decision was mainly made by the Wenchuan County education bureau, as it realised there was not enough safe space to build temporary schools and resettle the students within the county. The county education bureau asked the provincial education bureau to help with finding the destination schools that Wenchuan students could go to. The matching of Wenchuan schools and outside schools was not necessarily done in a systematic way. Personal connections, the willingness of enterprises, and administrative power all played a role in the process. For example, a private enterprise in Shanxi came to Wenchuan and expressed its willingness to move the middle school and high school at the epicenter (Yingxiu township) to Shanxi, and cover all the cost of the relocation.

In most cases, the students in one school moved together to one destination and almost all teachers moved with them. All the teachings were carried out by their own teachers during the relocation period. Local governments or enterprises at the destination provided the school buildings and financial support. In some cases, Wenchuan students might have shared the same school with the local students, but when possible, they usually had separate buildings. A small portion of Wenchuan students did not go with their schools but went to other schools their parents found for them. Very few dropped out of school temporarily.

This situation indicates that students and teachers in Wenchuan County were exposed to the outside schools exogenously. In other words, the classroom and school level peer effects were changed exogenously. This natural experiment will help identify how the peer effects affect the psychosocial and cognitive outcomes of students.

4.2. Psychosocial and Cognitive Outcomes

In order to capture the non-cognitive skills of children, we employ four different measures in this paper (see Table 7.5). First, we adopt the Center for Epidemiological Studies Depression Scale (CES-D), based on questions shown in Table 7.5 (A). This is one of the most popular measures to capture

depression. We aggregate and rescale the responses so that the CES-D indicator is increasing in less depression. Second, we utilise the Strengths and Difficulties Questionnaire (SDQ) developed by Goodman (1997) to quantify the psychological attributes in conduct and peer relationship problems (Table 7.5 [B]). The third measure is the Rosenberg Self-Esteem Scale assessment, which measures perceptions of self-worth (Rosenberg, 1965). This is a 10-item scale, designed for adolescents and adults, and measures an individual's degree of approval or disapproval toward himself (Table 7.5 [C]). The final measure is the Family Environment Scale (FES), developed by Moos and Moos (1976), to measure the social-environmental characteristics of a family (Table 7.5 D). All these four measures are normalised and rescaled so that each measure is increasing in better psychosocial situations. The average measures in each county are shown in Table 7.6; in general, psychosocial situations seem to be better in Wenchuan County than in Mao County, intriguingly.

Table 7.5: Psychological Measures

(A) Depression

a. I don't want to eat. I have lost my appetite.	1. never____ 2. occasionally____ 3. sometimes____ 4. often_____
b. I feel depressed.	1. never____ 2. occasionally____ 3. sometimes____ 4. often_____
c. I lack strength to do anything.	1. never____ 2. occasionally____ 3. sometimes____ 4. often_____
d. I do not sleep well.	1. never____ 2. occasionally____ 3. sometimes____ 4. often_____
e. I feel happy.	1. never____ 2. occasionally____ 3. sometimes____ 4. often_____
f. I feel lonely.	1. never____ 2. occasionally____ 3. sometimes____ 4. often_____
g. People are not friendly to me.	1. never____ 2. occasionally____ 3. sometimes____ 4. often_____
h. I live a happy life.	1. never____ 2. occasionally____ 3. sometimes____ 4. often_____
i. I feel worried.	1. never____ 2. occasionally____ 3. sometimes____ 4. often_____
j. I feel people hate me.	1. never____ 2. occasionally____ 3. sometimes____ 4. often_____
k. I feel people dislike me.	1. never____ 2. occasionally____ 3. sometimes____ 4. often_____
l. everything about me is not progressing.	1. never____ 2. occasionally____ 3. sometimes____ 4. often_____

(B) SDQ

a. I am very cranky and usually get angry.	1. wrong_____2. somewhat right_____3. completely right_____
b. Usually I do what people tell me to do.	1. wrong_____2. somewhat right_____3. completely right____
c. I often fight.	1. wrong_____2. somewhat right_____3. completely right_____
d. People often say that I am lying.	1. wrong_____2. somewhat right_____3. completely right____
e. I have taken things not belonging to me.	1. wrong_____2. somewhat right_____3. completely right_____
f. I usually like to be alone.	1. wrong_____2. somewhat right_____3. completely right____
g. I have at least one friend.	1. wrong_____2. somewhat right_____3. completely right_____
h. My peers generally like me.	1. wrong_____2. somewhat right_____3. completely right____
i. Those younger than me fool me.	1. wrong_____2. somewhat right_____3. completely right_____
j. Compared with my peers, I get on better with those older than me.	1. wrong_____2. somewhat right_____3. completely right____

(C) Rosenberg Self-esteem

a. I am generally satisfied with myself.	1. very disagree__ 2. disagree___ 3. agree___ 4. very agree____
b. Sometimes I feel I am totally powerless.	1. very disagree__ 2. disagree___ 3. agree___ 4. very agree____
c. I feel I have many merits.	1. very disagree__ 2. disagree___ 3. agree___ 4. very agree____
d. I can do as well as others.	1. very disagree__ 2. disagree___ 3. agree___ 4. very agree____
e. I think I have nothing to be proud of.	1. very disagree__ 2. disagree___ 3. agree___ 4. very agree____
f. Sometimes I feel I am useless.	1. very disagree__ 2. disagree___ 3. agree___ 4. very agree____
g. I feel I am a valuable person, at least the same as the others.	1. very disagree__ 2. disagree___ 3. agree___ 4. very agree____
h. I hope I can earn myself more respect.	1. very disagree__ 2. disagree___ 3. agree___ 4. very agree____
i. Generally, I am inclined to consider myself a loser.	1. very disagree__ 2. disagree___ 3. agree___ 4. very agree____
j. I have a positive evaluation of myself.	1. very disagree__ 2. disagree___ 3. agree___ 4. very agree____

(D) Family conflict

a. My family members always give me their utmost help and support.	1.right_____ 2.wrong___
b. My family members often quarrel.	1.right_____ 2.wrong___
c. I feel bored with my family.	1.right_____ 2.wrong___
d. My family members seldom show their anger openly.	1.right_____ 2.wrong___
e. My family members are willing to put in much effort to do all things at home.	1.right_____ 2.wrong___
f. Some of my family members crush things when they get angry.	1.right_____ 2.wrong___
g. There is a harmonious atmosphere in my family.	1.right_____ 2.wrong___
h. My family members seldom get angry with one another.	1.right_____ 2.wrong___
i. Rarely is anybody willing to take up what must be dealt with at home.	1.right_____ 2.wrong___
j. My family members often criticise one another.	1.right_____ 2.wrong___
k. My family members always sincerely support one another.	1.right_____ 2.wrong___
l. My family members sometimes fight with one another.	1.right_____ 2.wrong___
m. My family lacks a teamwork atmosphere.	1.right_____ 2.wrong___
n. My family members try to reduce their differences, and keep good manners even when they have different opinions.	1.right_____ 2.wrong___
o. My family members get on well with one another.	1.right_____ 2.wrong___
p. My family members often want to excel others.	1.right_____ 2.wrong___
q. Every member in my family has been paid full attention to.	1.right_____ 2.wrong___
r. In my family, we feel that quarrelling with loud voices will not help solve problems.	1.right_____ 2.wrong___

Table 7.6: Psychological Measures by County and School Type

Wenchuan	CESD	SDQ	Self-esteem	FES
Primary school	0.382	-0.073	0.036	0.083
Middle school	0.094	-0.024	0.031	-0.030
High school	-0.115	0.122	0.041	0.020
Total	0.147	-0.012	0.035	0.018
Mao				
Middle school	-0.291	-0.116	-0.119	-0.087
High school	-0.373	0.060	-0.069	-0.101
Total	-0.331	-0.029	-0.094	-0.094

As to cognitive achievements, we use the Chinese and mathematics test scores for the end of academic years 2008 and 2009. Both the tests are given in July. Moreover, we use the study hours in July 2008 and July 2009 to capture the intensity of study. Table 7.7 shows that the test scores improved in Wenchuan County but deteriorated in Mao County.

Table 7.7: Changes in Official Test Scores and Study Hours

	Test scores–Chinese 2008	Test scores–Chinese 2009	Test scores–Math 2008	Test scores–Math 2009	Study hour 2008	Study hour 2009
Wenchuan						
Primary school	-0.005	-0.008	-0.004	-0.007	1.596	1.383
Middle school	-0.034	-0.023	-0.040	-0.025	1.991	1.954
High school	-0.037	-0.131	0.036	-0.064	2.121	2.188
Total	-0.024	-0.035	-0.017	-0.026	1.882	1.806
Mao						
Middle school	0.985	-0.021	0.786	-0.027	1.966	2.029
High school	0.017	0.011	0.000	0.016	2.529	2.440
Total	0.028	-0.005	0.008	-0.004	2.239	2.229

5. Econometric Model and Estimation Results

In order to examine the relation between the disaster variables shown in Table 7.4 and the outcome variables such as the psychological measures in Table 7.5 and test scores, we set up an econometric model of each outcome variable, *Y*. Note that each damage variable is treated separately as a dichotomous variable *D*, which takes the value of 1 if damage arises, and zero otherwise. In other words, we postulate a model of treatment of disaster damage using the natural experimental nature of disasters. The level of an outcome variable with damage is denoted by Y^1, and without damage is denoted by Y^0. The average impact of damage caused by a disaster is shown as the following average treatment effects of the treated (*ATT*):

$$(1) \qquad E(Y^1 - Y^0 | D=1).$$

In equation (1), the fundamental issue is the way to grasp the counterfactual outcome, $E(Y^0|D=1)$, which cannot be observed directly. Rewriting equation (1), we obtain

$$\begin{aligned}(2) \quad & E(Y^1|D = 1) - E(Y^0|D = 0) \\ & = [E(Y^1 = 1|D = 1) - E(Y^0|D = 1)] + [E(Y^0|D = 1) - E(Y^0|D = 0)] \\ & = E(Y^1 - Y^0|D = 1) + [E(Y^0|D = 1) - E(Y^0|D = 0)].\end{aligned}$$

Equation (2) shows that the observable average difference between the treatment and control groups, i.e., $E(Y^1|D = 1) - E(Y^0|D = 0)$, deviates from *ATT*, $E(Y^1 - Y^0|D = 1)$, by the amount $E(Y^0|D = 1) - E(Y^0|D = 0)$. This discrepancy is called a selection bias, which basically shows the discrepancy between the average outcome of counterfactual situation $E(Y^0|D = 1)$ and the average observable outcome of the control group $E(Y^0|D = 0)$. Since disasters are unforeseen contingencies and cannot be manipulated by humans, they provide researchers with natural experiments in a sense similar to DiNardo (2008), in which people are exogenously assigned into treatment and control groups. We assume that such a natural experiment gives us a serendipitous

situation where the selection bias [$E(Y^0|D = 1) - E(Y^0|D = 0)$] converges to zero. Indeed, studies such as Kahn (2005) show that there is no systematic relationship between the observed income level and degree of disaster damage. Yet, it may be also true that post-disaster outcomes are also affected by pre-earthquake characteristics of each household or individual, and the condition [$E(Y^0|D = 1) - E(Y^0|D = 0)$] = 0 may not be satisfied in general. To handle this potential problem, we assume that given the same set of observables X, the selection bias becomes zero; i.e.,

$$E(Y^0|D = 1, X) - E(Y^0|D = 0, X) = 0. \quad (3)$$

This assumption is called ignorability, or selection on observables. To check the plausibility of this assumption, we perform a few balancing tests between the treatment and control groups following Bruhn and McKenzie (2009) and Imai *et al*., (2008). Using the student characteristics such as age, height, and sex, as well as pre-disaster household asset ownership as the elements of X, we confirm that the balancing tests are passed.

Furthermore, assuming a linear conditional expectation function and the ignorability of equation (3), we rewrite equation (2), conditional on observables X, as follows:

$$Y = \alpha + \delta D + X\gamma + u. \quad (4)$$

Also, for test scores and study hours, we have individual panel data before and after the disaster, and estimate the difference-in-difference model of equation (4):

$$\Delta Y = \alpha^d + \delta^d D + X\gamma^d + u^d, \quad (5)$$

where Δ is a first-difference operator. We quantify *ATT* by estimating the parameters δ in equation (4) and δ^d in equation (5). Admittedly, several

potential problems are left behind in estimating equations (4) and (5), so we take the analysis in this paper as our primary approach.

5.1. Unconditional *ATT*

We first estimate *ATT* based on equation (4) without the control variable *X*. In this case, *ATT* is quantified simply as a difference of the average value of the outcome variable between the treatment group ($D = 1$) and control group ($D = 0$). As a treatment variable, *D*, we use four indicator variables interchangeable for household member damage (killed or insured), unemployment due to earthquake, school-level human loss, and relocation of classroom/school outside the county.

Table 7.8 shows the *ATT* for each of the treatment variables using psychology and the family environment variables as outcomes, i.e., the Center for Epidemiologic Studies Depression scale (CES-D), the Strengths and Difficulties Questionnaire (SDQ) measure, the Rosenberg Self-Esteem Scale (RSES), and the Family Environment Scale (ES). We have two main findings from Table 7.8. First, household level damage uniformly worsens the psychosocial measures. In particular, the negative impacts on depression and family environments seem to be significant. Second, while school-level damage and changes seem to generate opposite effects, the effects of school-level human damage are not statistically significant. Classroom relocation helps to improve depression problems as well as enhance self-esteem significantly.

Table 7.8: Unconditional ATT of Exogenous Shocks on Non-Cognitive Outcomes

	N_CESD	N_SDQ	N_Rosenberg	N_FES
	CES-D	SDQ	RSES	FES
Treatment variable (household level)				
Household member(s) killed or injured	-0.103**	-0.053	-0.024	-0.085**
Household member(s) became unemployed	-0.175**	-0.159**	-0.111**	-0.112**
Treatment variable (school level)				
Serious human losses at school	0.006	-0.006	0. 075	-0.039
Relocated outside the county	0.267**	0.061	0. 145**	0. 082**

Note: ** and * show statistical significance at the 1% and 5% levels, respectively.

In Table 7.9, the earthquake impacts on cognitive outcomes captured by the Chinese and mathematics test scores as well as self-reported study hours are shown from the estimations of the difference-in-difference model of equation (5) without control variables, *X*. According to the estimation results, while household-level damage generates statistically insignificant impacts on test scores, school-level s improve test scores.

Table 7.9: Unconditional ATT of Exogenous Shocks on Cognitive Outcomes

	Change in Chinese test score	Change in Chinese (entrance) test score	Change in math test score	Change in math (entrance) test score	Change in study hours
Treatment variable (household level)					
Household member(s) killed or injured	-0.027	0.050	0. 002	0.027	0. 021
Household member(s) became unemployed	0. 012	0.059	-0.033	0.018	-0. 004
Treatment variable (school level)					
Serious human losses at school	-0.086	0.174	-0.145	-0.022	0 .159*
Relocated outside the county	0. 027	0.007	-0.016	0.112	-0.111**

Note: ** and * show statistical significance at the 1% and 5% levels, respectively.

According to Tables 7.8 and 7.9, we see heterogeneous effects of household- or individual-level earthquake damage on outcomes. Yet, before drawing conclusions based on these unconditional *ATT*s, we examine *ATT*s conditional on observables.

5.2. Conditional *ATT*

We estimate equations (4) and (5) conditional on observables such as student grade year, age, sex, and height, household pre-earthquake asset ownership, and parent education levels. To capture the non-essential heterogeneous treatment effects, we include multiple disaster variables in each specification shown in Table 7.10. Four main findings emerge from our estimation. First, household-level damage due to human loss and/or unemployment worsens all psychosocial measures and family environment measures uniformly. In particular, the depression problems that arise and the impacts generated by unemployment seem to be serious. Since after a disaster, emergency employment can be generated effectively by the government, this finding indicates the importance of an effective public policy after a disaster.

Table 7.10: Conditional ATT of Exogenous Shocks on Non-Cognitive and Cognitive Outcomes

	Non-Cognitive Human Capital				Cognitive Human Capital				
	CES-D	SDQ	RSES	FES	Change in Chinese test scores	Change in Chinese (entrance) test score	Change in math test scores	Change in math (entrance) test score	Change in study hours
Treatment variable (household level)									
Household member(s) killed or injured	-0.152*	-0.006	-0.056	-0.148**	-0.064	0.0003	0.000	0.009	0.022
Household member(s) became unemployed	-0.292**	-0.216**	-0.212**	-0.189**	-0.075	0.088*	-0.048	0.04	-0.045
Treatment variable (school level)									
Serious human losses at school	0.149**	0.003	-0.002	0.014	0.095*	0.136	0.173**	-0.012	0.086
Serious physical damage to school	0.141**	-0.003	0.043	-0.066**	0.169**	-0.106	0.101**	-0.055	0.023
Relocated outside the county	0.229**	0.083	0.24**	0.154**	0.075*	-0.07	-0.069	0.077	0.1
Study environment improvements	0.003	-0.003	0.015*	-0.007	0.029**	-0.002	-0.003	-0.04	0.025*
N	2732	2741	2736	2744	2693	3375	2693	3375	2715
R-squared	0.06	0.04	0.05	0.03	0.02	0.09	0.02	0.05	0.02

Note: We control for student grade level dummies, age, sex dummy, and height, household-level pre-disaster asset ownership, and parents' education level variables.

** and * show statistical significance at the 1% and 5% levels, respectively.

Second, intriguingly, the school/classroom-level damage and changes, captured by school building damage and classroom relocation outside the county, seem to improve psychosocial outcomes as well as cognitive outcomes, captured by test scores. In particular, classroom relocations mitigate depression, enhance self-esteem, and improve family environment.

Third, as to their influence on cognitive outcomes, household-level damage has insignificant impact. In contrast, school/classroom-level damage and changes improve test scores uniformly. We also observe marginal positive impacts on study hours. These positive effects of the Sichuan earthquake on cognitive outcomes are consistent with the findings of Park and Wang (2009), who collected and analysed a different dataset from the Sichuan earthquake victims. In particular, the positive coefficients of relocation outside the county and of improvements in study environment on Chinese test scores may reflect positive peer effects through the earthquake-affected students' unexpected exposure to students and facilities in better schools. While positive effects may arise from the solidarity of the relocated students who live together, in fact, on additional analysis, which is not shown in this paper, we find that among the relocated classrooms, the teachers' interaction and communication with the destination school and community are positively related with both the Chinese and mathematics test scores of the relocated students, confirming positive peer effects.

Fourth, the impact of school damage and relocation on cognitive outcomes faded out after all the students had come back to their newly constructed schools, as shown by the changes of their Chinese and math entrance exams. Reconstruction of new schools with high quality may mitigate the negative impact of the earthquake in the short term.

Yet, improvements in psychosocial measures may be a reflection of the students' mental problems such as survivor guilt among the control schools. If this interpretation is true, a disaster may generate negative psychosocial impacts indirectly through strong negative externalities. This implies that post-disaster mental care services should be provided not only to children in the directly affected schools, but also to students in the unaffected schools.

6. Concluding Remarks

In this paper, we employ original micro data collected from the students and schools affected by the Great Sichuan Earthquake to uncover the impacts of the earthquake on students' cognitive and non-cognitive outcomes. There are two main findings. First, the household-level shocks due to the earthquake worsen the child psychosocial as well as family environmental outcomes uniformly. Second, classroom relocations due to earthquake mitigate depression, enhance self-esteem, improve family environment, and improve Chinese test scores. These effects may reflect positive peer effects through the earthquake-affected students' unexpected exposure to students and facilities in better schools.

These findings indicate that there exist clear asymmetries in the impact of natural disasters on child cognitive and non-cognitive outcomes. The impact may differ greatly owing to the type and level of damage caused by a disaster. This suggests that children's post-disaster mental care should be carefully designed and customised in such a way that their human capital development processes are amended and facilitated effectively. In particular, the students who encounter serious losses and damage to their households should be provided with intensive psychological care. Also, we find that if carefully organised, the temporary relocation of affected students may mitigate the negative consequences of natural disasters, possibly through positive peer effects from their new school environment. Reconstruction of high quality new schools also helps mitigate the negative impact of school damage.

As opposed to the emphasis on cognitive skills or personality traits in human capital accumulation in the literature, James Heckman and his associates tried to address the importance of non-cognitive skills as determinants of economic and social outcomes (Heckman and Rubinstein, 2001; Heckman *et al*., 2006). While children's cognitive abilities appear to be fairly well determined by an early age, their non-cognitive skills such as motivation and self-discipline are more malleable at later ages than their cognitive skills. Mentoring and motivational programs oriented toward disadvantaged teenagers seem to be effective in the United States. In case such a mechanism is applied also to China (Glewwe *et al*., 2011), the government might play an important role in amending the non-cognitive skills of children affected by natural disasters

directly or indirectly. Concrete forms of public intervention include a variety of customised counseling services to treat post-traumatic stress disorders (PTSD) like survivor guilt, mentoring programs by senior people in the community, and temporal relocation of classrooms to outside of the disaster areas. These policies would render human capital investments in a broader sense effective.

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