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The Great East Japan Earthquake and subsequent tsunami on March 11 were a reminder of Japan’s huge earthquake risk and need for preparedness. The northeastern part of the country witnessed devastating human suffering and physical damage. The destructive impact of the earthquake has enhanced consumer’s earthquake preparedness even in unaffected areas. This paper uses unique survey data collected after the earthquake to study how consumers reacted to this catastrophic event. We find that self-reported, perceived preparedness for natural disasters has significantly improved even among low-income households after March 11, but that post-quake intentions for more specific risk mitigation activities were systematically associated with household income and wealth levels. High income households are more likely to plan purchase of earthquake insurance or to conduct seismic retrofitting following the March 11th earthquake, indicating that the recent events might have widened the gap in disaster preparedness between rich and poor.

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Earthquake Risk in Japan: Consumers' Risk Mitigation Responses after the Great East Japan Earthquake^{*}

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Abstract

The Great East Japan Earthquake and subsequent tsunami on March 11 were a reminder of Japan's huge earthquake risk and need for preparedness. The northeastern part of the country witnessed devastating human suffering and physical damage. The destructive impact of the earthquake has enhanced consumer's earthquake preparedness even in unaffected areas. This paper uses unique survey data collected after the earthquake to study how consumers reacted to this catastrophic event. We find that self-reported, perceived preparedness for natural disasters has significantly improved even among low-income households after March 11, but that post-quake intentions for more specific risk mitigation activities were systematically associated with household income and wealth levels. High income households are more likely to plan purchase of earthquake insurance or to conduct seismic retrofitting following the March 11th earthquake, indicating that the recent events might have widened the gap in disaster preparedness between rich and poor.

Keywords: Earthquake Risk, Disaster Preparedness, Risk Mitigation, Earthquake Insurance.

JEL classification: D81, G22, Q54

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Introduction

At 14:46 on March 11, a massive magnitude 9.0 earthquake struck the Sanriku Coast of northeastern Japan. The tsunami, reaching as high as 38 meters in some locations, pulverized coastal cities and villages in the Tohoku district along the Pacific Ocean, causing extensive human as well as physical damage. Tokyo also experienced tremors with a seismic intensity of 5, but damage there was relatively modest, related mostly to liquefaction near Tokyo Bay.

Basically, we cannot interfere with the natural processes that create earthquakes. Therefore, the key is to foster earthquake mitigation and resilience in quake-prone areas. Japan experiences about 20% of the world's 6+ magnitude earthquakes and is thus relatively well prepared compared to other countries. The region struck by the quake/tsunami has experienced massive disasters twice in the past 115 years, in 1933 and 1896. Following those catastrophes, survivors placed tsunami stones at the high water marks in their villages with stark warnings not to build anywhere below. Tragically, the sense of risk fades over time and these injunctions from ancestors were ignored.

According to a recent survey, only 24% of Japanese households purchased an earthquake insurance policy in 2011,¹ and approximately 25% of existing houses lack sufficient quake resistance as of 2003.² The limited demand for earthquake insurance and prevalence of housing without sufficient quake resistance carries important policy implications. First, and most importantly, uninsured victims of major earthquakes may incur severe financial and non-financial losses, which greatly influence the future well being of these survivors and their families. Earthquake insurance and seismic retrofitting can, at least partly, cover or reduce these severe losses. Second, once a massive earthquake occurs, the prevalence of uninsured individuals or houses vulnerable to earthquake requires large recovery costs in the form of government grants and low-interest loans to uninsured victims that are funded by all taxpayers. Furthermore, since these risk mitigation activities appear to be systematically related to key household characteristics such as income, wealth and educational level, a natural catastrophe does not victimize the rich and poor alike; poor households are less able to afford risk mitigation and thus after a disaster existing disparities may widen.

Devastating human suffering and physical damages in Tohoku, coupled with extensive media coverage, may alter consumers' earthquake risk perception and risk mitigation responses (Naoi et al., 2009). This paper

uses the most recent, unique survey data collected after the Great East Japan Earthquake to study how different consumers are reacting to this catastrophic event. Specifically, we examine the post-quake changes in earthquake preparedness among households that were not directly struck by the Great East Japan Earthquake. As far as we know, there is limited empirical evidence on this topic. We find that self-reported, perceived preparedness for natural disasters significantly improved after March 11, but that post-quake intentions for more specific and costly risk mitigation activities (insurance purchase and seismic retrofitting) are systematically associated with household income and wealth levels. High income households are now more likely to plan to purchase earthquake insurance or to conduct seismic retrofitting, indicating that the recent events might have widened the gap in disaster preparedness between rich and poor. Our findings suggest that there is still much room for improvement in promoting earthquake mitigation among low-income households.

The remainder of the paper is organized as follows. In the next section, we briefly introduce the data (Post-Quake Supplement of KHPS/JHPS). In Section 3, we present a set of empirical results about the determinants of earthquake victimization and post-quake changes in consumers' earthquake preparedness. Section 4 concludes the paper.

Post-Quake Supplement of KHPS/JHPS

In this paper, we use the 2011 Post-Quake Supplement (PQS, hereafter) of the Keio Household Panel Survey (KHPS) and Japan Household Panel Survey (JHPS). KHPS and JHPS are nationally representative panel surveys started in 2004 and 2009, respectively, with initial panel sizes of approximately 4,000 households. The two surveys essentially share the same questionnaire and are conducted every January on an annual basis. As of 2011, we have approximately 6,000 households in these surveys ($N = 3,030$ for the KHPS and 3,160 for the JHPS).

In the wake of the Great East Japan Earthquake, KHPS and JHPS conducted an extensive supplemental questionnaire about the post-quake situations of respondents. The PQS survey was conducted in June 2011, about three months after the Great East Japan Earthquake, as a follow-up to the regular survey. Each 2011 respondent of the KHPS/JHPS was mailed a self-administered questionnaire. As a result, we have 4,215 PQS households for a response rate of 68.1%, of which 3.7% were affected by 3/11. The supplement focused on the

degree and extent of damage caused by the earthquake, post-disaster situations of respondent's employment, housing, consumption and income, among others. The PQS also includes a wide array of questions about post-quake changes in respondent's earthquake preparedness activities.

In the following analysis, we focus on the post-quake changes in consumer's earthquake preparedness from various perspectives. Earthquake preparedness includes any pre-disaster action that can improve the safety and effectiveness of a disaster response. Having a first-aid kit and stocks of food and water, securing furniture with safety latches to prevent toppling, getting information about what to do in case of an earthquake, having earthquake insurance, and seismic retrofitting of housing are some of the measures that can be taken to prepare for earthquakes. In the empirical analysis, we first look at the perceived preparedness for natural disaster, namely, whether they are more concerned about natural disasters (including earthquakes) after March 11. We then look at two specific measures of earthquake risk mitigation activities—insurance purchase and seismic retrofitting.

Empirical Analysis

Determinants of Earthquake Victimization

Before proceeding to an empirical analysis of consumer's earthquake preparedness behavior, it is worth looking at the damage situation among the PQS respondents. From the PQS data we can identify families actually struck by the March 11th earthquake. Table 1 presents data on the regional distribution of earthquake victims and compares several socio-economic characteristics of victims and non-victims. Overall, approximately 3.7% of PQS respondents reported that their family was affected by the Great East Japan Earthquake (N = 154) and they are concentrated in the Tohoku region, closest to the quake's epicenter.³ The earthquake/tsunami victims are relatively old, female, and married while average household income and wealth are significantly lower than other respondents. Although our respondents are survivors of 3/11, i.e. those who survived the cataclysm, the quake-related mortality in three prefectures (Iwate, Miyagi and Fukushima) in Tohoku district shows a similar pattern. Among the quake victims who died in these three prefectures, 54% were women and 65% were those aged 60+ (Cabinet Office of Japan, 2011).

(Table 1 around here)

A multivariate analysis generally shows similar patterns. Table 2 presents probit estimates of the probability of PQS families being victimized by the Great East Japan Earthquake. Regression results with full sample (left column) shows that female and married respondents are significantly more likely to be victimized by the earthquake. For other variables, estimated marginal effects are consistent with the data shown in Table 1, but are not statistically significant. When we restrict our sample to households living in quake-hit areas, numbering 165 households in the Tohoku region (right column), the results become much clearer and stronger. The age effect is U-shaped, reaching a minimum at about age 50. The families of both young and elderly respondents were more likely to be victimized. This is perhaps because young respondents tend to have small children who are vulnerable to natural disaster, and because elderly are in many cases unable to move quickly out of harm's way.

Annual household income and net financial wealth are both negatively related to the probability of the respondent's family being victimized by the earthquake.⁴ Our findings are also consistent with previous studies (Kahn, 2005; Khandlhela and May, 2006). Household income and wealth can influence natural disaster victimization in a number of ways (Anbarci et al., 2005). Wealthy households are more likely to take earthquake preparedness actions. They often live in homes with good design/construction and self-insure against disaster. Also one might surmise that land in coastal areas was cheaper in the danger zones that are clearly marked by overhead street signs "Tsunami Risk Zone." So lower income households would concentrate in high risk zones while wealthier would live in safer, higher areas. In any case, we find that the massive earthquake does not victimize the rich and the poor alike.

(Table 2 around here)

Post-Quake Changes in Perceived Preparedness for Natural Disaster

Given our empirical results in the previous section, we then examine the post-quake changes in

earthquake preparedness. In this section, we focus on the self-reported, perceived preparedness for natural disaster. The question about perceived disaster preparedness is as follows:

Taken all together, how would you assess your general preparedness for natural disasters including earthquakes on a scale of 0 to 100? Describe your current preparedness for a disaster and that in February (prior to the earthquake), respectively. A rating of 0 represents not prepared at all for a disaster, and a rating of 100 represents complete preparation for a disaster.

Based on the answer to the above question, we define the changes in perceived preparedness before and after the Great East Japan Earthquake (i.e., difference between score at the time of the survey and that in February). The changes in respondent's score of perceived disaster preparedness clearly show that most respondents care more about earthquakes and other natural disasters after March 11. About 60% of all households in the survey reported that they are better prepared at the time of the survey than before, while the rest of households (about 40%) reported that they have not changed their preparedness. This result is expected as Russell et al. (1995) demonstrate that previous disaster experience is associated with preparedness for earthquakes.

Table 3 presents probit estimates of the changes in disaster preparedness after the Great East Japan Earthquake. The dependent variable takes the value of one if the respondent reported that he/she is better prepared at the time of the survey than before and zero otherwise.

(Table 3 around here)

In addition to the basic socio-economic characteristics used in the regression analysis in Table 2, the model also includes several explanatory variables taken from the PQS data. Disaster preparedness prior to March 11 is used to control for the baseline levels of consumers' disaster preparedness. Victimization of one's acquaintances ("any acquaintances struck by the earthquake") can serve as an additional source of information about the extent and severity of the earthquake. Dummy variables for physical damages to respondent's housing/household goods and disaster area pursuant to the "Disaster Relief Act" are used to control for any

direct damages caused by the earthquake. Finally, the 30-year probability of the JMA 6+ earthquake is taken from the website of the Japan Seismic Hazard Information Station (<http://www.j-shis.bosai.go.jp/>) to control for the objective measure of earthquake risk prior to March 11.⁵

The result shows that post-quake preparedness can be predicted by sex, marital status, pre-quake estimates of earthquake probability, baseline preparedness, and acquaintance's earthquake victimization. These results are basically consistent with the previous studies (Russell et al., 1995). An important point here is that there is no relationship between economic variables (income and wealth) and post-quake self-perceived disaster preparedness.

Post-Quake Intentions for Risk Mitigation Activities

In this section, we examine the determinants of post-quake intentions for more specific risk mitigation activities. In addition to the “perceived” disaster preparedness discussed in the previous section, PQS also has questions pertaining to the current and future intention of households to buy insurance and realize seismic retrofitting of their houses. For insurance purchase, the survey gives respondents three choices: (1) already had earthquake insurance prior to the Great East Japan Earthquake; (2) did not have insurance, but plan to purchase it in the future in response to the earthquake, or; (3) do not have insurance and will not buy it in the future. The question about seismic retrofitting is constructed in a similar manner. In the following analysis, we focus on the future intention of the insurance purchase/seismic retrofitting. Households that had earthquake insurance or seismic retrofitting prior to March 11 are omitted from the analysis.⁶

(Table 4 around here)

Table 4 presents probit estimates of the post-quake intentions regarding insurance purchase/seismic retrofitting. Two models include the same set of explanatory variables as in Table 3. For insurance purchase, the following results are obtained. Table 4 shows that people who are female and married are more likely to purchase insurance. These results can perhaps be attributed to the differential attitudes toward risk between men and women, and between married people and singles. Household income and wealth have contrasting

effects on the intention of earthquake insurance. While the post-quake insurance purchase is significantly positively associated with having a higher income, it is negatively associated with household wealth. The positive effect of household income on the probability of insurance purchase can be found in previous studies (Naoi et al., 2010). On the other hand, a negative marginal effect of household wealth can be interpreted as a result of self-insurance, i.e., a wealthy household might decide not to buy insurance and take on the risk of paying for recovery costs in case of massive earthquake. Furthermore, limited insurance coverage and uncertain damage assessment might be another reason to prevent wealthy households from obtaining earthquake insurance. In Japan, the limit of insurance coverage is 50 million JPY for buildings and 10 million JPY for household goods, and claims are adjusted based on damage assessments (100%, 50% and 5%, with no partial payment in between).

Consumer's intention to seismic retrofit their home shares a number of common determinants with insurance purchase. However, there are several notable differences. First, in contrast to intention of purchase insurance, household wealth is significantly and positively related to seismic retrofitting. Second, those who suffered damages to their house due to the recent earthquake are more likely to carry out seismic retrofitting in the future. This is consistent with empirical findings in the literature that people who experience personal losses in a prior event are more likely to engage in preparedness activities for future events.⁷

Conclusion

The Great East Japan Earthquake and subsequent tsunami on March 11 were a reminder of Japan's huge earthquake risk and need for preparedness. The northeastern part of the country along the Pacific Ocean known as Tohoku experienced the largest earthquake ever recorded in Japan and the fourth largest in the world. This magnitude 9 earthquake triggered a massive tsunami that killed about 20,000 people, destroyed 120,000 buildings and damaged a further 220,000 houses. Due to strict building codes, quake specific damage was limited.

The devastating impact of the earthquake, coupled with extensive media coverage, has enhanced consumers' earthquake preparedness even in unaffected areas. This paper uses unique survey data collected after the Great East Japan Earthquake to study how consumers reacted to this catastrophic event. Specifically,

we examine the post-quake changes in earthquake preparedness among households that were not directly struck by the Great East Japan Earthquake. We find that, while self-reported, perceived preparedness for natural disasters has significantly improved—for both the rich and the poor—after March 11, post-quake intentions for more specific risk mitigation activities (insurance purchase and seismic retrofitting) were systematically associated with levels of household income and wealth. High income households are more likely to express an intention to purchase earthquake insurance or to conduct seismic retrofitting after the March 11th earthquake.

Our results suggest that household income (and wealth as well, in case of seismic retrofitting) is an important determinant of affordability of costly mitigation activities, undermining the notion that many people are uninsured or unprotected by choice. Furthermore, if these costly mitigation activities are an effective way to cover or reduce potential losses from future natural disasters, the recent event might have widened the gap in disaster preparedness between rich and poor.

Notes

1. The General Insurance Association of Japan (http://www.sonpo.or.jp/archive/statistics/syumoku/pdf/index/kanyu_jishin.pdf).
2. Ministry of Land, Infrastructure, Transport and Tourism (http://www.mlit.go.jp/jutakukentiku/build/taishin/05jo_kyo.pdf).
3. In the questionnaire, a respondent was asked whether he/her, spouse and/or children, parents, grandparents, other relatives, or other acquaintances were affected directly by the Great East Japan Earthquake (in a “mark all that apply” format). “Victims” here is defined as the respondents who reported that he/her, spouse and/or children were affected directly by the earthquake.
4. Note that we use household income and wealth (as well as other explanatory variables) prior to the earthquake (i.e., taken from the regular survey of 2011 KHPS/JHPS conducted January 2011). Therefore, they do not reflect any influences caused by the Great East Japan Earthquake.
5. See Naoi et al. (2009) for details about this variable.
6. We also estimated the model including those households already insured/seismic retrofitted their home prior to the earthquake, controlling for selectivity bias. Since the results are not qualitatively changed, we omit these results from the analysis. Furthermore, since insurance purchase and seismic retrofitting are clearly associated with homeownership, we also estimated the model based only on homeowners. The results, again, are not qualitatively different.
7. Also because their house was damaged and in need of repair, it would make sense for them to report that any repairs would constitute retrofitting.

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Table 1. Earthquake Victimization and Household Characteristics

(a) Earthquake victimization		(b) Socio-economic characteristics of victims and non-victims		
	% Victimized		Victims	Non-victims
All PQS families	3.7%	Age	57.60	54.06
By region:		%Female	56.5%	53.0%
Hokkaido	2.6%	%Married	83.8%	78.5%
Tohoku	22.5%	Household size	2.98	3.19
Kanto	3.1%	Annual household income		
Chubu	2.3%	(in 10,000JPY)	605.07	681.71
Kinki	1.8%	Net financial wealth		
Chugoku	3.8%	(in 10,000JPY)	587.74	699.98
Shikoku	1.5%			
Kyushu	3.7%			

Notes: All individual/household characteristics are measured prior to March 11.

Table 2. Probit Estimate of Victimization in March 11th Earthquake

Victimized by March 11th Earthquake (= 1 if any family member victimized)	Full sample		R's in Tohoku region	
	Marginal Effect	(S.E.)	Marginal Effect	(S.E.)
Age/100	0.0246	(0.1479)	-3.1974	(1.7495) ⁺
(Age/100) ²	0.0356	(0.1350)	2.7740	(1.6050) ⁺
Female	0.0133	(0.0054) *	0.0235	(0.0673)

Married	0.0160	(0.0055)	*	0.1440	(0.0698)	+
Household size	-0.0028	(0.0023)		0.0377	(0.0237)	
Annual household income (in million JPY)	-0.0004	(0.0006)		-0.0413	(0.0129)	**
Net financial wealth (in million JPY)	-0.0002	(0.0001)		-0.0038	(0.0026)	
Log likelihood	-525.36			-79.74		
Pseudo R ²	0.1213			0.1380		
N	3,672			165		

Notes: **, * and + indicate that the estimated marginal effects are significant at 1%, 5% and 10% levels, respectively. Robust standard errors are in the parentheses. All explanatory variables are measured prior to March 11. Respondent's education, region, and city size are controlled but omitted from the results.

Table 3. Probit Estimate of Changes in General Disaster Preparedness After March 11th

Changes in disaster preparedness (= 1 if care more about natural disaster after March 11)	Full sample	
	Marginal Effect	(S.E.)
Age/100	-0.7250	(0.4773)
(Age/100) ²	0.6430	(0.4510)
Female	0.0590	(0.0183)
Married	0.0746	(0.0240)
Household size	-0.0015	(0.0072)
Annual household income (in million JPY)	0.0025	(0.0021)
Net financial wealth (in million JPY)	-0.0001	(0.0004)
30-year probability of the occurrence of JMA 6+ earthquake	0.1773	(0.0671)
Disaster preparedness prior to March 11 (0 to 100)	-0.0031	(0.0004)
Any acquaintances (other than R's family) struck by the earthquake	0.0456	(0.0183)
Physical damage caused by the March 11 Earthquake		
To house	(Omitted category)	
To household goods	0.0908	(0.0689)
To both house and household goods	0.0700	(0.0811)
None damaged	-0.0215	(0.0632)
Disaster area (pursuant to the “Disaster Relief Act”)	0.0751	(0.0560)
Log likelihood	-2159.72	
Pseudo R ²	0.0775	
N	3,455	

Notes: **, * and + indicate that the estimated marginal effects are significant at 1%, 5% and 10% levels, respectively. Robust standard errors are in the parentheses. Respondent's education, region, and city size are controlled but omitted from the results. All socio-economic characteristics (age, sex, marital status, household size, income and wealth) are measured prior to March 11.

Table 4. Risk Mitigation Activities after March 11

Intention for insurance purchase / seismic retrofitting (= 1 if plans to have purchase insurance / seismic retrofitting after March 11)	Insurance Purchase		Seismic Retrofitting	
	Marginal Effect	(S.E.)	Marginal Effect	(S.E.)
Age/100	-0.2882	(0.6158)	-0.3167	(0.3726)
(Age/100) ²	0.1890	(0.5910)	0.4020	(0.3490)
Female	0.0764	(0.0237) **	0.0401	(0.0146) **
Married	-0.0173	(0.0304)	-0.0335	(0.0199) +
Household size	0.0190	(0.0096) *	0.0172	(0.0055) **
Annual household income (in million JPY)	0.0050	(0.0029) +	0.0027	(0.0016) +
Net financial wealth (in million JPY)	-0.0015	(0.0005) **	0.0007	(0.0003) *
30-year probability of the occurrence of JMA 6+ earthquake	-0.0294	(0.0905)	0.0264	(0.0527)
Disaster preparedness prior to March 11 (0 to 100)	0.0010	(0.0005) *	0.0014	(0.0003) **
Any acquaintances (other than R's family) struck by the earthquake	-0.0189	(0.0241)	0.0209	(0.0149)
Physical damage caused by the March 11 Earthquake				
To house	(Omitted category)		(Omitted category)	
To household goods	0.0908	(0.0689)	-0.0663	(0.0375)
To both house and household goods	0.0700	(0.0811)	0.1629	(0.0828) *
None damaged	-0.0215	(0.0632)	-0.0912	(0.0547) +
Disaster area (pursuant to the "Disaster Relief Act")	0.0751	(0.0560)	-0.0293	(0.0354)
Log likelihood	-1304.68		-1240.26	
Pseudo R ²	0.0309		0.0461	
N	1,979		2,868	

Notes: **, * and + indicate that the estimated marginal effects are significant at 1%, 5% and 10% levels, respectively. Robust standard errors are in the parentheses. The sample is households without earthquake insurance/seismic retrofitting prior to March 11. Respondent's education, region, and city size are controlled but omitted from the results. All socio-economic characteristics (age, sex, marital status, household size, income and wealth) are measured prior to March 11.