How does risk preference change?
Evidence from the 2016 Kumamoto earthquake[1]

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Abstract

In this study, we investigate how individuals' risk preferences change after a natural disaster using the case of the 2016 Kumamoto Earthquake in Japan. Traditionally, general economic models have assumed that risk preference is stable over lifespan. While recent empirical studies have reported that negative shocks such as natural disasters can alter risk preference, there is little consensus on its direction. Utilizing the nationally representative panel surveys in Japan, we find that respondents who experienced greater intensity of the earthquake became more risk tolerant after the earthquake. In addition, the impact of the earthquake on risk preference is consistent across both gain and loss domains.

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1. **Introduction**

Risk preferences are an important factor in individual decision-making about economic behavior including consumption and savings. General models in economics have assumed that individual preferences are constant over their lives (see, e.g., Stigler and Becker. 1977). On the other hand, some papers suggested that individual preferences can be changed by shocks, such as financial crises, trauma from conflict, disasters, and pandemics (e.g., Akesaka. 2019; Hanaoka et al. 2018; Tsutsui and Tsutsui-Kimura. 2022). However, as discussed in Schildberg-Hörisch. (2018), it remains unclear how natural catastrophes or violent conflicts affect preferences.

In this study, we empirically examine how a natural disaster changed people's risk preference calculated in both gain and loss domains using the case of the 2016 Kumamoto Earthquake. Besides, we analyze whether changes in risk preference are temporary or permanent. To the best of our knowledge, this is the first study to examine the change of risk aversion in both gain and loss domains in the context of the impact caused by an earthquake in Japan. As Reynaud and Aubert. (2020) suggested, the difference in the effect of negative shock on risk aversion between loss and gain domains could explain the lack of consensus in previous literature. Thus, we tested our findings using different methods of measuring risk aversion.

Furthermore, we attempted to investigate the change of individual preference using the example of the 2016 Kumamoto earthquake which is a type of epicentral earthquake as opposed to the Great East Japan Earthquake in 2011, a subduction-zone earthquake. The epicentral earthquake refers to an earthquake that occurs directly beneath urban areas (Japan Meteorological Agency, n.d.). As previously mentioned, there is little consensus on how a negative shock affects people's preferences. Therefore, it is crucial, especially for countries that frequently experience disasters such as Japan, to study how various disasters affect individuals' preferences.

Our analysis mainly leads to the following three findings. First, our estimation results show that respondents who experienced higher intensity of earthquake became more risk-tolerant after the earthquake. Second, the effect of the 2016 Kumamoto earthquake on risk preference are consistent across both gain and loss domains. Third, the effect on risk preference disappeared five years after the earthquake, which implies that the effect is not persistent.

2. Data & Variables

2.1. Panel Survey

We mainly used the Japan Household Panel Survey on Consumer Preferences and Satisfaction (hereinafter referred to as JHPS-CPS) administered by the Institute of Social and Economic Research of Osaka University. This survey applied two-stage stratified random sampling using two types of criteria: geographical area and city size, and it is collected using self-administered questionnaires, which are hand-delivered to and picked up from the selected households every February.

2.2. The data on the seismic intensity of the 2016 Kumamoto earthquake

The 2016 Kumamoto Earthquake occurred on 16th April 2016 with a moment magnitude Mw of 7.3 (Japan Meteorological Agency. 2018). The earthquake triggered secondary disasters such as landslides and destroyed infrastructure. To capture the shocks by the earthquake, we focus on the seismic intensities measured for the main earthquake on April 16th, 2016[1]. In our panel survey, we are able to detect the geographic information of the respondents only at the municipal level. Thus, we also used the intensity level by municipal levels.

2.3. Measurement of risk aversion

This study uses a hypothetical lottery question in the JHPS-CPS to elicit the individuals' risk preferences[2]. Following Hanaoka et al. (2018), we define the reservation price as the mean of the two prices around the switching point. Following Cramer et al. (2002), risk preferences are calculated as,

$$transformedprice = 1 - \lambda/\alpha X$$

where X and α indicate the prize of the lottery, and the probability of winning the lottery, respectively; and λ denotes the reservation price.

2.4. Descriptive statistics

The mean of risk aversion calculated as a transformed price is approximately 0.77. Our main explanatory variable, earthquake intensity, takes the value from zero to 5.8 and the mean is 1.22. Regarding socioeconomic characteristics, the average age of our final sample is 57.4, 52.7% are female, and 69% of them are currently employed. In addition, the mean of annual household income is 6.1 million JP YEN.

3. Empirical Strategy

Using the variation of earthquake intensity, we compare the average risk preference between individuals who were not affected by the disaster and individuals who were affected.

Let Y_{ijt} be a degree of risk aversion for individual i at municipality j at year t, and Δ be the difference of value between pre-treatment period and post-treatment period; our basic model can be described as follow:

$$\Delta Y_{ijt} = \Delta\alpha + \beta\Delta intensity_{jt} + \gamma\Delta Z_{ijt} + \Delta\epsilon_{ijt},\ (1)$$

where $intensity_{jt}$ be a seismic intensity of the Earthquake at municipality j at year t;

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1 We obtained the data on seismic intensity from (Japan Meteorological Agency. 2016) and took the average of seismic intensity scale at municipality level.

2 Specifically, the survey captures participants' risk preferences through the question of lottery choice with a 50 percent chance of winning JPY 100,000 or nothing otherwise. This method was also applied by previous literature to calculate risk preferences (Hanaoka et al. 2018; Sasaki et al. 2017; Tsutsui and Tsutsui-Kimura 2022). The question presents the 8 different options for the lottery price, from JPY 10 in the first row to JPY 50,000 in the last row. Respondents choose one option out of two: "buy a lottery ticket at the price" as Option A or "not buy the ticket" as Option B. In this format, by capturing the point at which a respondent switch from Option A to Option B, we can elicit each respondent's preference for risk.

Z_{ijt} indicates time-varying individual characteristics; and ε_{ijt} represents the error term; α denotes the fixed effect of the year.

One possible concern is a nonlinear relationship between earthquake intensity and risk preferences. According to the guidelines of Japan Meteorological Agency (Japan Meteorological Agency. 2009), most people are frightened at the intensity level of 3.5 (*Shindo 4*). Moreover, previous literature mentions the nonlinear relationship around this level (Akesaka. 2019; Hanaoka et al. 2018). Thus, we consider this possible concern in the specification as follows.

$$\Delta Y_{ijt} = \Delta\alpha + \beta_1 \Delta intensity_{jt} + \beta_2 \mathbb{I}[\Delta intensity_{jt} \geq 3.5] + \rho \mathbb{I}[\Delta intensity_{jt} \geq 3.5] \times \Delta intensity_{jt} + \gamma \Delta Z_{ijt} + \Delta\epsilon_{ijt}, (2)$$

Importantly, the estimation of DID assumes that the trends of outcome would be the same in the pretreatment period. We checked the association between earthquake intensity at the location and changes in average risk preferences within the regions from 2013 to 2016[3]. Then, there seems to be no systematic association between them during the pre-treatment period.

4. Result

4.1 How did risk preference change? Estimation results of one year after the disaster.

The main results of the specification (2) are presented in Columns (1) - (3) of Table. 1 show a significant negative relationship between risk aversion and interaction term among full sample. The result implies that respondents who experienced higher than 3.5 on seismic intensity scale, became more risk tolerant after the earthquake.

In addition, we conducted specification (2) focusing on the sample who lived in the Western Japan area to address the issue of regional heterogeneity. If regional heterogeneity affects the trend of the outcome, the estimates can be biased. In particular, Japan experienced the Great East Japan Earthquake in 2011, which centered on Eastern Japan. Hanaoka et al. (2018) reported that the Great East Japan Earthquake affected people's risk aversion until 2016. Thus, it is crucial to consider heterogeneity across regions in Japan. However, our estimate doesn't change even after limiting the sample within Western Japan. (Table 1. (4) - (6)). [4]

4.2. Differences in the measurement of risk aversion

Moreover, we investigate whether the differences across the domains of risk aversion can change the estimates.

The results of regression analysis for full sample using the risk preference in the loss domain as a dependent variable[5] are presented in Column (7) - (9) of Table 1. The result shows that

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3 Due to the interruption of surveys in 2014 and 2015, we compared the changes of risk aversion between 2013 and 2016.

4 As robustness check, we run the regression with the additional socioeconomic factors as control variables, such as the change of household income and the change of employment status. The estimates almost remain unchanged even after they have been added.

5 We define risk aversion in loss domain as estimated absolute risk aversion. Following Cramer et al. (2002), Tsutsui and Tsutsui-Kimura. (2022), and Sasaki et al. (2017), absolute risk aversion is calculated as: $absoluteriskaversion = \lambda - \alpha Z/[(1/2)(\alpha Z^2 - 2\alpha Z + \alpha^2)]$

Table 1. Estimation Result

	Dep var: risk aversion in gain domain (transformed price)			**Dep var:** risk aversion in gain domain (transformed price)			**Dep var:** risk aversion in loss domain		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
intensity	-0.002	0.000	0.000	-0.005	-0.006	-0.003	0.000	0.000	0.000
	(0.003)	(0.005)	(0.004)	(0.004)	(0.006)	(0.004)	(0.000)	(0.000)	(0.000)
I[intensity≧3.5]		0.252			0.244			0.016	
		(0.060)			(0.061)			(0.006)	
intensity × I[intensity≧3.5]		-0.064			-0.058			-0.004	
		(0.014)			(0.015)			(0.001)	
I[intensity≧4]			0.427			0.421			0.009
			(0.007)			(0.011)			(0.000)
intensity × I[intensity≧4]			-0.094			-0.091			-0.003
			(0.004)			(0.004)			(0.000)
Constant	0.003	0.002	0.002	0.011	0.010	0.007	0.000	0.000	-0.000
	-0.007	-0.007	-0.007	-0.011	-0.011	-0.011	0.000	0.000	0.000
Observations	1,639	1,639	1,639	607	607	607	1,438	1,438	1,438

Notes: This table describes the results of running specification (2) between 2016 and 2017. intensity is the seismic intensity of the 2016 Kumamoto Earthquake measured at each municipality. Each of the dependent variables is described in the first row. Columns (4) - (6) represent the regression result among the samples who lived in Western Japan. We applied cluster-robust standard error as standard error, which is described in parentheses

Respondents who suffered from higher intensity of the earthquake became more risk tolerant after the earthquake, which is consistent with the case of risk aversion in the gain domain.

4.3. Is the impact long-lasting? Estimation results of five years after the disaster.

An additional question is how long the effect lasts. To investigate whether the effect remains for a long period, we conducted the regression (2) with the dependent variable measured in 2021. Then, the estimates became insignificant in the estimation, which implies that the significant association between the seismic intensity and the change in risk preference is not long-lasting.

5. Discussion

One possible mechanism behind the decrease in aversion is that natural disasters might alter people's psychological status. The literature in psychology and behavioral economics suggests that emotions, such as fear are associated with preferences for risks (e.g., Sato and Kitamura. 2012). Therefore, we checked whether emotional status changed among the samples highly affected by the earthquake.

The estimates show those who live in the regions which were measured intensity level higher than 3.5 tend to increase sleep deprivation. Previous literature reported that sleep loss can lead people to make risky choices (e.g., Harrison and Horne. 2000). The decrease in sleeping might be one of the possible causes to make residents in the specific location more risk tolerant.

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where Z is the value of loss, α denotes the probability of the occurrence of the loss, and λ is the willingness to pay for the insurance at the switching point.

6. Limitation

This study has several limitations. First, since the survey used in this study has been interrupted in 2014 and 2015, the exposition of the rationale underlying the common trend assumption may exhibit inadequacies in its thoroughness and clarity. Second, while we tried to discuss the mechanism behind the empirical results using psychological variables and the measure of risk preference, we cannot provide sufficient evidence to explain the result. Third, since we can detect respondent's geographic information only at municipal level, we cannot fully capture the variation of the exposure toward damages at individual levels.

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