Experience of technological and natural disasters and their impact on the perceived risk of nuclear accidents after the Fukushima nuclear disaster in Japan 2011: A cross-country analysis.

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Abstract

This paper uses cross-country data compiled immediately after the Fukushima nuclear accident to investigate how the experience of such disasters affects the perception of the risk of nuclear accidents. Estimation results show that the perceived risk of a nuclear accident is positively associated with experiencing technological disasters but not with that of natural disasters.

Keywords: Technological disaster, Natural disaster, Nuclear accidents, Risk, Fukushima accidents, Perception, Bayesian learning

JEL classification: D83, D84, Q54

1. Introduction

The devastating earthquake that occurred in Japan on March 11, 2011 was followed by a tsunami that ultimately crippled the Fukushima Daiichi nuclear power plants. These unprecedented disasters drew public attention from around the world. A G8 Summit was held 2 months after the Japanese disaster, and countries agreed to join forces in an effort to promote tighter international standards for nuclear safety.

A number of studies have previously considered perceptions and responses regarding low-probability events (Kunreuther and Pauly, 2004). To experience a natural disaster may influence individual risk beliefs through the updating of one's risk level. From the viewpoint of rational Bayesian learning, one would expect perceived risk to increase after experiencing a disaster. The Japanese disaster shows that nuclear disaster can be caused not only by human error with regard to technology, but also by unexpected natural disasters. Therefore, one's perception regarding the risk of nuclear accidents appears to depend not only the experience of technological disasters but also on that of natural disasters.

It has been argued that people who have experienced a disaster do not sufficiently update their perceived level of risk (Tversky and Kahneman 1974; Viscurrsi and Zeckhauser 2006). As noted by Zeckhauser (1996, p. 115), "Neither humans nor society deal effectively with information, particularly probabilistic information." Thus, the issue of the relationship between the subjective risk of a nuclear accident and experiencing natural and technological disasters appears to remain open to discussion. The perceptions of citizens' regarding risk do have an influence on policy concerning disasters (Viscurrsi and Zeckhauser, 2006; Kahn, 2007). Thus, it is worth exploring the relationship between them.

By using cross-country data collected immediately after the disaster in Japan in 2011, this paper aims to investigate how the experience of a technological disaster effects perceptions regarding the subjective risk of a nuclear accident.

2. Data and Model

Definitions and the descriptive statistics of variables used in this paper are presented in Table 1. Immediately after Japan's natural disaster, WIN-Gallup International (2011) conducted a survey in 47 countries regarding nuclear energy. The survey included the following question: "How high or low is your concern about the possibility of a nuclear incident in your country?" There were 5 response choices: "very high", "high", "medium", "low", and "very low". The WIN-Gallup International (2011) survey provides the responses for each county. Based on the WIN-Gallup survey data, I calculated the rate of respondents that believed there is a high (or very high) possibility of a nuclear accident—dependent variable PACCI. In addition, an alternative measure, PACCI2, is the rate of those respondents who believe there to be a very high possibility of nuclear accident. PACCI (or PACCI2) measures the subjective risk of a nuclear accident and is, therefore, used as a dependent variable. A key independent variable is the number of technological disasters that have occurred (in the respondent country) since 1990 (TDIS), which captures the experience of technological disasters. A cursory examination of Figure 1 shows that TDIS is positively associated with PACCI. The Fukushima nuclear accident was triggered by an earthquake and tsunami. Hence, the risk of natural disaster appears to be related to the perceived risk of a nuclear accident. Therefore, the experience of a natural disaster, a further independent variable, is captured by the number of natural disasters that have occurred (in the respondent country) since 1990 (NDIS).[1] For a closer examination of the relationship, regression estimations were conducted. The estimated function takes the following form:

$$PACCI\ (\text{or } PACCI2)_i = \alpha_0 + \alpha_1 Ln(TDIS)_i + \alpha_2 Ln(NDIS)_i + \alpha_3 Ln(GDP)_i + \alpha_4 Ln(POP)_i + \alpha_5 Ln(GOVSIZ)_i + \alpha_6 NUCLE_i + e_i,$$

where PACCI (or PACCI2) represents the subjective risk of a nuclear accident in country i, α represents regression parameters, and e is an error term. With the exception of the key variables explained earlier (TDIS and NDIS), the following control variables were included as independent variables. Economic factors were captured by population (POP), GDP per capita (GDP), and the size of government (GOVSIZ).[2] The greater the number of nuclear energy plants in an area, the higher the possibility a nuclear accident. The number of nuclear energy plants (NUCLE) is included to control for this effect[3]. As can be seen in Table 1, the standard deviations of each independent variable are large, thus, heteroscedasticity should be taken into account. To reduce heteroscedasticity, each independent variable, with the exception of NUCLE, is in log form.[4]

It is more likely than not, that nuclear plants are constructed in countries where people perceive there to be a low probability of nuclear accidents occurring. The OLS estimation results above possibly suffer from endogeneity bias because a reverse causality occurs between the dependent variable and independent variable (NUCLE). For the purpose of controlling for this bias, instrumental variables were used to conduct

[1] TDIS and NDIS were obtained from the International Disaster Database http://www.emdat.be (accessed April 30, 2011).
[2] The data was sourced from the Penn World Table (PWT 6.3). It is available at http://pwt.econ.upenn.edu/ (accessed 28 March 2011).
[3] POP, GDP, and GOSIZ are the values for 2007. NUCLE is the value for 2011.
[4] NUCLE is 0 in some countries where no nuclear plant exists and therefore cannot be expressed as a logarithm.

a GMM 2SLS (generalized method of moments two-stage least square) estimation.[5] Sufficient land area is required to build nuclear plants. Thus, densely populated countries encounter great difficulties in searching for space in which to build nuclear plants. Therefore, land area and population density were used as instrumental variables in the GMM 2SLS estimations. The data for the instrumental variables were sourced from World Development Indicators.[6]

3. Results

The estimation results for OLS are exhibited in Table 2. The results with PACCI as the dependent variable are presented in columns (1) and (2), and those for PACCI2 are shown in columns (3) and (4). The results of the GMM 2SLS estimations are shown in Table 3. The sample size was only 37 and therefore considered small. Thus, the jackknife method was used to calculate the standard error to ensure that the results were not spurious.

In Table 2, the results for Ln(TDIS) yielded the predicted positive signs, and were statistically significant in all estimations. The absolute values of Ln(TDIS) were approximately 15.4 and 15.1 in the PACCI estimation for columns (1) and (2), respectively, and 10.7 and 10.4 for PACCI2 in columns (3) and (4), respectively. These results imply that a 1% increase in TDIS increases PACCI by approximately 15%, whereas a 1% increase in TDIS increases PACCI2 by about 10%. In contrast, NIDS was not statistically significant although NDIS did produce the anticipated positive sign.

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[5] The GMM estimator allows for heteroscedasticity and brings efficiency gains in the presence of heteroscedasticity (Greene 2008, Ch. 15). This is why I used the GMM 2SLS rather than the 2SLS model.

[6] The data are available from the World Bank website: http://databank.worldbank.org/ddp/home.do (accessed 28 March 2011).

With the exception of POP, the other control variables were not statistically significant in all estimations.

With regard to the GMM 2SLS estimation results exhibited in Table 3, an over-identification test was used to test for exogeneity in the instrumental variables. Test statistics were not significant in columns (1) and (2) and, therefore, do not reject the null hypothesis that the instrumental variables are uncorrelated with the error term. This suggests that the instrumental variables are valid. TDIS continued to yield a positive sign and be statistically significant in columns (1) and (2). Its absolute values were 14.1 for PACCI and 9.62 for PACCI2, which are similar to those shown in Table 2. On the whole, the estimation results for TDIS did not change after controlling for endogeneity bias. Thus, from the results of Tables 2 and 3, I propose that the experience of a technological disaster increases the perceived risk of a nuclear accident.

The event that occurred in Fukushima is regarded as not only a natural disaster (tsunami and earthquake) but also a manmade disaster (nuclear accident). The Fukushima accident is thus regarded as a complex disaster. Furthermore, never before in history had people experienced such a devastating combination of nuclear accident and natural disaster, although previous manmade nuclear accidents such as Chernobyl and Three Mile Island had inflicted terrible harm. Despite the growing number of studies concerning natural disasters researchers have not yet investigated how natural disasters impact on manmade disaster—there has been no analysis regarding how people respond to such a complex disaster. Thus, this paper will be the first to investigate this matter, and as such, the findings of this paper are of value to the literature on behavioral economics and risk preferences.

People who have frequently experienced previous manmade disasters are more moderate in their response to the Fukushima accident, even if they have never been directly affected by such disasters. This suggests that the development of the mass media and its ability to disseminate news and information about the disaster immediately after its occurrence has influenced people's perceptions and views. Consequently, policy regarding nuclear power is expected to be influenced. This shows that even when a disaster occurs in a distant location and has no physical impact on a person's health, it can still have a critical influence on their views and, in turn, the direction of policy. In countries with less developed mass media, information regarding unforeseen events such as disasters is updated directly through their direct experience. However, through the development of media sources such as the internet, people can more easily obtain information about disasters in distant locations. Therefore, information can be updated not only through direct experiences, but also through indirect experiences. It follows from this that people more frequently "experience" disastrous events and hence information updates become more frequent too. Consequently, the learning effect will have a greater impact on their decision-making when the media coverage is more extensive. I interpret this as implying that the development of media has a critical influence on the learning process. The effects of such media coverage regarding low-probability events should be taken into account in the field of the theory of behavioral economics.

4. Conclusions

WIN-Gallup International conducted a cross-country survey on views regarding nuclear energy immediately after the Fukushima nuclear accident in Japan. Using this data, the present paper explored how the experience of a technological disaster affects the perceived risk of nuclear accidents. An analysis of the data has found that the experience of a technological disaster increases the perceived risk of a nuclear accident, whereas the experience of a natural disaster does not affect perceptions of risk. From this finding, I derive the argument that media coverage regarding low-probability disastrous events leads people to more frequently “experience” these events. Consequently, information updates become more frequent and so the learning effect has a greater influence on their decision-making.

The central aim of this paper was to examine people’s perceived risk response to Japan’s devastating and complex disaster event of tsunami, earthquake, and nuclear accident. However, the data used in this paper is not individual-level data and the sample size is very small. For a closer examination and a robustness check of the findings in this paper, richer individual-level data are required as well as further estimations. This remaining issue will be addressed in future studies.

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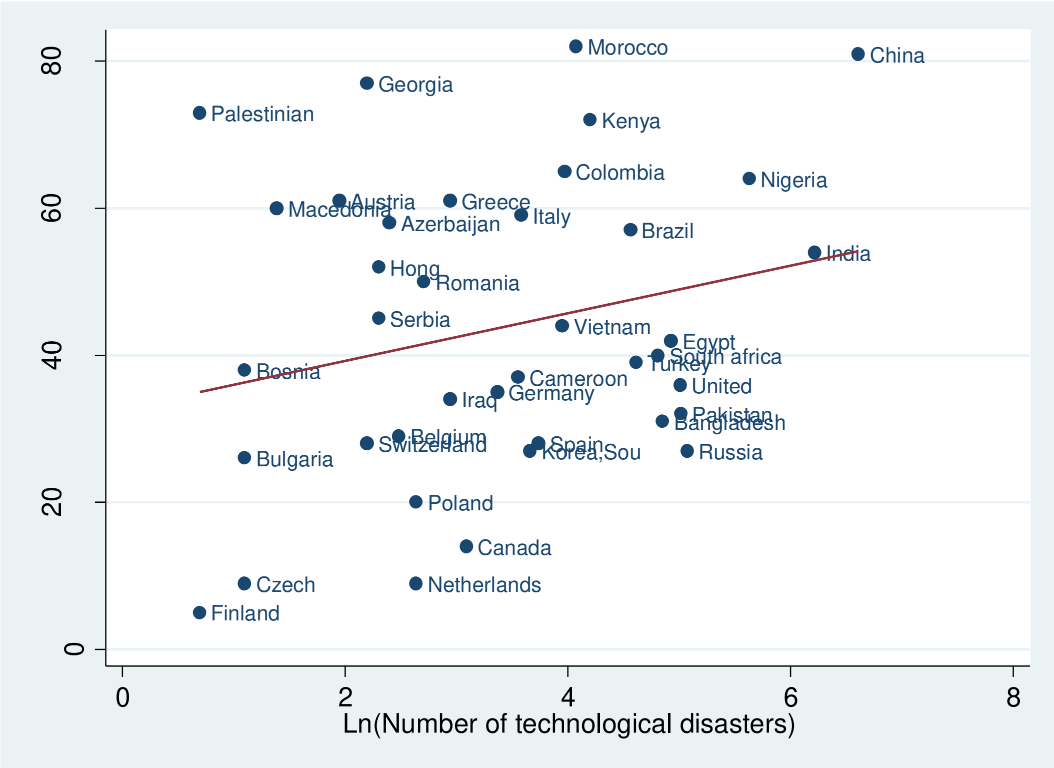

Figure 1. Association between the experience of technological disasters and the perceived risk of nuclear accidents.

Table 1 Definition of variables and descriptive statistics

	Definition	Mean	Max	Min	Standard deviation
PACCI	Rate of respondents who believe that the possibility of a nuclear accident is high (or very high) (%)	42.0	82	5	21.0
PACCI2	Rate of respondents who believe that the possibility of a nuclear accident is very high (%)	20.1	48	1	13.7
TDIS	Total number of technological disasters since 1990	81.3	744	2	144.0
NDIS	Total number of natural disasters since 1990	74.7	502	1	109.4
GDP	GDP per capita (million dollars)	1.83	4.55	0.21	1.44
POP	Population (million)	110.9	1321.8	0.3	267.8
GOVSIZ	Government size (Government expenditure/GDP) (%)	16.2	59.6	3.24	9.01
NUCLE	Number of nuclear plants.	8.41	105	0	18.9

Table 2 OLS estimation

	(1) Dependent variable: PACCI	(2) Dependent variable: PACCI	(3) Dependent variable: PACCI2	(4) Dependent variable: PACCI2
Ln(TDIS)	15.4*** (3.04)	15.1** (2.61)	10.7*** (2.81)	10.4** (2.57)
Ln(NDIS)	6.05 (1.64)	7.04 (1.68)	1.99 (0.71)	2.70 (0.85)
Ln(GDP)	–3.17 (–0.76)	–2.31 (–0.50)	–2.17 (–0.86)	–1.55 (–0.56)
Ln(POP)	–16.4*** (–3.08)	–15.8*** (–2.75)	–9.74** (–2.42)	–9.32** (–2.14)
Ln(GOVSIZ)	6.97 (0.83)	6.94 (0.79)	7.28 (1.44)	7.26 (1.35)
NUCLE		–0.10 (–0.48)		–0.07 (–0.48)
Constant	149.0** (2.42)	133.2* (1.90)	79.0** (2.17)	67.7 (1.59)
Adjusted R^2	0.25	0.23	0.30	0.28
Observations	37	37	37	37

Note: Values in parentheses are t-statistics calculated by standard errors obtained using the jackknife method. *, **, and *** denote significance at the 10%, 5% and 1 % levels, respectively.

Table 3 GMM 2SLS estimation

	(1) Dependent variable: PACCI	(2) Dependent variable: PACCI2
Ln(TDIS)	14.1**	9.62*
	(2.09)	(1.88)
Ln(NDIS)	9.17	5.13
	(1.36)	(0.91)
Ln(GDP)	–0.48	0.64
	(–0.08)	(0.15)
Ln(POP)	–14.3**	–7.91
	(-2.13)	(–1.37)
Ln(GOVSIZ)	7.14	6.70
	(0.68)	(1.04)
NUCLE	–0.35	–0.34
	(–0.60)	(–0.71)
Constant	97.2	29.6
	(1.01)	(0.39)
Over-identification test	0.66 P=0.41	0.16 P=0.68
Adjusted R^2	0.26	0.26
Observations	37	37

Note: Values in parentheses are t-statistics calculated by the robust standard errors obtained using the jackknife method. * and ** denote significance at the 10% and 5% levels, respectively. Instrumental variables are population density and land size. The Sargan test was used for the over-identification test.