



Changes in risk perceptions before and after nuclear accidents: Evidence from Japan



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ABSTRACT

We quantitatively analyzed changes in residents' perceptions of the net benefits derived from the Kashiwazaki–Kariwa nuclear power station (KK) before and after the accident at the Fukushima Daiichi plant (FD) following the Great East Japan Earthquake on March 11, 2011. Employing data from two surveys—conducted in January 2010 and December 2011 before and after FD accident, respectively—we found that KK's perceived net benefits declined after the FD accident. This decline resulted from changes in respondents' relative weightings of KK's costs and benefits rather than heightened expectations of future nuclear accidents. We also found that residents living near nuclear facilities are more concerned about health risks from nuclear accidents than the likelihood of such accidents caused by human error. We suggest that a more effective policy entails changing people's relative weighting of nuclear facilities' costs and benefits by protecting lives through enhanced evacuation planning and post-disaster support for rehabilitation, although Japan's current nuclear power policy aims to assuage people's risk perceptions by reducing the probability of nuclear accidents to zero.

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1. Introduction

In this study, we quantitatively analyzed changes in residents' perceptions of net benefits derived from the Kashiwazaki–Kariwa nuclear power station (KK) before and after the accident at the Fukushima Daiichi plant (FD) following the Great East Japan Earthquake on March 11, 2011. When they accept nuclear facilities nearby, residents gain benefits such as tax revenues, subsidies, or job opportunities. In contrast, a price such as health or damage to businesses' reputation arises if the facility is not safely operated.

KK facilities are located in the city of Kashiwazaki and the village of Kariwa in Niigata Prefecture—approximately 215 km west–northwest of the Tokyo Metropolitan Government building and approximately 215 km south of FD.¹ The similarity in distances is coincidental. According to Tokyo Electric Power Co. (TEPCO), the installed capacity of KK's seven reactors is 8212 MW (output was 29,764 GWh during fiscal 2010). Located on Japan's western coast, KK is separated from Tokyo and Fukushima on the east coast by a

mountain range that runs the length of the Japanese archipelago, causing people to perceive a greater distance from KK than the actual linear distance.

We conducted surveys in January 2010 before the FD accident and in December 2011 after the accident, which are referred to as the 2010 survey and the 2011 survey, respectively. The questionnaire was sent by post to residents living near KK. We categorized survey respondents as residents of Kariwa, Kashiwazaki, and Nishiyama. Response rates for both periods in these three areas were 50–60%.² In May 2005, the town of Nishiyama was incorporated into the city of Kashiwazaki. Here we refer to this part of Kashiwazaki—previously known as the town of Nishiyama—as Nishiyama and to all remaining areas as Kashiwazaki.³

The 2010 and 2011 surveys have nearly identical frameworks. Survey questions primarily attempted to assess residents' attitudes toward nuclear power and identify household attributes. Table 1 summarizes the sample data by residential area and by linear distances from respondents' addresses to KK. Response rates

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¹ Japan's governmental structure comprises the central (national) government, 47 prefectural governments, and nearly 1700 municipalities, which include cities (*shi*), towns (*cho*), or villages (*mura*).

² Kato et al. (2013) reviewed this survey in greater detail.

³ Similar to the former Nishiyama, the former Takayanagi was an independent municipality until it was incorporated into Kashiwazaki in May 2005. We excluded its population in this study.

Table 1
Sampling overview by distance from KK and residential area.

Objective distance (km)	Year 2010			Year 2011		
	Kashiwazaki	Nishiyama	Kariwa	Kashiwazaki	Nishiyama	Kariwa
0–2.5	n/a	n/a	37	n/a	n/a	32
2.5–5	3	51	130	16	32	124
5–10	231	132	18	169	127	12
10–15	140	20	n/a	107	6	n/a
15–20	48	n/a	n/a	6	n/a	n/a
More than 20	12	n/a	n/a	6	n/a	n/a

declined for some questions (e.g., those on income); therefore, the number of effective responses differed among the survey questions.

We noted two anomalies concerning our respondents. First, the 6.8-magnitude Niigata–Chuetsu-oki Earthquake, which occurred off the coast of Kashiwazaki in 2007, damaged the Kashiwazaki and Kariwa areas. Reactors 2–4, and 7 at KK underwent emergency shutdowns during which all power-generation equipment was safely cooled and confined (Fukushima, 2007). Presumably, survey respondents who had lived there for at least three years experienced this event, and KK's adroit management earned their trust. We captured this possibility using dummy variables that take a value of 1 for residents who had lived there three or more years and 0 otherwise.

The second anomaly is that KK powers Tokyo, and respondents are unnecessary exposed to any associated health risks. They purchase electricity from Tohoku Electric Power Company rather than from TEPCO. Therefore, they are ideal subjects from whom to seek opinions on the proximity of potentially high-risk facilities.

2. Literature review

Few nuclear accidents with an International Nuclear and Radiological Event Scale (INES) level of five or higher have affected environments outside the concerned power plant. Accordingly, earlier researchers had few quantitative resources for considering residents' awareness of accidents at their local plants. Therefore, they employed data from surveys on risk at facilities without real accidents.⁴

Kunreuther and Easterling surveyed the propriety of constructing a high-level radioactive waste disposal site at Yucca Mountain in Nevada, U.S., to conduct a logit analysis of residents' approval (Kunreuther and Easterling, 1990). They determined that residents regarded rebates up to \$5000 as insufficient compensation for accepting undesirable goods. Furthermore, Kunreuther and Easterling expanded their earlier study and found that direct compensation (cash) could increase the acceptability of undesirable facilities if residents believed that the facilities posed no risk to future generations (Kunreuther and Easterling, 1996). They noted that it was difficult to increase the acceptability of highly dangerous facilities by offering direct compensation. However, acceptance increased through a combination of indirect compensation (improved administrative services, real estate values, employment, etc.) and expenditure undertaken to foster understanding before querying residents regarding their willingness to accept these facilities.

Hoyt et al. (1992) noted that the more residents knew about nuclear power, the less they were bothered by living near nuclear facilities. Riddell and Shaw (2003) added compensation to the

framework in Hoyt et al. (1992) and found that some peoples' minds could be changed through a compensation effect. Bezdek and Wendling (2005) discovered a positive relation among seven U.S. nuclear facilities and property values and noted that their tax revenues had been critical in upgrading the quality of local schools. Kato et al. (2007) used a 2005 survey formatted almost identically to our 2010 and 2011 surveys to examine the benefits stemming from KK (employment, exemptions from electric power fees, social welfare policies, public facilities, and community pride). These benefits were considered as compensation for accepting the nearby nuclear plant, and they concluded there was an economic compensatory effect based on per capita public revenues (tax revenues and subsidies) related to KK.

Among studies of nuclear accidents in Japan, social surveys by Tsunoda (2001) and Kitada and Hayashi (2000) considered general public awareness regarding the Japan Nuclear Fuel Conversion Co. (JCO) criticality accident in the village of Tokai in Ibaraki Prefecture, which reached INES level 4. JCO, a private company, owned a nuclear fuel-processing facility situated approximately 5 km from the nuclear power plants in Tokai. Radiation from the accident, caused by careless work habits and neglect of procedures, killed two employees among the 677 victims, which included residents. These studies showed the decline in the evaluation of nuclear power in public awareness caused by the accident.

Kitada (2005, 2006) conducted surveys of citizens' attitudes toward nuclear power and compared the results of surveys conducted before and after the JCO accident and the 2004 INES level-2 accident at Mihama Unit 3 (owned by Kansai Electric Power Co.), in which high-temperature steam from a ruptured pipe had killed five and injured six workers though no radiation leakage occurred. Her results indicated that in 1998, 27% of respondents before the JCO accident stated that they "feel great anxiety" about nuclear power. This statistic increased to 36% two months after the accident and reverted to 27% one year afterward. Before the subsequent 2004 Mihama accident, 20% of respondents said that they "feel great anxiety" about nuclear power, and 24% responded identically two months after the accident. This response was less dramatic than that surrounding the JCO accident.⁵

Kitada (2013) conducted a survey after the FD accidents and found that the percentage of respondents who answered "rejection" to a question concerning constructing a nuclear plant in future was 30% at four months and 36% at nine months after the FD accident. This increase is inconsistent with other data, indicating that fewer respondents are averse to nuclear facilities as time passes. In case of the FD accident, negative factors (the difficulty of controlling contaminated water and radiation leaking) increased gradually as time passes. Attitudes toward nuclear power depended on the type and size of the accident and not on whether an accident had occurred.

⁴ Some studies considered how risk perception was formed while facing extreme danger (Riddell, 2009; Sjöberg, 2000; Slovic, 1987). Huang et al. (2010) studied nuclear power plants in China.

⁵ The temporal rise in percentage of respondents stated "feel great anxiety" about nuclear power after accident is statistically significant in the case of JCO (27–36%), but not in the case of Mihama (20–24%).

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