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A case study of economic incentives and local citizens' attitudes toward hosting a nuclear power plant in Japan: Impacts of the Fukushima accident

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Abstract

The attitude of local communities near a nuclear power plant (NPP) is a key factor in nuclear policy decision making in Japan. This case study compared local citizens' attitudes in 2010 and 2011 toward the benefits and drawbacks of hosting Kashiwazaki-Kariwa NPP. The Fukushima accident occurred in this period. After the accident, benefit recognition of utility bill refunds clearly declined, while that of public facilities did not, suggesting the influence of a bribery effect. The negative shift of attitudes about hosting the NPP after the accident was more modest in Kariwa Village, which saw a large expansion of social welfare programs, than in the other two areas, which lacked such a budget expansion. Policy implications of these results regarding the provision of economic incentives in NPP host areas after the Fukushima accident were discussed.

Acknowledgements

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Running headline

Economic incentives and hosting a nuclear power plant

Keywords: nuclear power plant, economic incentive, Fukushima accident

1. Introduction

The series of accidents at the Fukushima Daiichi Nuclear Power Plant (NPP) that followed the Tohoku earthquake and the huge tsunami on March 11, 2011 have accelerated discussions on the safety of nuclear energy in Japan and elsewhere. An April 2011 national opinion poll in Japan showed that 41% of respondents believed that Japan should reduce or abolish the use of nuclear energy, a 13% increase from the figure of 28% in 2007ⁱ (Asahi Shimbun, 2011a). In August 2011, 68% of respondents preferred that Japan gradually reduce its use of nuclear energyⁱⁱ (Asahi Shimbun, 2011b). Nuclear reactors throughout Japan are being shut down for regular maintenance. The Japanese government plans to resume operation of these reactors after completing maintenance, but this is not an easy task. Mainichi Shimbun (2012) reported in March 2012 that 57% of respondents were opposed to reopening these reactors. The Fukushima accident clearly changed people's views on nuclear energy at a national level.

However, the attitudes of local communities that host NPPs may be different from the national view. We have engaged in a case study of the three areas around the Kashiwazaki-Kariwa NPP in Niigata Prefecture. Our focus is on the compensation scheme used by the government to balance the risks of NPPs by providing economic incentives to local communities. This compensation scheme has been thought to be a powerful tool that enables the national government and nine regional-monopolistic utilities in Japan to expand the capacity of nuclear energy. This study compares the attitudes of citizens in the Kashiwazaki-Kariwa area before and after the Fukushima accident toward this compensation scheme. We investigate the following points.

- a. Citizens' attitudes toward the local benefits of hosting the Kashiwazaki-Kariwa NPP
- b. Citizens' attitudes toward the local drawbacks of hosting the NPP
- c. A comparison of the relative size of the local benefits and drawbacks
- d. The relevance of the benefit-drawback comparison to attitudes toward hosting the NPP

The Kashiwazaki-Kariwa NPP is owned by Tokyo Electric Power Company (TEPCO), which is the owner of the tsunami-damaged Fukushima Daiichi and Daini NPPs. The Kashiwazaki-Kariwa NPP has seven boiling-water reactors and is one of the largest NPPs in the

world. Its first reactor went into service in 1985 and its seventh in 1997. The power plant sends almost all the electricity it produces to the Tokyo Metropolitan Area and not to the local communities near the NPP. Fig. 1 shows the map of the area surrounding the Kashiwazaki-Kariwa NPP. The NPP compound is on the boundary between Kariwa Village and Kashiwazaki City. We conducted social surveys in three areas: Kariwa Village, the original territory of Kashiwazaki City before its expansion in 2005, and the former Nishiyama Town. Nishiyama Town was an independent municipality before it merged with Kashiwazaki City (along with Takayanagi Town) in May 2005. Hereafter, these three areas are referred to as “Kariwa,” “Kashiwazaki,” and “Nishiyama,” respectively. The Tohoku earthquake caused a tremor with a five-plus intensity on the Japanese seven-stage seismic scale in these areas. However, the tremor did not physically damage these areas because its epicenter was more than 350 km away. There was no increase in the radiation level in these areas as a result of the radioactive materials released from the Fukushima Daiichi NPP. However, the Fukushima accident should have given local residents a clear indication of the possible social chaos triggered by a severe nuclear accident.

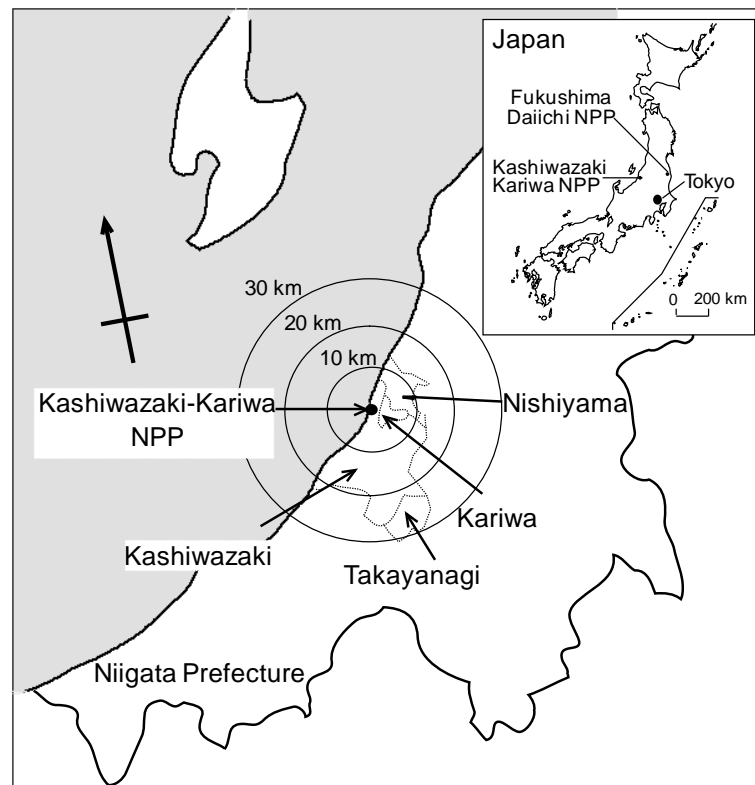


Fig. 1 Map of areas surrounding the Kashiwazaki-Kariwa NPP

In this study, we mainly compare the results of our social surveys conducted in January 2010 and December 2011. We consider three potentially influential factors on the attitudes of local citizens toward the benefits of hosting the Kashiwazaki-Kariwa NPP.

- a. Expenditure of the local government
- b. The bribery effect
- c. The pace of the local economy

The first factor is positively related to the benefits of hosting the NPP, while the other two factors are negatively related. The bribery effect was introduced by Frey et al. (1996) as a decisive factor in the effectiveness of using compensation to influence public opinion about hosting a noxious facility. Although the bribery effect played a significant role before the construction of the facility in their model, we think that this effect is important even after the construction of an NPP.

The remainder of this article is organized as follows. The second section shows the importance of local opinions to Japanese nuclear policy and an outline of the economic incentives provided to areas that host NPPs. The third section summarizes our survey methodology. The fourth section contains our survey results and discussions, and the fifth section concludes the article.

2. Importance of regional opinions and economic incentives to Japanese nuclear policy

Opinions within regions that host or will host an NPP have been a major factor in nuclear policy decision making in Japan. National opinions did not play a significant role prior to the Fukushima accident (Independent Investigation Commission, 2012). According to Miyamoto (2004), who summarized five series of national opinion polls between 1978 and 2001 conducted by the central government, mass media, and research organizations, opposition to the use of nuclear energy never exceeded half of respondents except for in Asahi Shimbun's survey in 1990. During the decade of the 2000s, a series of survey by the central government suggests that national opinions have shifted toward a favorable view of nuclear energyⁱⁱⁱ. Thus, Japan did not encounter overwhelming opposition to nuclear power at the national level until the Fukushima accident. Therefore, the role of local host communities

of NPPs became significant because they experienced many political disputes over the merits and safety concerns of the NPPs well before the Fukushima accident.

There are several cases in which a local advisory referendum and subsequent political decision resulted in the rejection of construction of a new NPP or the introduction of mixed oxide fuel to an existing reactor. A well-known example is the case of Maki Town in Niigata Prefecture (Kuwabara and Kuwabara, 2003). The governor of the prefecture hosting an NPP has the authority to effectively stop utilities from activating their reactors if he or she has strong safety concerns. Although the prefectural governor's authority is based on a gentlemen's agreement between the prefecture and the utility rather than law, it has become a de facto standard that an NPP cannot be operated without consent from the governor. The governor cannot ignore the opinions in the region around the NPP.

Economic incentives are provided to local communities that host an NPP to offset the anxiety about accident risks and to gain support for nuclear expansion policy from these communities (Pickett, 2002). There is much debate about the effectiveness and characteristics of this compensation scheme. Tanaka (2004) is skeptical about the effectiveness of using economic incentives to change the attitudes of local citizens concerning the future hosting of an NPP. In his social survey in the Kanto area, he found perceived risk, not perceived benefit, to be the most important factor influencing the acceptance of an NPP. However, once a community accepted an NPP, the influence of economic incentives became more significant, as Frey et al. (1996) theoretically predicted and empirically observed in the case of the introduction of a nuclear waste repository in Switzerland. The economic value of incentives for the host city of an NPP declines over time in Japan. The huge economic incentives during the construction phase result in the creation of many public facilities and the expansion of public welfare programs. However, the expense incurred in maintaining these facilities and services often cause financial problems later. As a result, some host cities have requested more reactors on their land to help maintain or increase revenues (Fukushima Project Committee, 2012). One example is Futaba Town, which hosts part of the compound of the Fukushima Daiichi NPP. The town's congress issued a plea for the

addition of two new reactors in 1991.

Whether economic incentives can actually cancel out the regional drawbacks of hosting an NPP is a curious question. Yamane et al. (2011) provide a Japanese example based on their hedonic house-rent analysis of the neighborhood communities of NPPs throughout the country before the Fukushima accident. In some plants, they found that the economic welfare of neighborhoods got worse, but in other cases, it did not. Thus, it was possible for economic incentives to offset the drawbacks of hosting an NPP, at least from an economist's perspective. The expansion of medical services in the host community was one of the most effective compensations for risks. There are criticisms of providing huge economic incentives to promote nuclear power. Shimizu (1994) warned that economic incentives do not last forever; however, the social changes caused by the economic incentives made it difficult to manage the local communities in a sustainable way. Kainuma (2011) includes a detailed report of the social changes that have occurred over the past four decades in the local communities that host the Fukushima-Daiichi and Daiini NPPs.

Table 1 shows the economic incentives that a local community hosting an NPP can receive. The first three categories of economic incentives mainly help local governments financially. The fourth category involves broader economic impacts. Among the local taxes, property tax and local corporation tax generally apply to business activities and are therefore not specific to the NPP. Nuclear fuel tax and spent fuel tax specifically apply to the NPP. The Three Laws for Power Source Development, which were passed in 1974 to boost construction of NPPs and other power plants (Yoshioka, 1999; Lesbirel, 1998; Lesbirel, 1990), provide the basis for various national subsidies. Some of the subsidies are specific to nuclear energy, whereas others apply to electricity production in general; however, nuclear energy enjoys favorable treatment. The Agency for Natural Resources and Energy (2010) simulated the value of national subsidies that would be passed to local communities hosting a nuclear reactor with 1350 Mw electricity output. The sum of the subsidies came to 44.9 billion yen during the ten-year preparation and construction period. Another 76.6 billion yen would be paid during the operation of the power plant over the next 35 years. In addition, there are sporadic donations from the utilities to the

local communities. Asahi Shimbun (2011c) reported that TEPCO donated a total of 39.7 billion yen since 1990 to the municipalities and public organizations in the areas where its three NPPs and single construction site are located. In addition to these financial benefits, there are benefits to the local economy from increased job opportunities and the propagation effects of expenditures from the utility and local government.

Table 1 Economic incentives

Category	Financial source	Major examples
Local tax	Utility	Property tax, local corporation tax, nuclear fuel tax, spent fuel tax
Subsidy	National government	Subsidies based on the Three Laws for Power Source Development
Donation	Utility	Construction of public facility, money
Local economy	Utility and government expenditure	Job opportunities, propagation effect

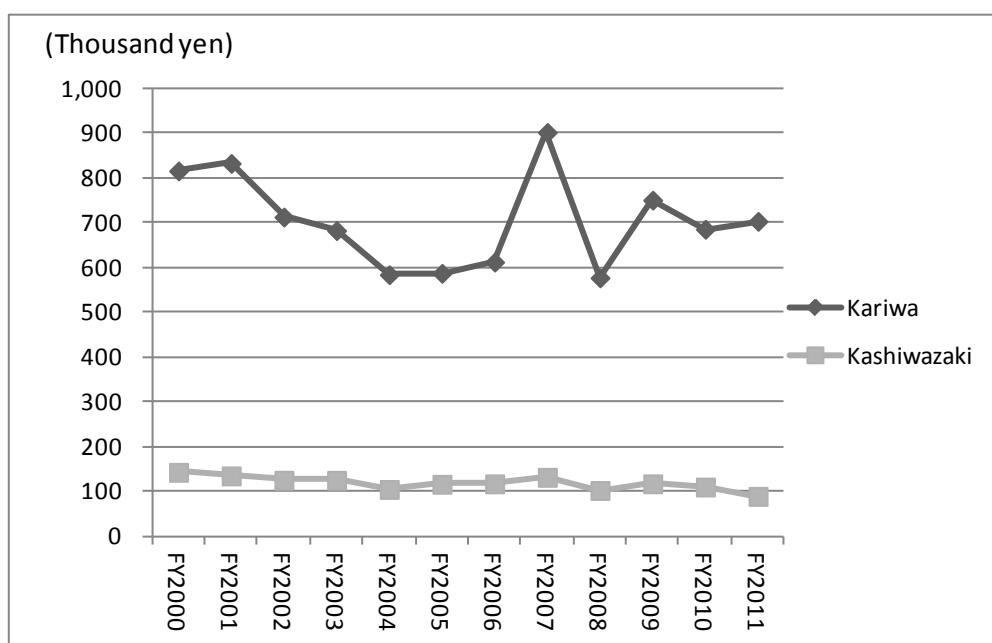


Fig 2 Per-capita economic incentives

Fig. 2 shows the per-capita annual financial incentives in Kariwa Village and Kashiwazaki City between FY2000 and FY2011. We

present the nominal values in Fig. 2 because Japan's consumer price index did not change substantially during this period, showing a 2.7% decline (Statistics Bureau 2012a). It should be noted that Kashiwazaki City in Fig. 2 includes the former Nishiyama Town (along with the former Takayanagi Town) after FY2004. We calculated these values based on information obtained from the local government officials of Kashiwazaki City and Kariwa Village. Revenues from property tax, nuclear fuel tax, and major national subsidies are included in these values. Kashiwazaki City collects a spent fuel tax; however, Kariwa Village does not. We were unable to consider revenues from local corporation tax and TEPCO's donations because these amounts were not fully disclosed to the public^{iv}. The values for property tax after 2006 in Kashiwazaki City and in 2011 in Kariwa Village are estimates based on the history of past values. We believe these to be conservative estimates of property tax revenues, as they ignore additional revenue from the installation of new equipment. The peak in 2007 in Fig. 2 is due to a temporary increase in the national subsidy that was provided after the powerful Niigataken Chuetsuoki (NCO) earthquake hit these areas.

Fig. 2 shows a large difference in amounts between municipalities. The factor that most explains this difference is population. In March 2011, Kariwa Village had a population of 4,870 and Kashiwazaki City a population of 90,766. Thus, the per-capita economic incentive is significantly larger in Kariwa Village than in Kashiwazaki City, although Kashiwazaki City as a whole earned 2.5 times more than Kariwa Village in FY2010. The number of reactors within the territory of each municipality and the ages of these reactors are other important factors.

The single largest source of economic incentives is property tax revenue, which accounted for 41-66% and 23-48% of nuclear-related revenue in Kariwa Village and Kashiwazaki City, respectively, during FY2005-FY2011. These nuclear-related revenues accounted for 37-68% and 15-24% of the total annual revenue of Kariwa Village and Kashiwazaki City, respectively, during the same period. Kariwa Village's dependence on nuclear-related revenue was much higher in FY2011 than is shown in Fig. 2 because a per-capita amount of 430.9 thousand yen was added to its budget from TEPCO's donation to boost

the local economy (Kariwa Village, 2011). Most of the nuclear-related revenue goes to public expenditures through local governments. Only a small fraction goes directly to the households and local factories as monetary compensation. In Kariwa Village and the original Kashiwazaki area, 18.9 thousand yen was paid annually per utility contract to households as a refund during FY 2005 and FY2011. In the Nishiyama area, the amount was 14.2 thousand yen per annum.

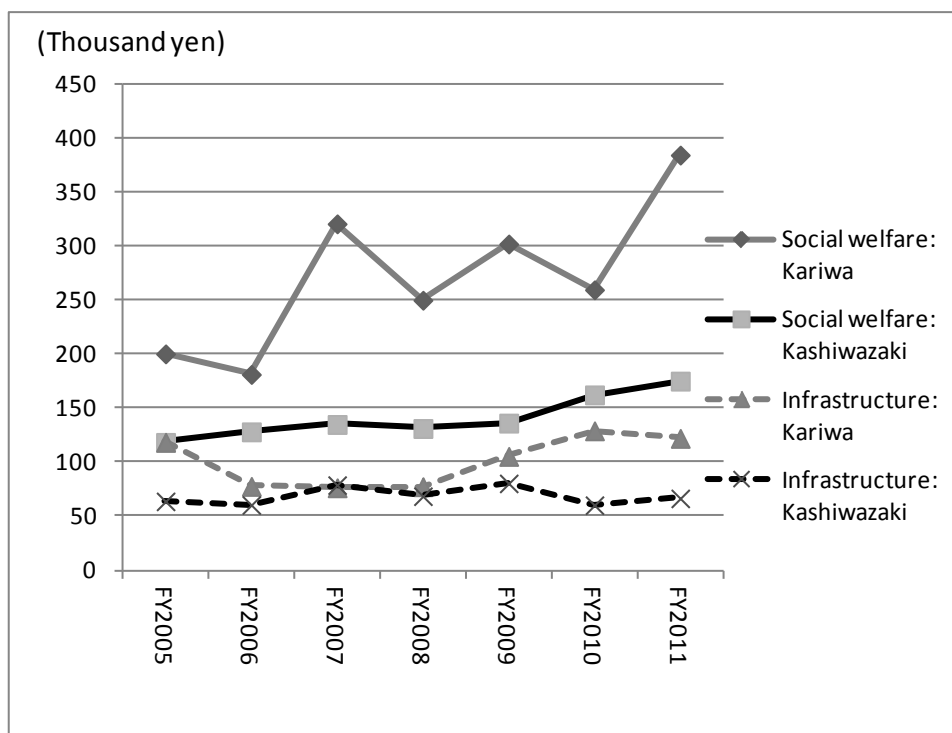


Fig. 3 Per-capita expenditure of local governments

Fig. 3 shows the per-capita expenditure of the local governments as per their budget proposals (Kashiwazaki City, 2011a; Kashiwazaki City, 2005-2011; and Kariwa Village, 2005-2011). Solid lines show the amounts spent on social welfare programs, including medical programs. Dashed lines show the amounts spent on local infrastructure. These expenditures are beneficial to most citizens. Fig. 3 does not contain expenditures such as agriculture subsidies that provide benefits to a specific part of the citizens. Kariwa Village's social welfare programs are strongly affected by the amount of nuclear-related revenue, as shown in Fig. 2 and Fig. 3, which have corresponding peaks in 2007 and 2009. The peak in 2011 in Fig. 3 is due to a large donation from TEPCO that Fig. 2 does not count.

3. Social survey

We conducted a social survey in the Kashiwazaki-Kariwa area regarding nuclear energy in 2010 and 2011. The Fukushima accident occurred between these surveys. Table 2 shows the outline of our samples. Kato et al. (2007) reported results of another survey done in November 2005, a part of which is comparable to our 2010 and 2011 surveys^v. We refer to this 2005 survey when relevant.

We chose three survey areas: Kariwa, Kashiwazaki, and Nishiyama. These areas cover a 10 km radius from the center of the Kashiwazaki-Kariwa NPP. This radius corresponds to the emergency planning zone (EPZ) at the time of the surveys in case of a nuclear accident. Most of the population of the three areas lives within the EPZ, since the area outside of the EPZ features mainly mountainous terrain. The present territory of Kashiwazaki City consisted of three independent municipalities until 2005: the original Kashiwazaki City, Nishiyama Town, and Takayanagi Town. Since all of its territory was located outside the EPZ, Takayanagi was not regarded as a primary target of nuclear disaster prevention before 2005. Thus, we exclude Takayanagi from our sample in consideration of a possible lack of knowledge on nuclear safety among the citizens there. Nishiyama is separated from the original area of Kashiwazaki because of its unique history of economic incentives. There was a large gap in economic incentives between these two areas until 2005. For example, the per-capita amount in Nishiyama in FY2004 was 33 thousand yen, compared to 105 thousand yen in Kashiwazaki. Nishiyama did not host the NPP compound in its territory and therefore did not have substantial access to sources of local taxation and national subsidy schemes.

We randomly sampled citizens aged between 20 and 74 from the official citizens' registry (Jumin Kihon Daicyo). The populations of Kariwa, Kashiwazaki, and Nishiyama in March 2011 were 4,870, 82,580, and 6,230, respectively. Thus, we took a larger sample from Kashiwazaki than from the other two areas. This is not a longitudinal panel, and the samples taken in different years are independent of each other. We mailed a questionnaire to the sampled citizens and asked them to fill it in and mail it back. Table 3 summarizes the personal attributes of the respondents. The columns of age, annual household income, and distance from the Kashiwazaki-Kariwa NPP show the averages of those attributes. Nuclear job shows the proportion of respondents who worked at a nuclear facility or had a family member that worked at the facility at the time of survey. Among the 2011 respondents, 97.3% had lived within the Kashiwazaki-Kariwa area for at least three years.

Table 2 Response rates and number of observations

Survey	Area	Number sampled	No. of returned questionnaires	Response rate
Jan. 2010	Kariwa	350	187	53.4%
	Kashiwazaki	800	435	54.4%
	Nishiyama	350	205	58.6%
Dec. 2011	Kariwa	300	168	56.0%
	Kashiwazaki	600	304	50.7%
	Nishiyama	300	165	55.0%

Table 3 Personal attributes of respondents

Area	Survey	Gender (Male)	Age (year)	Live with child	Annual household income (10 thousand yen)	Nuclear job	Distance ^b
Kariwa	2010	49.7%	56.6(11.6)	32.1%	623.2(355.1)	27.3%	3.51(1.58)
	2011	51.2%	55.2(13.4)	38.9%	610.6(350.8)	21.7%	3.48(1.38)
Kashiwazaki	2010	45.1%	54.1(13.9)	33.8%	559.7(312.3)	15.5%	10.39(3.81)
	2011	53.8%	55.4(13.4)	33.7%	545.6(299.9)	14.2%	9.37(3.14)
Nishiyama	2010	59.0%	55.1(14.1)	29.1%	578.5(317.2)	14.0%	6.53(2.04)
	2011	53.7%	53.9(12.5)	36.8%	538.2(323.4)	12.9%	6.51(1.90)

a. Standard deviation in parentheses

b. Straight distance from a representative point of the Kashiwazaki-Kariwa NPP

Our questionnaire consisted of three sections. The first section asked for respondents' opinions regarding the benefits and drawbacks of nuclear energy. This section also contained comparisons of the benefits and drawbacks specific to the Kashiwazaki-Kariwa area. The second section asked for respondents' opinions regarding nuclear disaster prevention schemes. The third section asked for the personal attributes of the respondents. Most questions were common to the 2010 and 2011 surveys.

4. Results and discussion

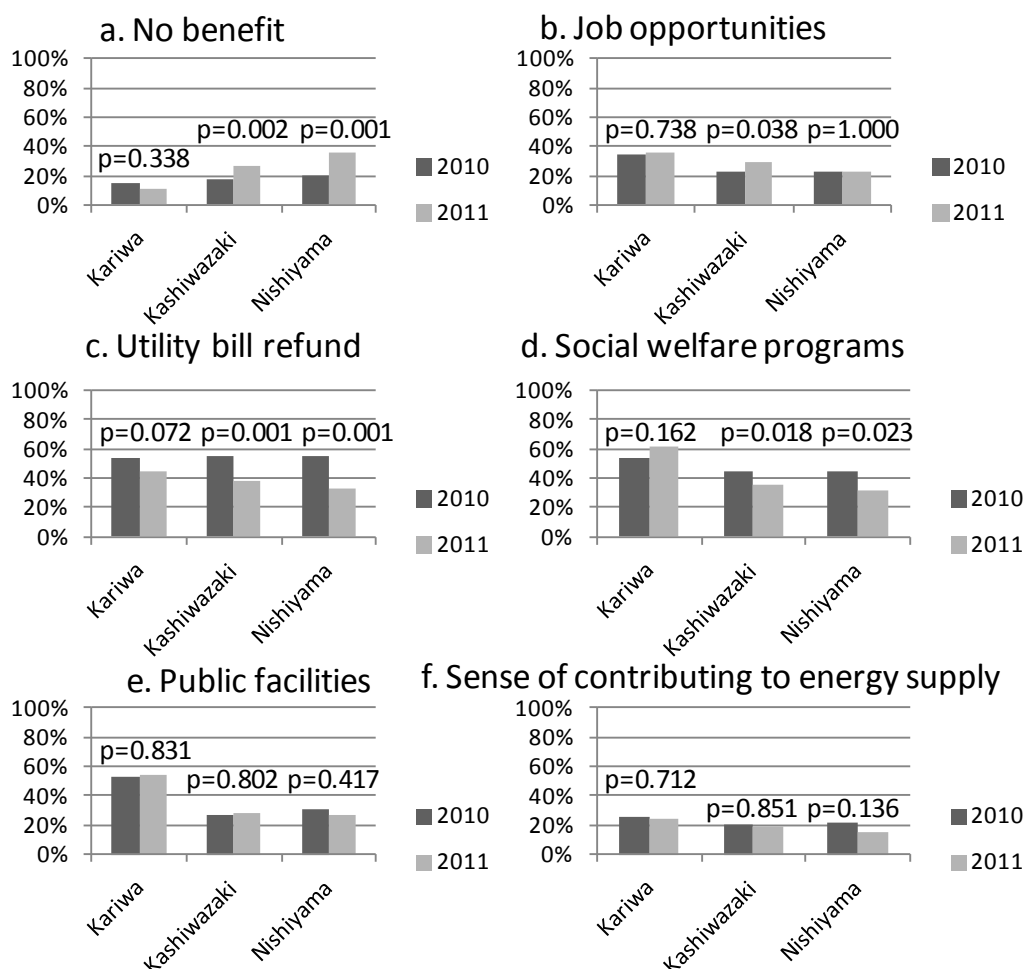
4.1 Local benefits

Fig. 4 shows the evaluation of local benefits by our respondents. The first question asked if the respondents had a negative opinion about any benefits that could arise from the Kashiwazaki-Kariwa NPP. The remaining questions asked if the respondents themselves benefitted from the five different kinds of benefits. The benefits presented to the respondents were "Job opportunities and more income" (hereafter, "job opportunities"), "Utility bill refund," "Improved social welfare programs due to good financial performance" (hereafter, "social welfare programs"), "Creation of convenient public facilities, such as roads and public meeting space" (hereafter, "public facilities"), and "Sense of contributing to the energy supply." The first four benefits are

related to the standard of material life, while the last is related to local morale. Fig. 4 includes p-values from the exact chi-square tests used to assess the difference between the 2010 and 2011 results. We recognize a difference between the results when a p-value is less than 0.050, i.e., the 5% statistical significance level.

Between the years 2010 and 2011, all three areas saw a decline in the benefit of utility bill refunds, with Kashiwazaki and Nishiyama's results being statistically significant at the 5% level. Since the unit amount of the refund remained the same during this period, people became less grateful for this monetary refund in 2011. In contrast, recognition of public facilities did not change over this period, nor did the per-capita amount of infrastructure budget shown in Fig. 3. The bribery effect can explain the variation of changes over time. After the Fukushima accident, criticisms of accepting an NPP in exchange for financial incentives became publicized. Uchihashi (2011) is an example of such criticism. These criticisms should strengthen the sense of bribery among the local citizens who had obtained financial incentives for hosting the NPP. Individual monetary compensation can evoke a stronger sense of bribery than compensation that provides for the public good (Frey et al., 1996; Mansfield et al., 2002). This theory explains why benefit recognition of the utility bill refund declined, but not those of public facilities. A combination of the bribery effect and temporary changes in government expenditures can explain peoples' responses to social welfare programs. Social welfare programs characteristically offer direct support for citizens' everyday life. Kashiwazaki and Nishiyama, where the per-capita budget stabilized over this period, saw a decrease in the benefit recognition of social welfare programs, suggesting an impact of the bribery effect. In contrast, Kariwa saw an increase in the recognition of social welfare programs, which suggests that the positive impact of its sharp rise in the social welfare budget in 2011 overcame the bribery effect. The unemployment rate in the Hokuriku area, which contains Niigata Prefecture, improved slightly, from 4.5% to 3.9%, from 2009 to 2011 (Statistics Bureau, 2012b). However, the average income of our respondents did not change statistically significantly at the 5% level during the survey period. This lack of income growth can be a factor for the slightly increased or at least maintained levels of recognition

regarding job opportunities during the survey period. Since the local economy did not experience abrupt changes during the period, it is unlikely that macro-economic factors significantly affected recognition of utility bill refunds, social welfare programs, and public facilities. Finally, recognition of the sense of contributing to the energy supply did not change clearly over this two-year period.



The p-values are computed from exact chi-square tests.

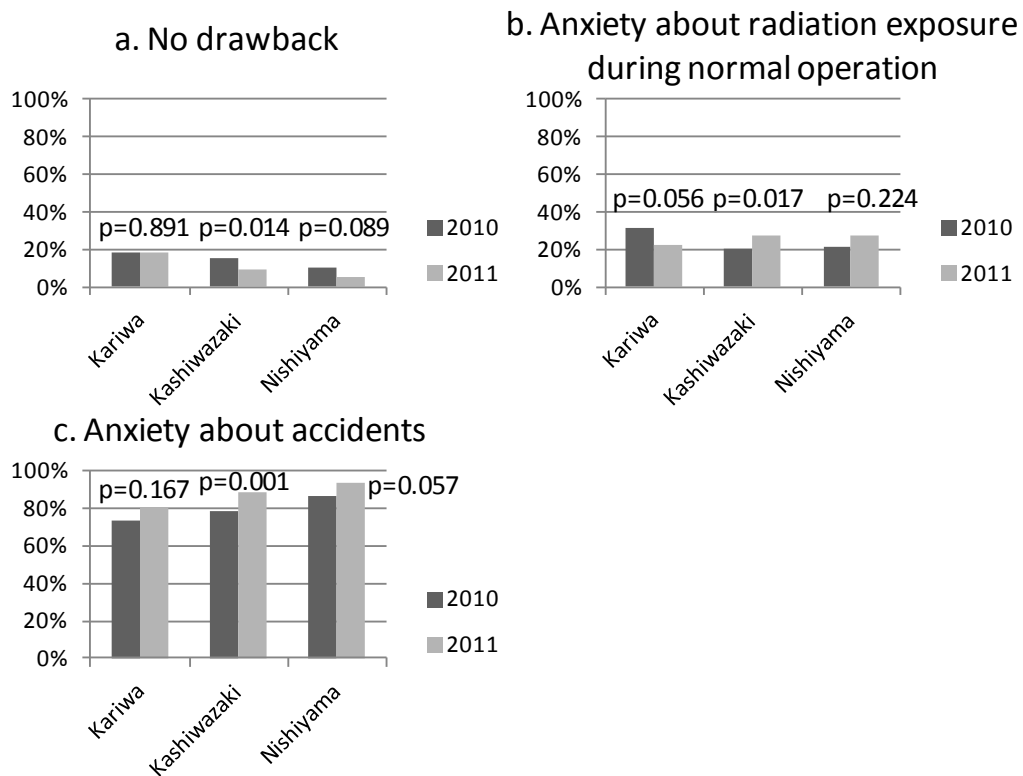
Fig. 4 Please choose items that you think describe the merits of hosting the Kashiwazaki-Kariwa NPP in your area.

We then provided typical sentences reflecting possible problems caused by financial incentives and asked if the respondents agreed with each sentence. In the 2011 survey, 45.5% agreed that “There is a mismatch to citizens’ needs in the way the local government utilizes the revenues” (hereafter, “inefficiency”); 23.3% agreed that “Most of the

revenues go to nuclear disaster prevention schemes and not to the welfare improvement of citizens” (hereafter, “disaster prevention costs”); and 14.4% agreed that “These revenues are harmful from the viewpoint of making the community sustainable” (hereafter, “unsustainability”).

4.2 Local drawbacks

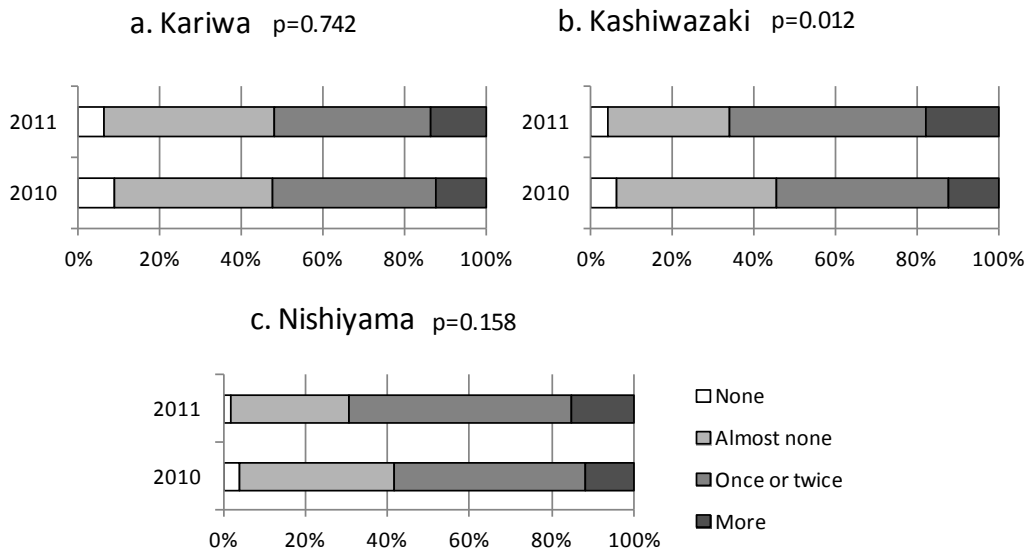
Fig. 5 shows the drawbacks perceived by the respondents themselves. The first question asked if there were any drawbacks to hosting the Kashiwazaki-Kariwa NPP. The next two questions presented two kinds of risks that the NPP might pose. In Kashiwazaki, the “no drawback” option became less popular in 2011 and our respondents became more anxious about both radiation exposures during normal operation and accidents statistically significantly at the 5% level. Nishiyama’s respondents showed similar changes, although the smaller sample there did not make the changes statistically recognizable. Kariwa’s results in 2011 are different from these two areas in that the “no drawback” option was chosen as frequently as before. Anxiety about radiation exposure during normal operation decreased from 31.7% in 2010 to 22.4% in 2011, which is similar to the 18.8% recorded in 2005 by Kato et al. (2007)^{vi}.



The p-values are computed from exact chi-square tests.

Fig. 5 Please choose items that you think describe the drawbacks of hosting the Kashiwazaki-Kariwa NPP in your area.

We asked respondents to estimate the number of earthquake-related events that would occur within the next 30 years that would require an in-house or area evacuation. Their answer was chosen from four options: “none,” “almost none,” “once or twice,” and “more.” Fig. 6 shows the results. Kashiwazaki and Nishiyama saw almost identical patterns of a negative shift of answers over this period. Among them, Kashiwazaki’s result is statistically significant at the 5% level. Kariwa did not show a clear shift in their answers. The results thus far mentioned show that people in Kariwa responded to the Fukushima accident more calmly than those in the other two areas.

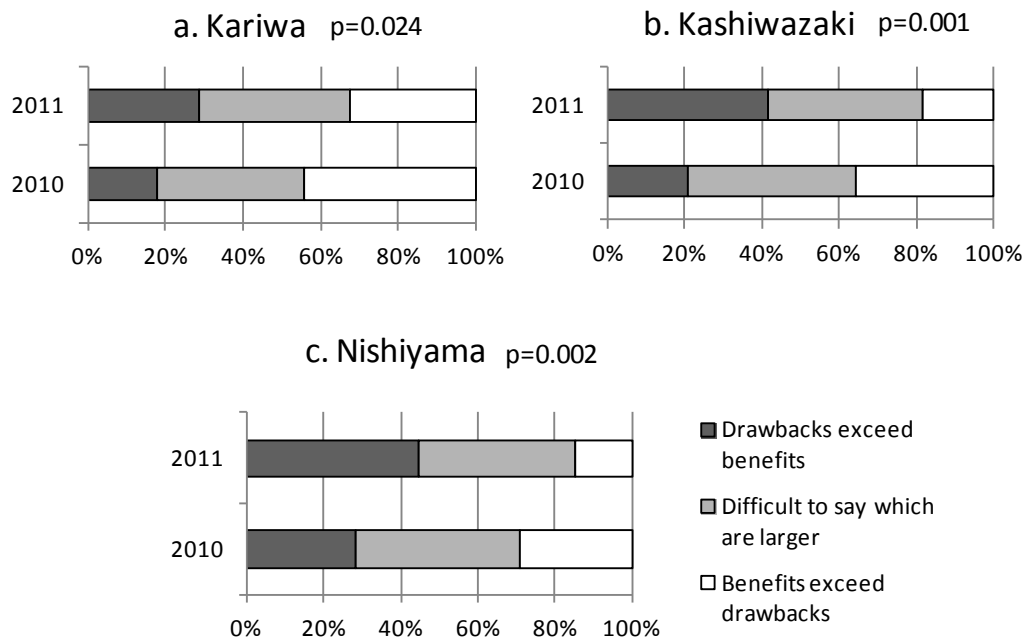


The p-values are computed from exact chi-square tests.

Fig. 6 How frequently in the next 30 years do you think in-house or area evacuations will occur because of the release of radioactive substances from the NPP triggered by an earthquake?

4.3 Benefit-drawback comparison

We asked our respondents to compare the local benefits and drawbacks of hosting the Kashiwazaki-Kariwa NPP. Fig. 7 shows the results. The answer was chosen from three options: “Benefits exceed drawbacks,” “Difficult to say which are larger,” and “Drawbacks exceed benefits.” Between 2010 and 2011, there was a statistically significant shift of answers at the 5% level in a negative direction in all three areas.



The p-values are computed from exact chi-square tests.

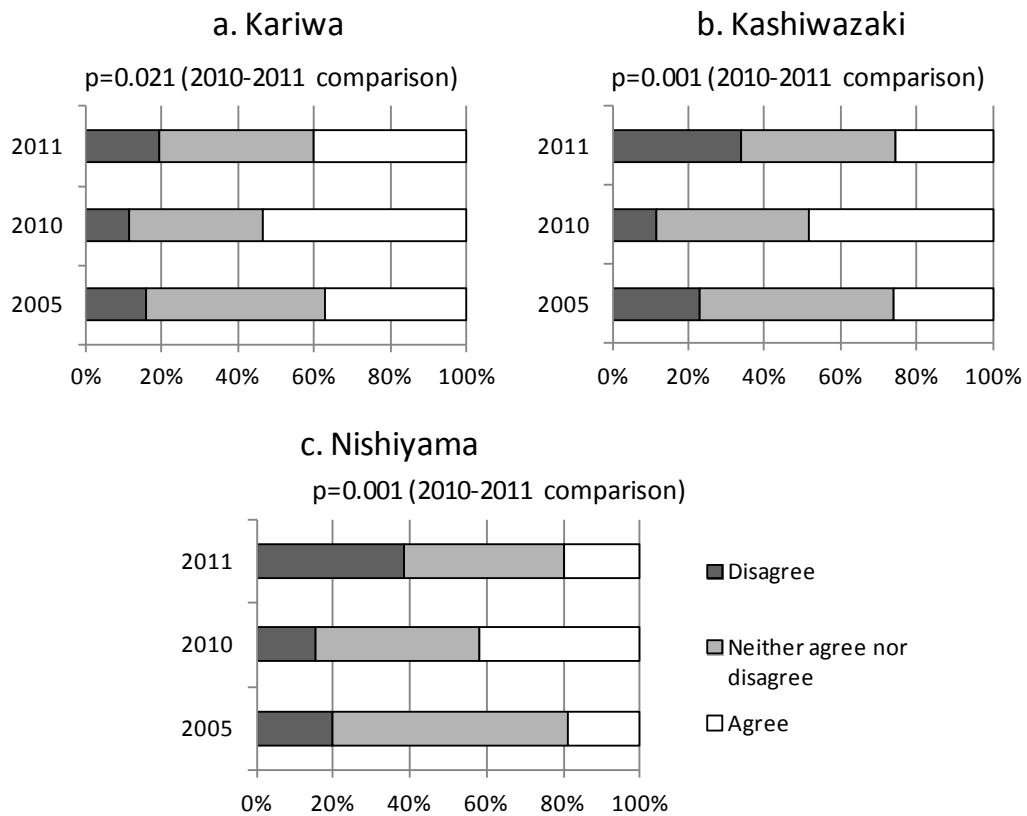
Fig. 7 Which do you think is larger, the merits or drawbacks of hosting the Kashiwazaki-Kariwa NPP in your area?

Fig 8 shows the results of the question that asked if the respondents agreed with the continuing operation of the Kashiwazaki-Kariwa NPP. An answer was chosen from three options: “Agree,” “Neither agree nor disagree,” and “Disagree.” The patterns of the temporal change are similar to those found in the benefit-drawback comparisons in Fig. 7. More local respondents had negative opinions about hosting the NPP after the Fukushima accident than in 2010. These changes were statistically significant at the 5% level in all three areas.

Fig. 8 also features the result for 2005 reported by Kato et al. (2007), which we can use in examining the magnitude of the negative shift from 2010 to 2011. People’s attitude toward continuing the operation saw a positive shift from 2005 to 2010 in all three areas^{vii}. In Kariwa, the negative shift recorded in 2011 is modest in that the 2011 level was similar to the 2005 level. In Kashiwazaki and Nishiyama, the proportions of “disagree” answers increased in 2011 from their 2005 levels, while those of “agree” answers in 2011 did not diminish from their 2005 levels. Thus, the negative shifts in people’s attitudes in

Kashiwazaki and Nishiyama were more critical than in Kariwa, and these shifts were mainly due to the shift from “neither agree nor disagree” to “disagree.”

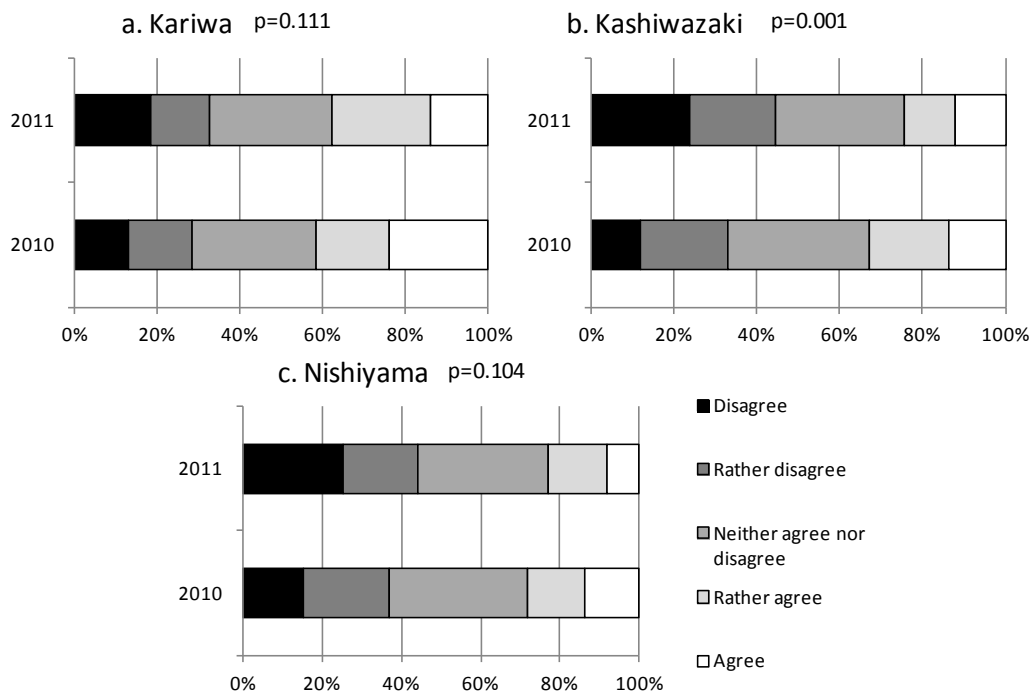
There are correlations between the answers to the two questions in Fig. 7 and Fig. 8. We pooled the respondents of the three areas for each survey year and calculated the rank correlation coefficient of Kendall’s tau. The resulting values were 0.681 and 0.706 for the 2010 and 2011 surveys, respectively. Thus, benefit-drawback comparison is an important factor for the attitudes toward continuing operation of the NPP.



a. The p-values are computed from exact chi-square tests.

b. Kariwa’s result in 2005 was derived from respondents aged between 20 and 69

Fig. 8 Do you agree or disagree with the continuing operation of the Kashiwazaki-Kariwa NPP?



The p-values are computed from exact chi-square tests.

Fig. 9 Do you think that the Kashiwazaki-Kariwa NPP provides sufficient financial benefits to compensate for its drawbacks?

Fig. 9 shows the results of comparisons between financial incentives and the drawbacks of hosting the NPP. We provided information on per-capita financial incentives for a two-year period and asked if these amounts were enough to cancel out the drawbacks^{viii}. The respondents chose one answer from five options, as shown in Fig. 9. The answers shifted in a negative direction in 2011, with the results from Kashiwazaki being statistically significant at the 5% level. Those respondents who chose “Agree,” who were compensated for the risks by financial incentives, were 14.2%, 12.9%, and 8.1% in 2011 for Kariwa, Kashiwazaki, and Nishiyama, respectively. It is reasonable that the percentage in Kariwa is higher than those in Kashiwazaki and Nishiyama, since Kariwa received a significantly larger per-capita amount than the other areas, while risk perceived in Kariwa was not as much as in the other areas. However, despite the large amount provided to Kariwa, the majority of respondents did not state that they were compensated for the risks posed by the Kashiwazaki-Kariwa NPP.

4.4 Factors in the benefit-drawback comparison

Did the Fukushima accident alter the factors for deciding on the relative size of the local benefits and drawbacks? We employed the ordered-probit method to investigate this issue. The ordered-probit method can assess the strength of relationships between a categorical-dependent variable and multiple independent variables. In our case, the dependent variable is the comparison between local benefits and drawbacks. This variable has three categories: “Benefits exceed drawbacks,” “Difficult to say which are larger,” and “Drawbacks exceed benefits,” as shown in Fig. 7. We assume that a response of “Benefits exceed drawbacks” indicates greater satisfaction with compensation. Independent variables are the recognition of local benefits, the recognition of local drawbacks, problems with financial incentives, risk perceptions, and personal attributes. A linear combination of 19 independent variables is considered to explain the individual variation of the dependent variable. An additional two threshold variables, which define the semantic distances among the three categories of the dependent variable, are required for this ordered-probit analysis. These independent variables are dummy variables with the exception of the following four variables: “Estimation of evacuation frequency,” “Age,” “Income per household member,” and “Distance.” “Nuclear job” indicates the respondents who work for a nuclear facility or who live with someone who does. The characteristics of the individual variables have already been presented; therefore, we investigate the influence of these variables in combination.

Tables 4 and 5 show the results of the ordered-probit analyses. We focus on the signs of the coefficients and the sizes of the corresponding p-values in the tables. A positive sign of a coefficient means that an increase of the variable is related to greater satisfaction with compensation. A negative sign means a reverse relationship. Statistical significance is considered at the 5% level. Table 4 shows that, in 2010, recognition of local benefits including “Utility bill refund” shifted the dependent variable positively, while local drawbacks did negatively. Among the three possible problems with financial incentives, recognition of the “Cost of disaster prevention” and “Unsustainability” negatively shifted the dependent variable, as did a larger value of

“Estimation of evacuation frequency.” All the directions of the impacts of these variables are sound on the basis of common sense. “Live with child” and “Distance” positively shifted the dependent variable. The latter means that taking a distance from the NPP made more respondents feel that the benefits exceeded the drawbacks.

Table 5 shows that some important changes occurred in 2011 after the Fukushima accident. Among the local benefits, “Utility bill refund” no longer had a statistically significant impact. This change is in line with our assertion that the bribery effect regarding direct compensation became stronger after the accident. Two local drawbacks continued to shift the dependent variable negatively, as before. Among the problems with financial incentives, only the negative influence of “Unsustainability” was statistically significant. A larger value of “Estimation of evacuation frequency” shifted the dependent variable negatively, as before. Unlike the 2010 results, living with children or living away from the NPP no longer shifted the dependent variable positively. The farthest respondent lived 22.8 km away from the Kashiwazaki-Kariwa NPP in the 2011 survey. After witnessing the large evacuation area of the Fukushima accident, which spanned an area extending more than 40 km from the damaged reactors, and given the fear of radiation-related diseases among children, the weakened impacts of these variables in 2011 is understandable. “Nuclear job” clearly shifted the dependent variable positively, and thus, the difference between the respondents who or whose family worked for a nuclear facility and the remaining respondents became larger.

Table 4 Ordered-probit analysis of benefit-drawback comparison
(2010 survey)

	Variable	Coefficient	Wald	p-value
Threshold	a ₁	-1.560	14.914	.000
	a ₂	.119	.089	.765
Area	Kariwa	.321	3.111	.078
	Nishiyama	.004	.001	.981
Benefit	Job opportunities	.667	23.363	.000
	Utility bill refund	.408	14.098	.000
	Social welfare programs	.587	25.382	.000
	Convenient facilities	.296	5.677	.017
	Sense of contributing to energy supply	.714	24.588	.000
Drawback	Anxiety about radiation exposure during normal operation	-.573	19.172	.000
	Anxiety about accidents	-.849	27.574	.000
Problem of financial incentive	Inefficiency	-.071	.425	.514
	Disaster prevention costs	-.335	5.451	.020
	Unsustainability	-.701	13.004	.000
Risk estimation	Estimation of evacuation frequency	-.401	26.052	.000
Personal attributes	Gender (male)	.036	.110	.740
	Age (years)	.001	.130	.718
	Income per household member (10 thousand yen)	.001	1.169	.280
	Live with child below 19 years old	.241	3.877	.049
	Nuclear job	.331	3.631	.057
	Distance (km)	.040	5.556	.018
Sample size	597			

a. Degree of freedom of Wald tests is 1.

Table 5 Ordered-probit analysis of benefit-drawback comparison
(2011 survey)

	Variable	Coefficient	Wald	p-value
Threshold	a ₁	-2.566	27.068	.000
	a ₂	-.788	2.687	.101
Area	Kariwa	.096	.227	.634
	Nishiyama	.114	.531	.466
Benefit	Job opportunities	.665	20.760	.000
	Utility bill refund	.149	1.527	.217
	Social welfare programs	.312	5.493	.019
	Convenient facilities	.448	11.531	.001
	Sense of contributing to energy supply	.664	18.786	.000
Drawback	Anxiety about radiation exposure during normal operation	-.702	23.810	.000
	Anxiety about accidents	-.919	20.487	.000
Problem of financial incentive	Inefficiency	-.073	.383	.536
	Disaster prevention costs	-.107	.571	.450
	Unsustainability	-.441	5.192	.023
Risk estimation	Estimation of evacuation frequency	-.552	36.861	.000
Personal attributes	Gender (male)	.089	.565	.452
	Age (years)	-.004	.668	.414
	Income per household member (10 thousand yen)	.000	.783	.376
	Live with child below 19 years old	-.051	.156	.693
	Nuclear job	.411	4.965	.026
	Distance (km)	.004	.038	.846
Sample size	493			

a. Degree of freedom of Wald tests is 1.

5. Conclusions

Our focus in this paper was on the compensation scheme used by the government to balance the risks of Kashiwazaki-Kariwa NPP by providing economic incentives to local communities. The paper showed that the comparison of local benefits and local drawbacks is an important factor for attitudes among the local people toward continuing operation of the NPP. Of course, we recognize the other factors that affect the attitudes of the local people toward NPPs. Kimura and Furuta (2003) showed that trust of the utility and recognition of the national merit of nuclear energy also affected the preference for nuclear policy among the local citizens who hosted TEPCO's NPPs. We focused on the local economic incentives in this paper because they have been an integral part of Japan's nuclear policy for promoting the use of nuclear energy, and we need to assess their effectiveness after the Fukushima accident.

The local benefit-drawback comparison largely affected the attitudes of local citizens toward the continuing operation of the Kashiwazaki-Kariwa NPP both before and after the Fukushima accident. Thus, providing more benefits or eliminating drawbacks of hosting the NPP could, in theory, create more positive attitudes toward the operation of the NPP. However, there are difficulties in effectively controlling for these parameters, given that people's perceptions rather than the quantities of benefits and drawbacks are most relevant to the benefit-drawback comparison. After the Fukushima accident, a per-capita financial amount of 105 thousand

yen per annum compensated 12.1% of respondents in Kashiwazaki, as shown in the 2011 survey. Providing a much larger benefit of 719 thousand yen per annum in Kariwa only slightly increased the proportion of compensated respondents, 14.2% (Fig. 9)^{ix}. Before the accident, 601 thousand yen per annum compensated 24.0% of respondents in Kariwa in the 2010 survey. Thus, even before the accident, it was a difficult task to financially compensate a majority of the local people who hosted the NPP. This task apparently became more difficult after the accident.

Perceptions of benefits depend on the mode of benefits. More local people acknowledged utility bill refunds than local infrastructure improvements as benefits (Fig. 4). Among the three survey areas, this difference between the benefit modes was particularly clear in Kashiwazaki and Nishiyama, where local people were more critical of hosting the NPP. Thus, direct compensation, such as utility bill refunds, is a more efficient tool to increase the number of people who feel they benefit from the NPP than is indirect compensation through infrastructure provisions. The Fukushima accident gave us another look at benefit modes. After the accident, the number of people who considered the utility bill refund to be a benefit was reduced significantly (Fig. 4). In contrast, those who benefited from infrastructure improvements did not diminish. A bribery effect can explain this phenomenon. The literature has focused on the bribery effect regarding compensation in the introduction phase of a noxious facility, as we have summarized, but this paper showed that the effect

is important during the operational phase of a noxious facility as well. In our study, expenditures on social welfare programs were also vulnerable to the bribery effect. Finding an efficient mode of compensation helps the government to use its budget more effectively. Exploitation of an optimal combination of compensation modes upon consideration of their static and dynamic characteristics is a curious theme left for future research.

There are regional differences in the responses to the Fukushima accident. Kariwa showed different results from the other areas in some aspects. The benefits of social welfare programs and public facilities are perceived by a larger proportion of the respondents in Kariwa than in the other two survey areas (Fig. 4). Estimation of future in-house or area evacuations did not increase in Kariwa, unlike the other two areas, even after the Fukushima accident (Fig. 6). In conjunction with the lower estimation of the risk of the NPP in Kariwa, this higher recognition of benefits resulted in more favorable answers in the benefit-drawback comparison and in more supporters of the continuing operation of the NPP. Kariwa's larger share of the households that included at least one worker for the NPP contributed to the village's unique characteristics. Percentages of those households in our sample were between 22% and 27% in Kariwa and between 13% and 16% in Kashiwazaki and Nishiyama. These households, more than other households, tended to perceive the benefits as larger and the drawbacks as smaller. However, eliminating these households from the sample did not remove the

regional differences thus far mentioned. Therefore, households without a nuclear job also contributed to the differences between Kariwa and the other two areas. Kariwa's large per-capita economic incentive can explain the greater recognition of benefits among non-nuclear job households in Kariwa. Our survey, however, did not indicate the reasons for lower recognition of risks in Kariwa. There might have been differences between Kariwa and the other areas in trust of the utility, knowledge on nuclear safety, or recognition of the national merits of nuclear energy. We need further research before we can determine the true causes of the regional differences in risk perception. Future research should also investigate regional impacts of the new nuclear disaster prevention scheme to be legislated by the Japanese government^x.

At the time of this writing (March 2013), the Japanese government is struggling to reopen the NPPs in which operations were suspended amid fears of another severe accident. Gaining support to reopen from NPP host communities is a necessary procedure. When all the reactors of the Kashiwazaki-Kariwa NPP were shut down because of the powerful shock of the Niigataken Chuetsuoki (NCO) earthquake in July 2007, the national government chose to provide more economic incentives amid highlighted NPP safety concerns among host communities. The NCO earthquake, unlike the Tohoku earthquake, did not cause a health-threatening accident. It is questionable whether the same strategy will effectively increase support for the NPP after the Fukushima accident given the

strong national criticism of nuclear energy. Because of the bribery effect, the efficiency of gaining more support by adding a unit of economic incentives is low. Thus, if the government is to restart the NPPs, an integrated approach of limiting accident risks, rebuilding trust of its nuclear policy, careful consideration of national merits, and a proper choice of the mode of provision of economic incentives is important^{xi}.

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Notes

ⁱ The answer was chosen from four options: “Increase,” “Keep the present level,” “Reduce,” and “Abolish.” The 2011 survey excluded the areas damaged by the Tohoku Earthquake.

ⁱⁱ This survey excluded the areas damaged by the Tohoku Earthquake.

ⁱⁱⁱ Expansion of nuclear energy was supported by 42.7%, 55.1%, and 59.5%, respectively, in 1999, 2005, and 2009 government surveys (Prime Minister's Office, 1999; Cabinet Office, 2005 and 2009).

^{iv} Details of the donations for each NPP are not available, although the total amount of donations per prefecture was reported by Asahi Shimbun (2011c).

^v The November 2005 mail survey randomly sampled 300, 750, and 350 citizens from Kariwa, Kashiwazaki and Nishiyama, respectively. Response rates were 42.7% in both Kariwa and Kashiwazaki and 48.0% in Nishiyama. The Kashiwazaki-Kariwa NPP resumed operations after April 2003, when all TEPCO reactors were shut down following the revelation of improper management of the reactors by the company. The NPP resumed normal operation by April 2004, and continued to work normally until the Niigataken Chuetsuoki (NCO) earthquake hit the area on July 16, 2007. Thus, the 2005 survey was done in a relatively trouble-free period of the operation of the Kashiwazaki-Kariwa NPP.

^{vi} The Kariwa sample in the 2005 survey consisted of citizens aged between 20 and 69, while the 2010 and 2011 surveys consisted of those between 20 and 74. We confirmed that this age difference did not affect Kariwa's results mentioned in the main text by comparing the answers from those between 20 and 69 from the three survey years. Kashiwazaki and Nishiyama samples in 2005 consisted of those between 20 and 74.

^{vii} During this period, the 6.6 moment-magnitude NCO earthquake caused a tremor with an intensity of at least 6-plus on the Japanese seismic scale in the compound of the NPP, and the power plant had to withstand an unprecedented shock from the earthquake. “A very limited amount of radioactive material” was released to the sea and the air (IAEA 2008). There was no emergency evacuation of local residents. It was not until June 2009 that the power plant resumed operation after the inspection and repair work of its facility. When our January 2010 survey was done, Reactors 6 and 7 of the Kashiwazaki-Kariwa NPP were active. A slowdown of the local economy was clear between the 2005 and 2010 surveys, as the unemployment rate of the Hokuriku area, which contains Niigata prefecture, worsened from 3.3% in 2005 to 4.5% in 2009 (Statistics

Bureau, 2012b), and the per-capita regional income in Kashiwazaki City decreased by 8.6%, from 3,034 thousand yen in 2005 to 2,773 thousand yen in 2008 (Kashiwazaki City, 2011b).

^{viii} Each respondent was provided with the per-capita annual financial incentive of the municipality where he/she lived. The 2010 survey presented 588 thousand yen (FY2005) and 613 thousand yen (FY2006) in Kariwa, and 114 thousand yen (FY2005) and 118 thousand yen (FY2006) in both Kashiwazaki and Nishiyama. Although the FY2007 and FY2008 amounts were available at the time of the survey, we did not show them because these values were largely affected by the NCO earthquake. The 2011 survey presented 751 thousand yen (FY2009) and 686 thousand yen (FY2010) in Kariwa, and 120 thousand yen (FY2009) and “Approximately 90 thousand yen” (FY2010) in both Kashiwazaki and Nishiyama. Because of the limited availability of financial information at the time of the survey, we had to approximate the values for Kashiwazaki and Nishiyama, which are smaller than our present estimate of 110 thousand yen.

^{ix} The per-capita economic incentives shown in this paragraph are averaged values of the two-year financial incentives for each area provided to the respondents in our survey questionnaire (see note viii). We asked our respondents to assess whether these amounts were enough to compensate for the drawbacks of hosting the NPP.

^x Nuclear Regulation Authority has set up an Urgent Protective Action Planning Zone (UPZ), which covers a 30 km radius from each NPP, and argued for setting up the Plume Protection Planning Area outside the UPZ (Nuclear Regulation Authority, 2012).

^{xi} The Japanese government has had to cope with criticism, not only at the local level, but also at the national level, since the Fukushima accident. This article assumed continuing use of NPPs and discussed compensation strategy to gain support from host communities. We recognize, however, the argument over what nuclear policy the government should choose after the Fukushima accident.