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# Consumer responses to food products produced near the Fukushima nuclear plant

Kentaka Aruga\*

## Abstract

The study examines the consumer survey data collected for the seven agricultural products (rice, apple, cucumber, beef, pork, egg, and shiitake mushrooms) of regions near the Fukushima Daiichi nuclear power plant (FDNP) to find out what factors and attributes of consumers affect their purchasing behavior by using the contingent valuation method. In most of the agricultural products, we found that consumers who put high priority on food safety issue, think the risk of radiation contamination became high after the Fukushima nuclear incident, live distanced from the FDNP, and live with children under the age of 15 require a higher discount rate to accept agricultural products of regions near the FDNP. On the other hand, our study indicated that consumers who trust the current safety standard for radioactive material concentrations in food, knowledgeable about radiation and radioactive materials, have high environmental consciousness, and aged are more likely to accept buying products of regions near the FDNP.

*JEL Classification:* D12, Q13

*Keywords:* radioactive contamination, willingness to accept, CVM survey

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## 1. Introduction

On March 2011, the Fukushima Daiichi nuclear power plant (FDNP) was hit by a tsunami and this resulted in a meltdown of three nuclear reactors. Right after this accident, the FDNP started to release substantial amounts of radioactive material into air, and hence, many food products have been contaminated with radioactive material. Up to the present, radioactive materials are found in various food products such as vegetable, meat, seafood, rice, and in drinking water as well. The Japanese government has soon set a severe safety standard to regulate the limits of radioactivity in food products and only products that met this standard could be distributed in the market. However, after the nuclear incident, many consumers started to avoid purchasing food that is produced near the FDNP. Because of such consumer response toward agricultural products of regions near the FDNP, the prices of these products depreciated remarkably compared to those produced in other parts of Japan. For an example, as seen in Figure 1, after the year 2011, the rice of the eastern part of Fukushima (*Hamadori* rice), which is located along the coast line of Fukushima prefecture, is traded at a lower price compared to the national average price.

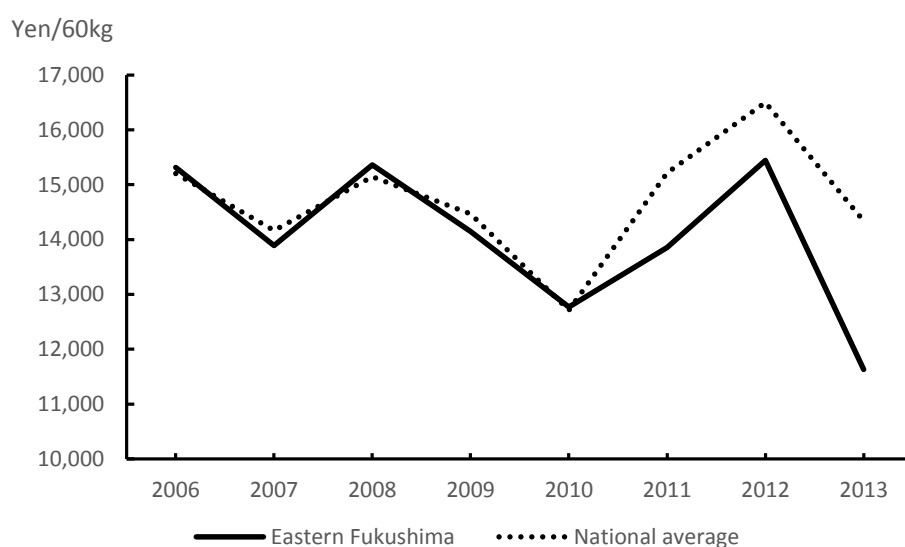


Figure 1 Fukushima average annual rice price before and after 2011

Source: Ministry of Agriculture, Forestry and Fisheries of Japan

Note: Fukushima rice price represents the average annual price of the regions located at the eastern part of the Fukushima prefecture (the *Hamadori* rice price).

It is now almost four years since the Fukushima incident occurred and now no radioactive materials are detected in almost all agricultural products produced in Fukushima. However, there are still consumers who avoid purchasing agricultural products of regions near the FDNP and the sales of products in these regions remain stagnant. One of the causes of such consumer reaction toward agricultural products produced near the FDNP is the false rumor that these products contain radioactive materials. There are consumers who do not obtain themselves the information about the nuclear contamination risk of foods produced near the FDNP and some consumers only believe false rumors that products of regions near the FDNP contain radioactive materials. Decline in the sales of agricultural products in regions near the FDNP from false rumor or gossip is called the “fuhyou” damage in Japan. Local governments of regions near the FDNP are now trying to remove such false reputation and mitigate the effects of the “fuhyou” damage on their agricultural industry. For these purposes, more information is required to understand what factors affect consumer responses toward agricultural products of regions near the FDNP.

Thus, the objective of this study is to investigate the factors involved in consumer responses for agricultural products of regions near the FDNP in order to provide useful information for applying policies to mitigate the effects of rumors that induce anxiety toward such products. To achieve this goal, the study examines the consumer survey data collected for the seven agricultural products (rice, apple, cucumber, beef, pork, egg, and shiitake mushrooms) of regions near the FDNP and find out what factors and attributes of consumers affect their purchasing behavior by using the contingent valuation method (CVM). The attributes tested in this study are consumers’ perception about food safety when buying food products, trust in safety standard, risk perception, knowledge on radiation, distance of consumers’ residence from the FDNP, environmental consciousness, number of children, and demographical characteristics such as age, sex, education, and income. So far, no other studies have investigated how all these factors affect the consumers’ purchasing behavior toward agricultural products of regions near the FDNP.

We expect that consumers who put importance on food safety issue, do not trust the current safety standard, perceive the risk of radiation contamination as high, are ignorant about radiation, live far from the FDNP, have low environmental consciousness, and have many children likely avoid products of regions near the FDNP. First, the reason for consumers that put priority on food safety issue when buying food products, cannot trust the safety standard, perceive the risk of radiation contamination as high, and are ignorant about radiation to avoid products of regions near the FDNP is obvious because such consumers are the ones who are cautious about food safety issue, believe the risk of foods being contaminated with radioactive materials is high, and have few knowledge about the risk of radiation contamination. Second, we believe consumers that reside far from the FDNP likely avoid products of regions near the FDNP because consumers that live far from the FDNP have fewer chances to see products of regions near the FDNP in their local grocery stores. As they do not have many opportunities to purchase products of regions near the FDNP, they do not know much about these products, and hence, uncertainty of how safe these products becomes high for these consumers. Third, the reason for consumers that do not care much about environmental problems to have a lower willingness to buy products of regions near the FDNP is that environmental consciousness is often related to altruism. According to Popp (2001), consumers that are environmentally active and care much about environmental problems are more likely to be altruistic so it is believable that such consumers are more willing to support and help the people in Fukushima by buying its products. Thus, it is likely that consumers with low environmental consciousness behaves the opposite way and are not so active in supporting the people in Fukushima by purchasing its products and only care about minimizing the risk of buying radiation-contaminated foods. Finally, the reason why we expect that consumers with more children to avoid buying products of regions near the FDNP is that it is known that children have a higher risk of getting thyroid cancer when exposed to radioactive materials (Nikiforov, 2006) and it is likely that consumers who have more children tend to be more sensitive toward the risk of buying radiation-contaminated foods.

There are many studies investigating how consumers respond toward food safety issue such as in genetically modified food (Costa-Font et al., 2008; McCluskey et al., 2003) or in mad cow disease (Pennings et al., 2002), but until recently, there are only few studies that covered the consumer responses toward radiation contamination. Just after the Fukushima incident occurred in 2011, Ujiie (2012) conducted a research to estimate the willingness to accept (WTA) for spinach and milk produced in Fukushima and Ibaraki prefectures using an Internet survey. He finds out that around 30% of the consumers are not willing to purchase products produced near the FDNP even no radioactive materials are found in the products. Yoshida (2013) also investigated the consumer attitudes toward agricultural products produced in Fukushima prefecture after the Fukushima incident and reveals that consumers are not willing to buy products of Fukushima compared to products of other parts of Japan. The big difference of this study from these previous studies is the way the hypothetical market is set when asking the consumers about their willingness to accept products of areas near the FDNP. Previous studies set the hypothetical market to products of prefectures near the FDNP while this study set the market to products that are geographically closely located to the FDNP. We used the geographical distance from the FDNP because we believe the distance is the important factor for consumers to avoid purchasing the products of regions near the FDNP. Some areas of Fukushima prefecture are further than some of the prefectures that are adjacent to Fukushima prefecture. Thus, we believe that we can determine the consumer's purchasing attitudes for products of regions near the FDNP more accurately if we use the geographical distance.

In the next section, we explain the details of the methods for identifying the factors that affect the consumers' willingness to buy products produced near the FDNP and talk about our consumer survey data. In the third section, we present the results of the empirical analysis. Finally, in the last section, we discuss the conclusions of the study.

## 2. Methods

### *The econometric model*

We use the contingent valuation method (CVM) to elicit consumer's willingness to accept (WTA) the agricultural products of regions near the FDNP and identifying the attributes that could affect the WTA. CVM has long been mainly used for analyzing the value of public and environmental goods but now it is also used in valuing private goods and services by creating hypothetical markets (Lusk and Hudson, 2004). There are many different types of CVM survey to elicit the WTA such as open-ended, close-ended, single bounded, double bounded, payment card, iterative bidding game, and so on. In this study, we used the dichotomous choice with close-ended iterative bidding game type questionnaire.

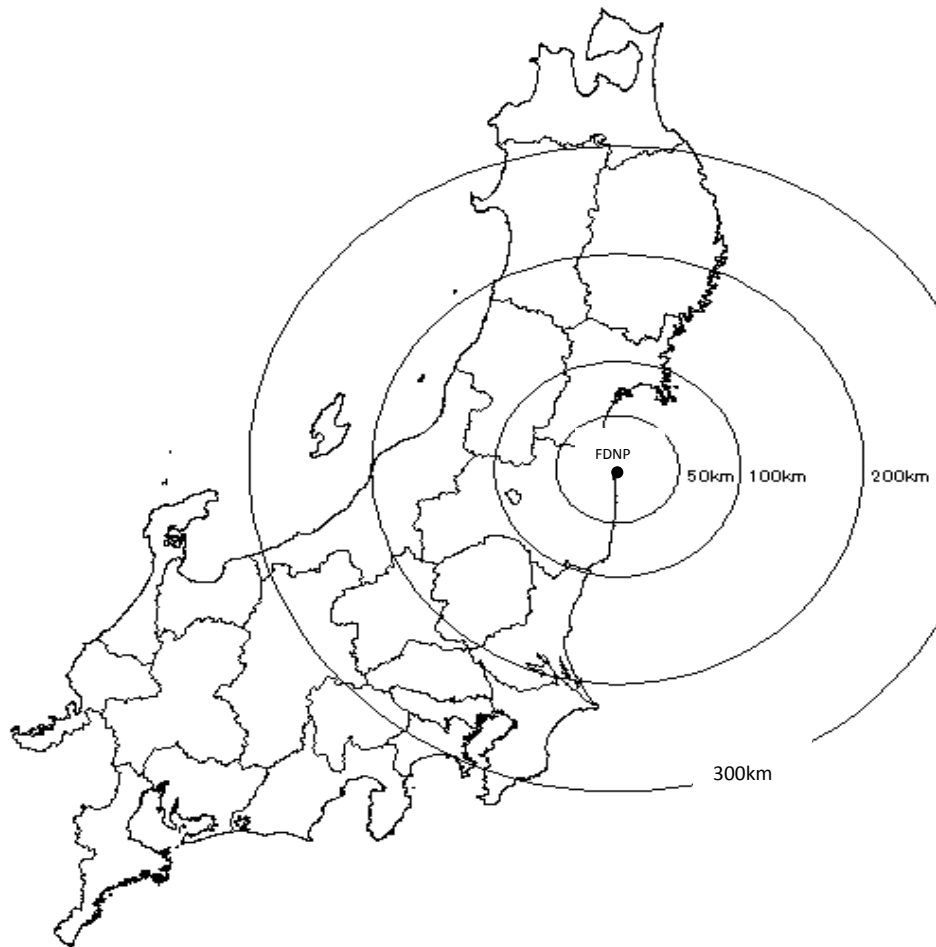


Figure 2 Distance from the Fukushima Daiichi nuclear power plant (FDNP)

The CVM questionnaire we used in this study to configure consumer's WTA for food products produced near the FDNP was as follows: *Please see Figure 2, which shows the distance from the FDNP.*<sup>1</sup> *Imagine a case where \_\_\_\_\_ that is produced at a region 100km apart from the nuclear plant and the same product of a region 300km apart from the nuclear plant are sold next to each other in a grocery store. Are you willing to buy \_\_\_\_\_ of a region 100km apart from the nuclear plant if the discount rate of this product was \_\_\_\_\_% compared with the product of a region 300km apart from the FDNP?* The product name was randomly set to either rice, apple, cucumber, beef, pork, egg, and shiitake mushrooms. The discount rate is initially asked at a zero discount rate and is increased by 10% up to 60% if the consumer answers "no" to the question. If the respondent keeps answering "no" to the given discount rates, the respondent will have to answer the follow-up questions seven times until the discount rate reaches 60%. On the other hand, if the respondent answers "yes" to some given discount rate at some point, no follow-up questions will be asked and the question will end at that point. The rationale for no follow-up question after the respondent answered "yes" is that the main focus of this study is to identify the factors that lead consumers to avoid purchasing agricultural products of regions near the FDNP. Thus we are more interested in the consumers who avoid products of regions near the FDNP than those that are indifferent to such products.

Using the above mentioned question to identify the consumers' WTA the agricultural products of regions near the FDNP, we set the following three discrete outcomes as an ordered dependent variable:

$$WTA_i = \begin{cases} 1: WTA_i \leq 0, \\ 2: 0 < WTA_i \leq 0.6, \\ 3: 0.6 < WTA_i. \end{cases} \quad \text{for } i = 1, 2, \dots, N \quad (1)$$

The first category represents consumers who are willing to buy an agricultural product of a region 100km apart from the FDNP at the same price as a product of a region 300km apart

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<sup>1</sup> The actual map we used during the survey was provided in Japanese and had labels for the major cities as well.



from the FDNP. Such consumers are indifferent about the area of production and do not care whether the product is from the region near the FDNP. Consumers that belong to the second category are the ones who buy a product of a region near the FDNP at some discount rate between 10 to 60 percent. Finally, the third category corresponds to consumers who are not willing to buy a product of a region near the FDNP at any discount rate offered during the survey. Hence, the observed variable  $WTA_i$  in equation (1) denotes the consumers' WTA for the products of regions near the FDNP in an order form.

Based on this variable we set the  $WTA_i^*$  as an indicator variable for the individual's latent WTA value for the agricultural products of regions near the FDNP. The WTA model we build is specified as:

$$WTA_i^* = \beta' x_i + \varepsilon_i \quad (2)$$

where  $x_i$  is the vector of explanatory variables that have potential effects on the willingness to accept for agricultural products of regions near the FDNP,  $\beta$  are the vector of coefficients, and  $\varepsilon_i$  is the normally distributed error term. This WTA model is estimated using the ordered probit model.<sup>2</sup>

We assume the respondent's true  $WTA_i^*$  lies within the interval defined by the lower and upper thresholds:

$$WTA_i^* = \begin{cases} 1 & \text{if } WTA_i^* \leq 0 \\ 2 & \text{if } 0 < WTA_i^* \leq \mu \\ 3 & \text{if } \mu \leq WTA_i^* \end{cases} \quad (3)$$

where  $\mu > 0$  is the unknown threshold parameter. Assuming  $\varepsilon_i \in N(0, \sigma^2)$  in equation (2), the choice probabilities for the individual  $i$  can be expressed as:

$$\text{Prob}(WTA_i^* = j | x_i) = \begin{cases} 1 - \phi(-\beta' x_i) \\ \phi(\mu - \beta' x_i) - \phi(-\beta' x_i) \\ 1 - \phi(\mu - \beta' x_i) \end{cases} \text{ for } j = \begin{cases} 1 \\ 2 \\ 3 \end{cases}. \quad (4)$$

Under these assumptions the log likelihood function becomes:

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<sup>2</sup> To avoid multicollinearity, we made sure that the correlations between the explanatory variables in the probit model are all lower than 0.5.

$$\ln L = \sum_{i=1}^N m_i \ln \{ [1 - \phi(-\beta'x_i)] [\phi(\mu - \beta'x_i) - \phi(-\beta'x_i)] [1 - \phi(\mu - \beta'x_i)] \} \quad (5)$$

where  $m_i = 1$  if  $WTA_i^* = j$  and 0 otherwise.

Table 1 Descriptions for consumer information and perception variables

Variable	Description
<i>Safety</i>	Importance of food safety when buying food products: 1 = yes, 0 = no
<i>Trust</i>	Trust on the current safety standard for radioactive material concentrations in food, based on a scale of 1 to 10: 1 = Do not trust the standard at all to 10 = Highly trust the current standard
<i>Risk</i>	Perception of the risk of radiation-contaminated food sold at groceries after the Fukushima incident, based on a scale of 1 to 10: 1 = low risk to 10 = high risk
<i>Knowledge</i>	Have some knowledge in the following descriptions about radioactive materials: a. There are three types of radiation rays, alpha, beta, and gamma rays, and these rays have different abilities to pass through materials. b. Radioactive isotopes continue to decay until they become a stable isotope. c. Among the units to indicate the level of radioactive materials in food, Sievert (Sv) represents the degree of influence on human body while Becquerel (Bq) is used to measure the strength of radioactivity. d. Regardless of human activities, radiation exists in nature such as cosmic rays, earth rays, and so on. e. It is said that when additional amount of radiation received exceeds 100 mSv the probability of developing cancer in a lifetime increases about 0.5%. 1 = know any of the above descriptions, 0 = do not know any of the above descriptions
<i>Distance</i>	Distance of the residence from the Fukushima nuclear plant: 1 = less than 100km, 2 = 100km to 200km, 3 = 200km to 300km, 4 = 300km to 400km, 5. greater or equal to 400km
<i>Environment</i>	Willingness to join environmental activities such as conserving ecosystem and preventing climate change, based on a scale from 1 to 10: 1 = not willing to attend at all to 10 = very much willing to attend

Table 2 Descriptions for demographic variables

Variable	Description
<i>Age</i>	1 = 20 to 29 years, 2 = 30 to 39 years, 3 = 40 to 49 years, 4 = 50 to 59 years, 5 = 60 to 69 years
<i>Sex</i>	1 = male, 0 = female
<i>Education</i>	1 = primary and junior high school, 2 = high school, 3 = junior college, 4 = some college credit, but no degree, 5 = bachelor's degree, 6 = master's degree, 7 = doctorate degree
<i>Children</i>	Number of children that are under the age of fifteen in the family
<i>Income</i>	1 = less than 2 million yen, 2 = 2 to 4 million yen, 3 = 4 to 6 million yen, 4 = 6 to 8 million yen, 5 = 8 to 10 million yen, 6 = 10 to 12 million yen, 7 = 12 to 14 million yen, 8 = over 14 million yen

Tables 1 and 2 describe the details of the explanatory variables included in our WTA model. Table 1 shows the variables to configure the consumers' perception of food safety, trust toward the current Japanese safety standard for food, risk consciousness, knowledge about radioactive materials, distance of their residence, and environmental consciousness. Table 2 illustrates the variables related to consumers' demographic information such as age, sex, education, number of children, and income.

### *The survey data*

We collected the survey data through online questionnaire, which was conducted during the Jan. 30, 2014 – Feb. 4, 2014 period. In total, 6945 sample respondents were collected from all 47 prefectures of Japan based on the current population distribution by prefectures. Table 3 shows the distance of the sample respondents' residence from the FDNP. As shown in the table, most of the respondents lived at least 200km apart from the FDNP because most of the people in Japan reside around the three large cities Tokyo, Nagoya, and Osaka.<sup>3</sup>

As already mentioned, we asked the respondents their WTA for the seven agricultural products of regions near the FDNP. These products were chosen because they are among the highly produced agricultural products in the Fukushima prefecture. For rice, apple and cucumber we did not put any explanation for their specifications in the questionnaire but for beef, pork, and egg we mentioned in the survey that they are the meat and egg of livestock and poultry that are fed with local diets produced near the production regions. We also put a specification for the shiitake mushrooms that the mushrooms are raw and produced using the local lumbers of the production regions. We would also like to note about the way we asked the respondents the questions for their willingness to accept the seven agricultural products. Every respondent had to answer the WTA questionnaire for either one of the following pairs of products: (rice, mineral

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<sup>3</sup> Tokyo, Nagoya, and Osaka are approximately 211km, 440km, and 563km apart from the FDNP respectively.

water), (apple, cucumber), (beef, pork), and (egg, shiitake mushroom).<sup>4</sup> The pairs of the products that the respondents answered were selected randomly. In order to remove the order bias that could occur when asking the WTA questions for the pairs of products, we split the samples for the every pairs of products into two and changed the order within the samples. For example, as seen in Tables 3 and 4, the number of respondents that answered the WTA questionnaire for beef and pork were 1768 but half of these respondents answered the WTA questions by answering from beef to pork while the other half answered from the opposite order.

Table 3 Distance distribuion of the sample respondents' residence from the FDNP

	Rice	Apple & Cucumber	Beef & Pork	Egg & Mushroom
Less than 100km	2.9%	3.6%	2.5%	2.8%
100-200km	6.0%	5.2%	6.2%	5.3%
200-300km	28.9%	32.7%	30.1%	30.4%
300-400km	5.0%	3.9%	4.0%	5.8%
Greater or equal to 400km	57.3%	54.6%	57.2%	55.7%
Sample size	1710	1757	1768	1710

Table 4 Sex and age distribution of the sample

	Rice	Apple & Cucumber	Beef & Pork	Egg & Mushroom
Male percentage	52.5%	49.9%	52.1%	53.1%
Ages 20-29	15.4%	15.9%	16.2%	15.5%
Ages 30-39	22.6%	22.9%	21.7%	21.8%
Ages 40-49	15.7%	15.1%	17.3%	16.7%
Ages 50-59	18.2%	18.4%	16.5%	18.3%
Ages 60-69	28.0%	27.6%	28.4%	27.8%
Sample size	1710	1757	1768	1710

Table 4 illustrates the sex and age distribution of the sample respondents. As seen in the table, the age and sex distribution of the samples are similar among the agricultural products investigated in this study. It is noticeable that the respondents that are 60-69 of age had the highest percentage within the whole sample but this is simply reflecting the current age distribution of

<sup>4</sup> We did not include “mineral water” in this study because the focus of this study is on agricultural products.

Japan because in 2014 the percentage of population ages 65 and above is over 25 percent of the whole population in Japan.

### 3. Results

Table 5 Percentages and distribution of WTA responses for the agricultural products of regions near the FDNP

	Rice	Apple	Cucumber	Beef	Pork	Egg	Mushroom
WTA = 0	48.7	55.0	55.0	53.3	52.4	50.6	49.7
$0 < \text{WTA} \leq 0.6$	18.3	24.2	18.2	19.5	19.8	19.7	18.8
WTA > 0.6	33.0	20.8	26.9	27.2	27.8	29.7	31.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 5 shows the distribution of WTA responses for the agricultural products of regions near the FDNP. The table suggests that in all seven agricultural products nearly half of the respondents are willing to buy products 100km apart from the FDNP at a same price with products 300km apart from the FDNP. This means that quite a few people perceive the risk of radiation contamination from buying products of regions near the FDNP as low and are indifferent about the area of production. However, the table also indicates that the rest half of the respondents do perceive the risk of radiation contamination when buying products of regions near the FDNP. Except for apple, more than half of the respondents among those that demanded some discount rate answered they are not willing to buy the products of regions near the FDNP at any discount rate offered in the survey. Especially, for rice and shiitake mushrooms, over 60% of the respondents among those that requested some discount rate show a strong refusal to buy these products of regions near the FDNP. Because rice is the staple food in Japan and the amount and frequency of consuming rice are high in most households in Japan, it is probable that the respondents put importance on avoiding the risk of radiation contamination from buying the rice of regions near the FDNP. The reason for having a high refusal rate to buy shiitake mushrooms is perhaps because it is known that fungal species are known to accumulate radio-caesium (Yamada,

2013) and many respondents thought the risk of containing radioactive materials in shiitake mushrooms is higher than other food products.

The estimation results of the ordered probit model are presented in Table 6. First let's look at the factors that affected positively on the WTA for products of regions near the FDNP. For all the seven agricultural products, the table suggests that consumers that put high priority on food safety issue, think the risk of radiation contamination became higher after the nuclear incident, live distanced from the nuclear plant, and live with children under the age of 15 require a higher discount rate for accepting the agricultural products of regions near the FDNP.

Table 6 Estimates for the ordered probit model

	Rice		Apple		Cucumber		Beef		Pork		Egg		Mushroom	
	Coeff.	Z-stat	Coeff.	Z-stat	Coeff.	Z-stat	Coeff.	Z-stat	Coeff.	Z-stat	Coeff.	Z-stat	Coeff.	Z-stat
Safety	0.30 ***	4.48	0.21 ***	3.40	0.18 ***	2.75	0.24 ***	3.74	0.21 ***	3.41	0.23 ***	3.70	0.27 ***	4.30
Trust	-0.15 ***	-8.12	-0.12 ***	-7.27	-0.11 ***	-6.36	-0.15 ***	-8.48	-0.13 ***	-7.66	-0.14 ***	-7.92	-0.15 ***	-8.38
Risk	0.27 ***	15.39	0.22 ***	13.27	0.23 ***	13.59	0.24 ***	14.81	0.24 ***	14.75	0.21 ***	12.90	0.21 ***	13.03
Knowledge	-0.14 *	-1.78	-0.19 **	-2.53	-0.22 ***	-2.85	-0.23 ***	-3.07	-0.23 ***	-3.16	-0.22 **	-2.00	-0.14	-1.29
Distance	0.12 ***	4.43	0.08 ***	2.97	0.09 ***	3.50	0.09 ***	3.27	0.12 ***	4.56	0.07 **	2.47	0.04 *	1.70
Environment	-0.09 ***	-4.95	-0.08 ***	-5.14	-0.09 ***	-5.42	-0.05 ***	-3.18	-0.05 ***	-2.90	-0.04 **	-2.26	-0.03 *	-1.66
Age	-0.03	-1.47	-0.03	-1.43	-0.01	-0.48	-0.02	-1.09	-0.01	-0.57	-0.07 ***	-3.36	-0.07 ***	-3.32
Sex	-0.13 *	-1.80	-0.20 ***	-3.01	-0.20 ***	-2.88	-0.29 ***	-4.31	-0.23 ***	-3.44	-0.10	-1.51	-0.04	-0.62
Education	-0.02	-0.80	-0.01	-0.34	-0.01	-0.64	0.00	-0.17	-0.01	-0.30	0.03	1.14	0.01	0.47
Children	0.07 **	2.44	0.12 ***	3.76	0.11 ***	3.38	0.09 ***	2.90	0.10 ***	3.41	0.06 **	2.05	0.09 ***	2.82
Income	0.02	0.96	0.08 ***	3.55	0.06 ***	2.99	0.07 ***	3.29	0.06 ***	2.66	0.03	1.29	0.02	0.88

Note: \*\*\*, \*\*, \* represent significance at 10%, 5%, and 1% levels.

These results are more or less consistent to our expectations but we would like to give our intuition for the reasons. Consumers that are cautious about food safety issue require a high discount rate or not willing to buy products of regions near the FDNP at any discount rate because they put high priority on avoiding the risk of buying products with radioactive materials. Similarly, consumers who think the risk of radiation contamination became higher after the nuclear incident are more likely to avoid products of regions near the FDNP because they see these products as

risky. The reason for consumers that lived further from the FDNP to have a higher WTA is perhaps because consumers are less familiar with products of regions near the FDNP as their residence become further from the FDNP. Most Japanese consumers in general buy agricultural products of regions near their residence so if consumers who live further away from the FDNP see products nearer to their residence together with the products of regions near the FDNP, they are likely to prefer the former products which they are familiar with. Finally, consumers with children showed a higher WTA toward products of regions near the FDNP because they are afraid of their children to eat food with radioactive materials.

It is noticeable that income is also a factor that increases the WTA for products of regions near the FDNP although it did not become significant for rice, egg, and mushroom. The reason for income to affect positively on the WTA is perhaps because for consumers with a higher income paying a higher price to avoid buying products of regions near the FDNP is not much of a burden.

Now, we explain the factors that affected negatively on the WTA. As seen in Table 6, in most of the seven agricultural products, trust in the current safety standard for radioactive material concentrations in food, knowledge toward radiation and radioactive materials, willingness to join environmental activities, and sex seem to lower the WTA for products of regions near the FDNP. For egg and mushroom, age also had a negative impact on the WTA. Education too had a negative impact on the WTA, but it did not become significant in any of the seven agricultural products.

First, the reason for consumers that trust the safety standard to have a lower WTA is perhaps because these consumers believe that the current food safety standard is severe enough to control products that contain radioactive materials from being distributed.

Second, consumers that are knowledgeable about radiation and radioactive materials have a better understanding toward the risk of radiation contamination so that it is likely that they perceived the risk of consuming products of regions near the FDNP to be lower compared to

consumers that are ignorant about radiation and radioactive materials. Thus they have the tendency to accept products of regions near the FDNP at a lower discount rate.

Third, the reason why consumers who are willing to support solving environmental problems to have a lower WTA maybe because these consumers are more or less altruistic and are hoping to help the economy of regions near the FDNP by buying products of these regions. Table 7 shows the correlation between the variable “environment” and “support.” “Environment” is the variable whose description is explained in Table 1 and “support” is the variable where we asked in the survey based on a scale from 1 (low degree) to 10 (high degree) how much the respondents are willing to help the regions that had damages from the Fukushima incident.<sup>5</sup> According to Table 7, in all agricultural products “environment” was highly correlated with “support,” which suggests that consumers with high environmental consciousness likely buy products of regions near the FDNP in hope of helping the regional economies.

Table 7 Correlations between environment and support

Correlation	Rice	Apple & Cucumber	Beef & Pork	Egg & Mushroom
Environment vs support	0.62	0.63	0.65	0.59

Fourth, the reason for sex to have a negative impact on the WTA is possibly due to the fact that male is less cautious about the effect of children eating food contaminated with radioactive materials. It is believable that because women usually have a longer time to be with her children compared to men in Japan, women are more willing to avoid buying products of regions near the FDNP to protect their children from eating products that have the risk of radiation contamination.

Finally, as studies have shown that risk of becoming cancer declines with increasing age at exposure to radiation (Cucinotta and Durante, 2009), it is likely that the perception of the risk

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<sup>5</sup> The reason why we did not include “support” in our probit model is that “environment” had a high correlation with “support.”



of having food containing radioactive material became lower as the respondents' age increased. Hence, the WTA for agricultural products of regions near the FDNP became smaller as the age of the respondents increased.

#### **4. Conclusions**

We found that consumers who put high priority on food safety issue, think the risk of radiation contamination became high after the Fukushima nuclear incident, live distanced from the FDNP, and live with children under the age of 15 require a higher discount rate to accept agricultural products of regions near the FDNP. This implies that it is difficult to sell products of regions near the FDNP unless these products can regain trust on their safety standard, and broadening the market area to regions apart from the FDNP is not effective for increasing the sales of their products.

On the other hand, our study indicated that consumers who trust the current safety standard for radioactive material concentrations in food, knowledgeable about radiation and radioactive materials, have high environmental consciousness, and aged are more likely to accept products of regions near the FDNP. This result suggests that improving the current food safety standard in a way that the consumers have a better understanding of the risk of radiation contamination, and educating and training consumers to become more knowledgeable about radiation and radioactive materials would be effective for regaining the trust toward products of regions near the FDNP. The result where consumers with high environmental consciousness are more willing to accept products of regions near the FDNP imply that conducting marketing strategies to target consumers that are somewhat altruistic may help increase the sales of products produced near the FDNP. As our results suggest that broadening the market area by targeting the consumers of the whole Japan is not so effective for recovering the sales, the local government should focus their marketing strategies for consumers that are altruistic and are willing to support the economies of regions near the FDNP.

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