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Consumers' Attitude Toward Inspection Methods and Institutions for Potential Radioactive Contamination: A Choice-based Conjoint Analysis

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【abstract】
Japanese fisheries suffered substantial damages from the tsunami in March 2011. The subsequent accident at the Fukushima nuclear power plant raised serious concerns among consumers about the potential contamination of fishery products by radioactive substances. Inspections for radioactive contamination has been conducted since then, but it is not clear whether the current practice is the most desirable one. In this paper, we employ a choice-based conjoint analysis using data from online survey conducted during August 21-23, 2012 to examine how consumers evaluate the inspection methods and inspection institutions for fishery products, and how providing information may change their evaluation. We find that consumers have a very high evaluation for full (100%) inspection for radioactive contamination for salmon (rather than sample inspection), which does not change after providing two different sets of information. We also find that consumers prefer universities and fishery cooperatives to government institutions as an inspection institution. This evaluation is, however, reversed after providing scientific information about radioactive contamination. Further, our result indicates that providing information about how local producers are suffering does not change consumers' evaluation. These results suggest that the inspection for all marketed products, together with effective communications to consumers, are crucial in dealing with potential radioactive contamination.

【keywords】
conjoint analysis, consumer attitudes, Fukushima, radioactive contamination, salmon

1. Introduction

Japanese fisheries suffered substantial damages from the earthquake and

subsequent tsunami in March 2011. The tsunami not only physically damaged fishing vessels and ports in northeastern areas of Japan, it also raised serious concerns among consumers about the risk of potential radioactive contamination of fishery products following the accident at the Fukushima nuclear power plant (Ito *et al.* (2011)). All commercial fishing activities in Fukushima waters were suspended from March 2011 to June 2012 (Yagi (2014)). Limited fishing operations has restarted since June 2012 as "trial operation" under close supervision of the government and fisheries organizations, and the amount of landing in 2015 is still around 1/30th of that harvested by commercial fisheries before the disaster (Yagi (2016)).

Concerns among consumers were reported in newspapers and other media regarding the quality and frequency of inspections for radioactivity. For instance, the Kahoku Shimpo, one of the major newspaper based in tsunami damaged area, reported in its article on 7 September 2013 about an incident: a retailor in Fukushima sold a fish to a customer, but the fish was returned to the store the next day by the consumer who claimed that her family raised a concern on this product. This kind of concern is unlikely to be unique to the Fukushima nuclear plant accident. As such, we believe it is important to know how consumers evaluate inspection methods and inspection institutions for radioactive contamination. It is also crucial from policy perspectives to know what kind of information, if any, changes their evaluation.

There is a large literature examining consumer's risk preference and attitude toward various products. Many studies find that consumers give premiums for inspected or certified food (e.g., McCluskey *et al.* (2005), Wang *et al.* (2009), Chalak and Abiad (2012)). However, to the best of our knowledge, there is no study that examines the consumers' evaluation for inspection methods. Alternatively, there is a few studies that examine inspection institutions. Holland and Wessells (1998) show that consumers in the north-eastern and mid-Atlantic states in the United States prefer United States Department of Agriculture (USDA) to Food and Drug Administration (FDA) as an agency for seafood safety and quality inspection. Ortega *et al.* (2011) show that Chinese consumers have higher willingness to pay for pork with a government certification program than third-party certification. In a somewhat different context, Wessells, Johnston and Donath (1999) find that consumers are indifferent among the World Wide Fund for Nature (WWF), the Marine Stewardship Council (MSC), and National Marine Fisheries Service (NMFS) as a certifying agency for an eco-labels. Thus, our study is the first to analyze the consumers' evaluation for inspection agency (and methods) in the context of radioactive contamination.

Another related set of studies show that providing information can potentially change consumers' behaviors. For instance, Uchida *et al.* (2014) use an auction experiment to show that consumers give about a 20 percent premium for a MSC certified salmon only if they are provided information on both the status of global fish stocks and the goal of the MSC programs. In contrast, Miyata and Wakamatsu (2015) also use an auction experiment to find that providing scientific information about radioactive contamination does not affect consumers' willingness to pay for wakame seaweed; it merely affects their perceptions about radioactive contamination. We contribute to this literature by testing the effect of a unique information set. Specifically, in addition to scientific information, we also test the effect of providing local information about how producers are suffering from decreased prices. We do not find any research that implement a similar information treatment.

We use a choice-based conjoint analyses in this study, which has already been applied for Japanese seafood market by several authors. The first application appears to be Ariji (2006) that examines consumers' evaluation for flounder harvested in Kyoto prefecture. More recently, Oishi *et al.* (2010) and Uchida *et al.* (2014) both focus on how consumers evaluate ecolabels for sliced salmon in Japan. Ariji (2010) also investigates the impact of product type and ecolabels for Bluefin tuna. We follow their study design and compare our results with theirs if possible.

The rest of the paper proceeds as follows. In Section 2, we describe the designs for our survey and choice experiments. In Section 3, we explain the conceptual framework behind our conjoint analysis, and describe four alternative econometric specifications. Section 4 includes estimation results and the willingness to pay for each attribute derived from the results. Finally, in Section 5, we discuss the interpretation and policy implications.

2. Survey design

We conducted our online survey during August 21-23, 2012 under the title "The survey for seafood products." It consists of four parts that include 39 questions in total. The first part includes general questions about the respondent's attitudes towards fish consumption and their familiarity with several fish species. In the second part, we first provide basic information about the inspection methods for radioactive contamination, and then conduct five choice experiments. In the third part, we randomly divide the respondents into two groups and provide scientific information about radiation to one

group while the information about the local situation in the affected areas to the other group. Five choice experiments are conducted again after the new information is provided. Finally, the survey closes with questions about the demographic information of the respondents.

To quantify the consumers' evaluation for inspection methods and institutions, we need to determine the focus product that is used for the choice experiments. We select sliced salted salmon (two pieces, 160 gram) shown in Fig.1 for three reasons. First, sliced salmon is one of the most popular fishery products sold in Japan and is therefore easily recognizable to respondents. Second, it is a major farmed fishery product in the area affected by the 2011 tsunami. Finally, although Coho salmon was never reported to be contaminated, it faced a major decrease in ex-vessel price after the Fukushima nuclear power plant accident. This decrease was mainly driven by imported Coho salmon from Chile(1), but we cannot entirely exclude the possibility that the demand for the domestic Coho salmon decreased due to the concern for radioactive contamination. Thus, Coho salmon seems to be a good subject to examine whether providing new information to respondents changes their product evaluation.

We contracted out our online questionnaire survey to Macromill, Inc., an internet research company based in Tokyo, Japan. The questionnaires were designed by the authors, and Macromill distributed them to a prospective pool of respondents. The respondents are pre-registered Japanese residents, whose identities are known to Macromill. By answering questionnaires, the respondents can earn "points" which are exchangeable for gifts in several stores. A total of 840 people was surveyed, which consists of 21 people from each combination of two genders (male and female), five cohorts (20-29, 30-39, 40-49, 50-59, and 60-), two areas (Tokyo and Osaka), and two information treatments (A and B). Following Oishi *et al.* (2010), we selected Tokyo and Osaka, which are two major seafood consumption areas in Japan.

Figure 1 Picture of salmon product subject to study

2-1. Product attributes and levels

Although our primary interest is the consumers' evaluation for the inspection methods and institutions, a sliced salted salmon has number of other attributes. To uncover the consumers' preference, it is desirable to include in the choice experiments other key attributes to mimic the actual purchasing situations. As such, we include three other attributes following previous studies: price, product type, country or area of origin. In terms of price, we assume four price levels for two pieces of salmon based on the actual retail price: 150 yen, 200 yen, 300 yen, and 400 yen. These price levels are also consistent with those employed by Oishi *et al.* (2010) and Uchida *et al.* (2014). As for the product type, wild and farmed are considered as two options. Regarding the country or area of origin, we assume four possibilities: Miyagi (tsunami-affected area located next to Fukushima), Hokkaido (far northern area of Japan with minimal tsunami damage), Chile, or Norway. Although previous studies do not distinguish among production areas in Japan, we treat Miyagi and Hokkaido as separate areas. As Miyagi is much closer to Fukushima, it is possible that consumers evaluate products from these areas quite differently.

The inspection method is specified as either sample inspection or full (100%) inspection(4). Sample inspection refers to the inspection of randomly selected samples using a germanium semiconductor detector, and has been under implementation since January 2013. This method takes a long time due to the large number of requests for inspections being received by the limited number of inspection institutions in Japan. It also requires fish samples to be grinded and, as such, the inspected products cannot be sold on the market even if they turn out to be free of radioactive contamination. On the other hand, a new equipment was developed in 2012 that can measure the level of radioactive substances contained in the whole fish in 10 seconds without grinding it. This equipment looks like an airport security machine for scanning carry-on luggage. Fish products within a box are placed on a belt conveyer and the level of radioactive contamination is measured while the fish passes under the sensor. Because it does not require the grinding of the fish, this type of full inspection for marketed fish is theoretically feasible. In this study, full inspection is defined as the inspection of all marketed products using the belt conveyer method. This information is given to the respondents, along with the explanation that cross-checking of the level of contamination would be conducted using germanium semiconductor detector devices for selected samples to standardize the accuracy of the measurement by the two different types of devices.

Table 1 Product attributes and levels

Attribute	Level
Price	150 yen, 200 yen, 300 yen, 400 yen
Origin	Miyagi, Hokkaido, Chile, Norway.
Product type	Farmed, Wild
Inspection method	Full (100%) inspection, sample inspection
Inspection institution	Government, Fishery cooperative, Universities, Consumer

We consider four potential inspection institutions: government agencies, fishery cooperatives, universities, and consumers' self-inspection. After the accident at the nuclear power plant in Fukushima, various institutions have been involved in the inspection of seafood products. Government agencies at national and prefectural levels are playing major roles in inspection, but the number of inspectors and inspection machines are currently unable to meet the large demand for such inspections. University research laboratories voluntarily help to analyze the level of radioactive substances included in the seafood products. In addition, fishery cooperatives are also engaged in similar inspections to maintain accountability towards their customers. The summary of product attributes and levels are shown in Table 1.

Given the number of attributes and levels, the possible number of profile sets is 4 x 4 x 2 x 2 x 4 = 256. To reduce the burden of the respondents, however, we assume that there is no interaction effect among attributes/levels, and use the L16 orthogonal table to create 16 profile sets. One profile set was further dropped due to its unrealistic combination of profiles: Chile, farmed, sample inspection, government agency, and 400 yen[(2)]. This results in the total of 15 profile sets, which then allows us to create five choice experiments, each containing three alternatives. By randomly shuffling the 15 profile sets, we create 10 choice experiments No.1 - No.10. The respondents answer choice experiments No.1 - No.5 after receiving the basic information, while they answer choice experiments No.6 - No.10 after receiving the new information. In each choice experiment, respondents are asked to choose one of four alternatives, three profile sets and a "None of the above" option.

2–2. Information treatment

Prior to the initial choice experiments, we provide to all the respondents basic information that clarifies the definitions of and the difference between sample inspection and full inspection. This procedure ensures that respondents accurately

Table 2 Content of information treatment

Basic Information	1. Sample inspection is such that randomly selected samples at landing ports are sent to research institutes and tested. The level of radioactive substances is measured using germanium semiconductor detectors. This method requires fish to be grinded up, and, as such the inspected products cannot be sold on the market. It usually requires 2 or 3 days before the results can be obtained from research institutes. 2. Full (100%) inspection is such that fish products are placed on a belt conveyer and the level of radioactive contamination is measured while the fish is passing under the sensor. It takes 10 seconds without grinding the fish. Because it does not involve a process for fish to be grinded, full inspection for marketed fish is theoretically feasible. 3. In the questionnaire, full inspection is defined as the inspection for all the marketed products using the belt conveyer method. Full inspection involves cross checking the level of contamination with germanium semiconductor detector devices for selected samples to standardize the accuracy of the measurement by two different types of devices.
Information set A	1. Radioactive substances naturally exist in food and our atmosphere. The Codex Commission set standards on acceptable levels of radioactive Cesium 134-137. The most recent regulations in Japan are fully consistent with this standard. 2. Sample inspection method does not exclude the possibility that some marketed fish contains radioactive substances above the criteria. However, it is extremely unlikely that one consumer purchases such a fish repeatedly. The total yearly intake of radioactive substances would still be reasonably lower than the allowable level, even if a consumer inadvertently purchases contaminated fish.
Information set B	1. The price of farmed Coho salmon in Miyagi Prefecture has dropped to half of the average price in past years. 2. Producers in Miyagi say that "we have tried hard to recover from the tsunami, but our efforts cannot be sustained under this situation." 3. JF Miyagi is appealing that the "feed materials and environment to farmed salmons are free of radioactive substances", "product inspections are rigorously conducted", and that "the tsunami-damaged Miyagi salmon farming industry cannot be sustained without supports from consumers through actual consumption behaviors."

recognize their trade-offs, which is crucial in uncovering their preference toward various attributes. In addition, providing the basic information to respondents makes it more credible that they accurately understand the new information we provide after

the initial choice experiments. A caution is required, however, because after providing the basic information, our sample is no longer a representative sample of the population. Our results can only be extended to the general population conditional on providing the basic information.

After the first set of choice experiments, the participants are randomly divided into two groups, each of which is offered a different set of information A or B. Information Set A is about the risk management action, which is taken from the websites of the Consumer Affairs Agency of Japan and independent scientific institutions. It explains that radioactive materials exist in nature independent of the nuclear power plant accident. It also states that the regulation criteria for radioactive contamination is set following inter-governmental organization guidelines, and that the radiation level is unlikely to exceed the permissible level unless one repeatedly consumes a contaminated fish by chance.

Information set B is based on newspaper articles which describes the state of the producers in Miyagi in 2012. It states that the producers are suffering from decreased prices despite that their products are shown to be radioactive free, and that they need support from consumers to make their living. The difference between Information sets A and B is that the former provides objective and scientific information about radioactive contamination, while the latter conveys information about local situations in an emotional manner. The summary of the basic information, Information set A, and Information set B are given in Table 2.

3. Conceptual framework and econometric model

We conduct a conjoint analysis using the results from the choice experiments. It is assumed that consumers make their purchasing decision by comparing utilities obtained from the combination of product attributes. Denote the utility for an individual consumer n from option i at choice experiment t as:

$$U_{nit} = V_{nit} + e_{nit}$$

where V_{nit} is the utility from observable product attributes and e_{nit} is the unobservable component of utility. This unobservable component includes utility from unmeasured characteristics of the product and other idiosyncratic shocks such as the consumer's mood and physical conditions. Given a choice set C, the probability of the consumer choosing option i is given by:

$$\Pr(U_{nit} > U_{njt}) = \Pr(V_{nit} - V_{njt} > e_{njt} - e_{nit}) \quad \forall j \in C, \mathrm{j} \neq \mathrm{i}$$

Thus, if we specify a functional form for the observed component V and assume a probability distribution for the unobservable component of utility e, the probability of choosing option i can be expressed in terms of observable attributes.

We assume that attributes linearly enter the observed component of utility. We employ dummy coding and use the following base categories: Norway, farmed, sample inspection, and consumer self-inspection. Thus, the explanatory variables in our estimation are price, three country of origin dummies (Hokkaido, Miyagi, and Chile), wild dummy, full inspection dummy, three inspection institution dummies (University, Fishery cooperative, and Government), and the common alternative specific constant for choice 1-3. Further, to assess the effect of information treatments, we include interaction terms of these variables with the information A and information B dummy variables. Thus, our base specification includes 30 explanatory variables in total. The magnitude of each parameter estimates will be evaluated by the marginal willingness to pay (MWTP), which is calculated as the price change that offsets a unit change in the attribute while keeping the total utility constant.

As for the unobservable component, we employ four alternative specifications and examine the robustness of our results. The first specification is the usual conditional logit specification where the unobservable component is assumed to follow the iid Type-I extreme value distribution.

$$U_{nit} = \boldsymbol{X'_{nit}\beta} + e_{nit}, \;\; e_{nit} \sim iid\; G(0,1)$$

where $\boldsymbol{X'_{nit}}$ is a vector of explanatory variables. In this specification, the choice probability has a closed form solution so that the estimation is relatively simple. The assumption of the iid Type-I extreme value distribution, however, implies the independence from irrelevant alternatives (IIA), which states that the odds of choosing between two alternatives is independent of other alternatives. This is a quite restrictive assumption to make for studies that use observational data, because unmeasured characteristics of each product are likely to exist (which makes some alternatives closer substitutes than others). In our study, however, this assumption seems more innocuous because our data is generated from choice experiments, where there is no unmeasured characteristics in principle. A potential concern is that IIA implies that unobservable components of utility across 10 choice experiments by the same respondent are independent. However, if a respondent is in a bad mood in the first choice experiment, it is likely that he/she is in the same mood until the last choice experiment (which

results in a correlation between e for the same person over choice experiments).

To deal with these concerns, we estimate three other models that do not require IIA: multinomial probit model, nested logit model, and mixed logit model. In a multinomial probit model, the unobservable components of utility are assumed to be distributed jointly normal. With four alternatives in each choice experiment, there are 10 elements to estimate in the covariance matrix. By removing parameters related to scale and level of utilities, the number of parameters to be estimated reduces to five (Train (2007)). Thus, the multinomial probit model in our analysis has five additional parameters.

$$U_{nit} = \boldsymbol{X'_{nit}\beta} + e_{nit}, \;\; e_{nit} \sim MVN(0, \Omega)$$

In our nested logit model, we assume that the respondents first decide whether to purchase or not, and conditional on deciding to purchase, they choose among the three profile sets (Haaijer et al. (2001)). Thus, we model three profile sets in the first nest while the "None of the above" option in the second nest. It is assumed that IIA holds within the first nest. We have one additional parameter to estimate (i.e., dissimilarity parameter), which measures the degree of independence among unobserved components of utility for the three alternatives in the second nest. The utility function is given by

$$U_{nit} = W_{nk} + \boldsymbol{X'_{nit}\beta} + e_{nit}, \;\; e_{nit} \sim iid\; G(0,1)$$

where W_{nk} is the common utility from alternatives in the nest k.

Finally, in a mixed logit model, potential heterogeneity in preference across respondents can be modelled by treating some parameters to be random. We specify the price parameter as fixed while other nine parameters are distributed normal. All the interaction terms are also assumed to be fixed due to the computational complexity.

$$U_{nit} = \boldsymbol{X'_{nit}\beta_n} + e_{nit}, \;\; e_{nit} \sim iid\; G(0,1)$$

We use likelihood ratio (LR) tests to determine the preferred model between the conditional logit and the nested logit models, and between the conditional logit and mixed logit models. As multinomial probit is not nested with any other model, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) are used to make comparison.

4. Results

We collected data from 840 people in total. As designed, it consists of 21 people from each city, gender, cohort, and information treatment. Their other demographic

characteristics are as follows: 37% of them are full-time company employees, 21% are a full-time housewives/husbands, and 13% are part-time workers. 23% of the respondents have the annual household income of 4-6 million yen, followed by 22% having the household income of 2-4 million yen. In terms of the highest educational level completed, 45% have a university degree, 21% have a college degree, and 27% have a high school degree. Regarding their attitude towards seafood consumption, 78% of the respondents answered that they liked to eat fish, and more than half of the respondents consumed fish two days or more per week. 17% of the respondents indicated that they had previous knowledge about the inspection methods for radioactive materials explained in our questionnaire.

The number of observations for our conjoint analysis is 33600 (= 840 x 10 x 4). To account for the differential demographic composition of our sample relative to the population in Japan, we used the inverse probability weighing by age class and gender in each city, based on the population data in 2012 estimated by Statistics Bureau. Estimations were conducted using Stata 12. Columns 1-4 in Table 3 show the results from the conditional logit, multinomial probit, nested logit, and mixed logit models, respectively(3). Although not shown in the table due to the space limitation, three out of five parameters for the covariance matrix are statistically significant in the multinomial probit model, the dissimilarity parameter is significantly different from one in the nested logit model, and the standard deviations for the random parameters are all significant for the mixed logit model.

When the four columns are compared, they show overall consistent results in terms of the signs of the parameter estimates. No parameter exhibits statistically significant estimates with opposite signs across the four columns. We view that those parameters that are statistically significant with the same sign across the four columns are our most robust results. As for the main effects, the four models agree that Miyagi and Chile are less preferable to Norway, wild salmon is more preferred to farmed salmon, full inspection is preferable to sample inspection, universities and fishery cooperatives are better than consumers' self-inspection, and a lower price is desirable. Regarding interaction terms, the four models agree that providing Information A raises consumers' evaluation for Chilean salmon, but decreases their evaluation for universities and governments as an inspection institution. Alternatively, they agree that providing Information set B raises consumers' evaluation for Chilean salmon.

There are also some differences across the four models. First, the conditional logit model indicates that Hokkaido salmon is indifferent with Norwegian salmon for

consumers, while the other three models suggest that Hokkaido salmon is preferable to Norwegian salmon. Second, the conditional logit and the mixed logit suggest that government agencies are preferable to consumer self-inspection, while the other two models suggest these two options are indifferent. Third, the conditional logit, the multinomial probit, and the nested logit indicate that providing either Information set A or B raises consumers' evaluation for Miyagi salmon. However, the mixed logit model suggests this is not the case. Finally, the conditional logit model indicates that providing either information reduces their evaluation for full inspection relative to sample inspection, but the other three models do not agree with it.

We choose the mixed logit model as our preferred model based on the log likelihood, AIC, and BIC: LR tests reject the hypothesis that the conditional logit is preferable to the nested logit ($p<0.000$) and to the mixed logit model ($p<0.000$), and AIC and BIC suggests the mixed logit is preferable to the multinomial probit and the nested logit models. Therefore, our main results, in addition to the ones listed above, are as follows. First, Hokkaido salmon is preferable to Norwegian salmon. Second, government agencies are preferable to consumer self-inspection. Third, the negative evaluation for Miyagi salmon does not change with Information set A or B. Finally, the consumers' evaluation for full inspection is not affected by Information set A or B.

Column 5 and 6 in Table 3 show the mixed logit estimation results for Tokyo and Osaka, respectively(5). Although our aim in this paper is to examine the consumers' evaluation for inspection methods and institutions on average, it is of some interest to see if there is any regional difference in their evaluation. Given that Tokyo is much closer to Fukushima, and that there are differences in the consumption of various fish products between these two areas, it is plausible that their evaluation for inspection methods and institutions may also differ. The estimation results suggest that the two cities have overall consistent preference toward various attributes, as almost all the parameter estimates have the same sign across two columns. There are, however, some notable differences in terms of statistical significance. First, Miyagi salmon is indifferent with Norwegian salmon in Tokyo, but it is less preferable in Osaka. This is consistent with Aruga (2016) that shows more distant consumers require a higher discount rate to accept agricultural products from regions near the Fukushima nuclear plant. Further, when Information set A is provided, consumers' evaluation for Miyagi salmon does not change in Tokyo, but it earns even worse evaluation in Osaka. Second, full inspection is preferred in both cities, but when Information set A is provided, it

Table 3 Estimation results

	CLogitAll	MProbitAll	NLogitAll	MLogitAll	MlogitTokyo	MlogitOsaka
ASC	1.821***	2.432***	2.263***	4.337***	3.851***	4.307***
	(0.186)	(0.607)	(0.215)	(0.460)	(0.596)	(0.642)
ASC x infoA	-0.062	-0.320	-0.435*	0.288	0.276	0.404
	(0.240)	(0.292)	(0.236)	(0.367)	(0.503)	(0.580)
ASC x infoB	-0.116	-0.344	-0.411*	0.357	0.453	0.411
	(0.242)	(0.288)	(0.221)	(0.388)	(0.547)	(0.542)
Hokkaido	0.121	0.284*	0.366***	1.381***	1.058***	1.661***
	(0.135)	(0.158)	(0.128)	(0.207)	(0.272)	(0.307)
Hokkaido x infoA	0.300*	0.020	-0.017	-0.923***	-0.558	-1.483***
	(0.162)	(0.172)	(0.160)	(0.254)	(0.343)	(0.352)
Hokkaido x infoB	0.396**	0.107	0.044	-0.802***	-0.742**	-0.894***
	(0.162)	(0.163)	(0.164)	(0.228)	(0.313)	(0.323)
Miyagi	-0.709***	-0.496***	-0.290**	-0.332**	-0.146	-0.796***
	(0.117)	(0.126)	(0.133)	(0.166)	(0.234)	(0.273)
Miyagi x infoA	0.586***	0.392***	0.270**	-0.229	-0.047	-0.622**
	(0.146)	(0.138)	(0.119)	(0.188)	(0.237)	(0.290)
Miyagi x infoB	0.780***	0.565***	0.391***	-0.039	-0.065	0.114
	(0.146)	(0.137)	(0.133)	(0.200)	(0.274)	(0.286)
Chile	-1.151***	-0.827***	-0.638***	-1.206***	-1.216***	-1.170***
	(0.112)	(0.125)	(0.180)	(0.145)	(0.197)	(0.211)
Chile x infoA	1.038***	0.696***	0.697***	0.435**	0.667**	0.052
	(0.159)	(0.135)	(0.160)	(0.198)	(0.268)	(0.277)
Chile x infoB	1.109***	0.757***	0.750***	0.515**	0.641**	0.310
	(0.160)	(0.143)	(0.161)	(0.214)	(0.298)	(0.286)
Wild	0.422***	0.469***	0.482***	0.752***	0.709***	0.808***
	(0.142)	(0.148)	(0.104)	(0.186)	(0.238)	(0.291)
Wild x infoA	-0.255*	-0.254	-0.400***	-0.236	-0.171	-0.366
	(0.153)	(0.161)	(0.115)	(0.207)	(0.275)	(0.313)
Wild x infoB	-0.415***	-0.374**	-0.497***	-0.489**	-0.321	-0.722**
	(0.154)	(0.168)	(0.110)	(0.193)	(0.249)	(0.302)
Full inspection	0.653***	0.430***	0.258**	0.995***	1.075***	0.956***
	(0.061)	(0.096)	(0.126)	(0.104)	(0.149)	(0.160)
Full inspection x infoA	-0.262**	-0.008	0.084	-0.218	-0.051	-0.585**
	(0.116)	(0.160)	(0.123)	(0.161)	(0.205)	(0.268)
Full inspection x infoB	-0.199*	0.069	0.140	-0.156	-0.158	-0.294
	(0.117)	(0.169)	(0.125)	(0.178)	(0.238)	(0.261)
University	0.760***	0.427**	0.476***	1.051***	0.751***	1.448***
	(0.132)	(0.208)	(0.130)	(0.165)	(0.226)	(0.233)
University x infoA	-0.615***	-0.425*	-0.508***	-0.772***	-0.629**	-0.897***
	(0.162)	(0.232)	(0.118)	(0.199)	(0.266)	(0.282)
University x infoB	-0.382**	-0.271	-0.399***	-0.429*	-0.215	-0.692**
	(0.164)	(0.227)	(0.105)	(0.224)	(0.311)	(0.290)
Fishery coop	1.147***	0.870***	0.733***	0.852***	0.633***	1.139***
	(0.123)	(0.147)	(0.156)	(0.146)	(0.192)	(0.220)
Fishery coop x infoA	-0.917***	-0.715***	-0.662***	-0.405**	-0.332	-0.484*
	(0.152)	(0.162)	(0.129)	(0.185)	(0.256)	(0.250)
Fishery coop x infoB	-0.761***	-0.615***	-0.601***	-0.164	-0.006	-0.417
	(0.153)	(0.166)	(0.112)	(0.195)	(0.263)	(0.262)
Government	0.774***	0.335	0.079	0.724***	0.799**	0.628
	(0.207)	(0.268)	(0.253)	(0.264)	(0.348)	(0.410)
Government x infoA	-0.428*	-0.194	0.056	-0.249	-0.420	-0.060
	(0.229)	(0.292)	(0.220)	(0.297)	(0.393)	(0.441)
Government x infoB	-0.280	-0.087	0.131	-0.153	-0.162	-0.159
	(0.230)	(0.291)	(0.205)	(0.289)	(0.380)	(0.436)
Price	-0.008***	-0.007***	-0.007***	-0.010***	-0.009***	-0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Price x infoA	0.002*	0.002*	0.003***	0.000	-0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Price x infoB	0.002*	0.002	0.003***	0.000	-0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
N	33600	33600	33600	33600	16800	16800
LL	-442701	-442066	-442448	-354088	-214510	-138758
AIC	885463	884202	884959	708255	429098	277594
BIC	885716	884497	885220	708583	429399	277895

Notes: Clogit stands for conditional logit, MProbit multinomial probit, NLogit nested logit, and MLogit mixed logit. The inverse probability weighing by age class and gender in each city is used to account for different composition between the sample and the population. * P<0.1, ** P<0.05, *** P<0.01

Table 4 Marginal Willingness to Pay for each attribute

	Base	InfoA	Diff	InfoB	Diff
Hokkaido	141.39***	46.91**	Yes	59.27***	Yes
Miyagi	-33.96*	-57.45***		-37.97*	
Chile	-123.48***	-78.92***	Yes	-70.78***	Yes
Wild	77.04***	52.92***		26.92***	Yes
Full	101.86***	79.55***		85.91***	
University	107.60***	28.59**	Yes	63.70***	
Fish coop	87.27***	45.80***	Yes	70.45***	
Government	74.09**	48.62***		58.44***	

Notes: Diff shows whether the estimates are significantly different from the Base estimates at the 10% level of significance. * P<0.1, ** P<0.05, *** P<0.01

becomes less important only in Osaka. Finally, government agencies are preferred in Tokyo, but it is indifferent with consumer self-inspection in Osaka.

The MWTP calculated from the mixed logit model are shown in Table 4. All the estimates are significantly different from zero. Without providing new information, consumers give a premium of 101 yen for full inspection and premiums of 107 yen, 87 yen, and 74 yen to universities, fisheries cooperatives, and government, respectively. These are quite large numbers given that the price of the sliced salmon ranges between 150-400 yen. When Information set A is provided, the premium for full inspection decreases by 20% to 79 yen, although the difference is not statistically significant. The premiums for inspection institutions are also decreased. At the same time, however, a negative premium for Miyagi salmon increases from -33 yen to -57 yen (though, the difference is not statistically significant). Providing Information set B has similar, but smaller, effects: the premium for full inspection decreases to 85 yen, for inspection institutions are all decreased, while the negative premium for Miyagi salmon increases.

5. Discussion

In this paper, we used a choice-based conjoint analysis to examine how consumers evaluate inspection methods and inspection institutions for radioactive contamination, and how providing new information changes their evaluations. In the choice experiments, we included other key attributes of the product to mimic the actual purchasing situations, which also allows us to compare our results with those from

previous studies. Knowing that different econometric models may generate different results, we estimated four different models to ensure the robustness of our results.

Three main findings were obtained from our analysis. First, consumers have a very robust and high evaluation for full inspection relative to sample inspection. This evaluation does not change, on average, even after providing information that radioactive substances exist in the nature and the occasional consumption of contaminated seafood does not cause any health problem. Providing information about how local fishermen suffer from reputational damages does not change this evaluation, either. The MTWP from the mixed logit model suggests that consumers are, on average, willing to pay 101 yen for full inspection relative to sample inspection. Miyagi prefecture has annual Coho salmon production of about 13,000 ton, which amounts to 13,000 * 0.7 * 1,000,000 / 160 = 56,875,000 packs of sliced salmon (assuming the yield ratio of 70%). Thus, full sampling is expected to raise an additional revenue of 101 * 56,875,000 =5.7 billion yen, which seems sufficiently high to cover the initial and running costs for the equipment for the entire Miyagi prefecture(6).

Second, as an inspection institution, universities and fishery cooperatives earn a higher evaluation than governments. Although further research is needed, the lower consumer evaluation for products inspected by government agencies may represent their (relative) distrust in governments. The poor information disclosure regarding the magnitude of damages to the Fukushima nuclear power plant may have particularly raised consumers' distrust to the government. Interestingly, however, after providing Information set A, consumers prefer government agencies rather than universities and fishery cooperatives. One possibility is that Information set A, which describes how the government objectively set the criteria for radioactive contamination, may have raised the relative evaluation for the government. In contrast, Information set B has limited effect on the consumers' evaluation for inspection institutions (and full inspection). It appears that consumers are less affected by emotional and local information, and can be more affected by scientific and objective information.

Finally, the parameter estimates for other characteristics are aligned with those in previous studies. For example, our results show that Chilean salmon is less preferable to Norwegian salmon, which is consistent with the findings in Oishi *et al.* (2010) and Uchida *et al.* (2014). Also, we find that wild salmon is preferable to farmed salmon, which is the same finding as Uchida *et al.* (2014). These consistencies indicate that the parameter estimates for inspection methods and inspection institutions in our study are also reliable. In addition, we find that the evaluation for Hokkaido salmon and

Miyagi salmon are dramatically different, with the former more preferred to Norwegian salmon while the latter less preferred to it. This presumably reflects consumers' low level of confidence in the safety of food products from the area adjacent to Fukushima. This result suggests that, as in Uchida *et al.* (2014), it may be more desirable to specify the area of origin rather than to use the word "domestic," since the evaluation can be significantly affected by which area of origin the respondent has in mind.

Based on these results, several policy recommendations can be identified. First, the introduction of full inspection should be seriously considered. Based on the results from our analysis, it appears that consumers have very high and robust preference toward full inspection. That said, the MWTP from stated preference studies like ours is likely to be an overestimate of the actual value, because respondents are not required to pay for the product when answer the questions. Therefore, more studies are warranted before introducing full inspection in a large scale. Second, to raise consumers' seafood consumption, it is recommended that scientific and objective information be provided, rather than emotional and local information. Our results suggest that consumers are unlikely to increase their consumption just because producers are suffering. Also, it appears that there are some regional differences in terms of how information affects consumers' evaluation. Thus, it will be more effective if a policy is tailored to each region. Finally, in addition to providing proper information to consumers, additional policies may be required to improve the efficiency of market value chains of fishery products. If additional payment by consumers, intended for helping fishers in disaster areas, are mostly absorbed by other persons in distribution channels as extra revenue, consumer willingness to pay more may dwindle. The domestic fish distribution channel in Japan is composed of multiple layers of purchasers and middlemen (Yagi *et al.* (2012)). Economic inefficiencies in the value chains of fishery products in Japan could also be addressed as part of a wider restructuring program that includes vertical integration of production, processing, and distribution sectors.

Notes

(1) We thank an anonymous referee for pointing this out.

(2) This profile set was unlikely to be selected for the following reasons: Chilean salmon is the lowest priced salmon in the market; wild salmon is generally preferred to farmed salmon in Japan; sample inspection is less preferred to full inspection; government agencies were losing trust due to its poor information disclosure; and 400 yen is the highest price tag. This profile set is unlikely to exist

in a real market and, therefore, we removed this particular profile set from our choice experiments to reduce burden of respondents.

(3) Results are similar if we use a limited sample of respondents who is in charge of grocery shopping in the household.

(4) We do not consider the option of "no inspection." As the survey was conducted on August 2012 when the concern for radioactive contamination was still serious, we believe that no inspection was not an option.

(5) Note that we cannot compare the magnitude of the parameter estimates across these two columns in this table because these parameter estimates are relative to the error variance in each sample.

(6) More than one full inspection equipment may be needed to cover the entire prefecture. Also, we do not find the actual cost estimate for a full sampling equipment. Even so, however, this additional revenue seems sufficiently large.

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