Energy Economics 65 (2017) 262–270

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneeco

Public preferences for alternative electricity mixes in post-Fukushima Japan

Katrin Rehdanz [a,b,*], Carsten Schröder [c,d], Daiju Narita [e], Toshihiro Okubo [f]

[a] Kiel University, Department of Economics, Kiel, Germany
[b] Kiel Institute for the World Economy, Kiel, Germany
[c] DIW Berlin/SOEP, Germany
[d] Free University Berlin, Berlin, Germany
[e] Graduate School of Economics and Business, Hokkaido University, Sapporo, Japan
[f] Keio University, Faculty of Economics, Tokyo, Japan

ARTICLE INFO

Article history:
Received 29 May 2016
Received in revised form 7 February 2017
Accepted 25 April 2017
Available online 2 May 2017

JEL codes:
D12
Q40
Q42

Keywords:
Electricity mix
Willingness-to-pay
Preference heterogeneity
Renewables
Spatial heterogeneity
Fukushima
Nuclear power

ABSTRACT

Using representative household survey data from Japan after the Fukushima accident, we estimate peoples' willingness-to-pay (WTP) for renewable, nuclear, and fossil fuels in electricity generation. We rely on random parameter econometric techniques to capture various degrees of heterogeneity between the respondents, and use detailed regional information to assess how WTP varies with the distance to both the nearest nuclear power plant and to Fukushima. Compared to fossil fuels, we find a positive WTP for renewable and a negative WTP for nuclear fuels. These effects, in absolute terms, increase with the proximity to Fukushima.

1. Introduction

Numerous studies investigate peoples' willingness to pay (WTP) for alternative energy and electricity mixes, defined by the fuel shares of renewables, nuclear, and fossil resources in the production process. The results show that people are willing to pay a significant price premium for electricity generated from renewable sources (see Sundt and Rehdanz (2015) for a recent overview of the literature).[1] The present study focuses on Japan, a country with very little evidence on peoples' WTP for alternative electricity mixes despite the country's particular situation: its long-term energy security concerns and the March 11, 2011, Fukushima accident.[2]

Since the two oil crises in the 1970s, Japan's government has undertaken policies promoting the diversification of energy sources in order to reduce its reliance on imported oil. As a result of the diversification policy, 57 nuclear power reactors were constructed across the country. At the time of the 2011 Fukushima accident, nuclear power provided about one-third of electricity in Japan. Other than hydropower (7.5% in 2012), the share of renewable power in the domestic electricity mix has been negligible. A candidate explanation for the low share of renewables is that intensive use of renewable resources in electricity generation may raise electricity prices, which are already high by international standards (Agency for Natural Resources and Energy, 2014a).

* Corresponding author at: Kiel University, Department of Economics, Olshausenstrasse 40, 24098 Kiel, Germany.
E-mail address: rehdanz@economics.uni-kiel.de (K. Rehdanz).

[1] This is supported by social survey findings (e.g., Ertor-Akyazi et al., 2012).

[2] In Japan, about 90% of all primary energy is imported (Agency for Natural Resources and Energy, 2014a).

http://dx.doi.org/10.1016/j.eneco.2017.04.026
0140-9883/

In the aftermath of the Fukushima accident, the government changed its energy policies. Specifically, a feed-in-tariff system was introduced in July 2012 and expanding the share of renewable resources used in electricity production was put on the political agenda.[3] To stimulate the usage of renewable resources for electricity production, the Three Power Source Development Laws gave generous subsidies to local governments, while prefectures and municipalities have also benefitted from special tax revenues from the nuclear power-plant operators.[4] In order to restart and operate nuclear power plants, various regulatory and other legal hurdles were put in place. As of September 2015, there are no nuclear power plants in operation, other than Sendai-1, due to new technical examination standards set in July 2013, lack of approval by governors of local prefectures, and lawsuits by residents.

Given the challenges for Japanese energy supply on the one hand, and the security concerns on the other hand, investigating public preferences for alternative electricity mixes in post-Fukushima Japan is rather timely. In this respect, we make two contributions. First, we study consumer's WTP for different fuel mixes of renewable, nuclear, and fossil fuels in electricity generation for post-Fukushima Japan. The underlying database is a new vignette survey tool in the Keio Household Panel Survey (KHPS) that elicits peoples' preferences for different fuel mixes. These vignette-survey data are used to derive WTP for different fuel mixes using random parameter econometric techniques that can capture potential heterogeneity in peoples' preferences. Vignette studies gain more and more attention in social sciences. Indeed, Krueger and Stone (2014) assess vignettes as a new important advance toward the improvement of well-being evaluations in economic policy. The general idea of a vignette study is to place respondents in a hypothetical but well-defined situation (environment), characterized by a vector of attributes, ask the respondents for a particular outcome (here: WTP), and then repeat the task – like in a natural experiment – for a set of well-defined environments. To keep the cognitive burden for respondents low, this set can be a random subset from all possible environments. The underlying assumption for the suitability of the vignette to assess respondents' WTP, for which we find supportive evidence, is that respondents understand the environments described in the vignettes and provide credible information.[5]

Second, we augment the KHPS data with detailed accounts of spatial characteristics to study not-in-my-backyard (NIMBY) effects. i.e., it could be that residents dislike nuclear power plants in close distance. In this respect, we assess the variation of WTP with proximity to the closest nuclear power plant and, in addition, to the plant in Fukushima. The variation in the measured distances across survey respondents is used to study how WTP varies with proximity to nuclear power plants in general and to Fukushima in particular.

The remainder of the paper is as follows: The related literature is presented in Section 2. Section 3 describes the design of our survey, the survey instrument and the sample. Section 4 provides a sample breakdown and descriptive statistics of consumers' WTP. The econometric model and regression results are provided in Section 5, while Section 6 concludes.

2. Literature review

A large literature on people's WTP for alternative electricity mixes is surveyed in Sundt and Rehdanz (2015). Over space and time, these studies are unevenly distributed; most focus on European countries, are published from 2007 onward, and are more frequently based on contingent-valuation (CV) rather than choice-modeling approaches. Turning to the literature on spatial dependence, a number of studies finds support for the so-called NIMBY effect, where proximity to sites like nuclear waste depository sites, reduces support toward the location (e.g. Kraft and Clary, 1991) or raises concerns for environmental contamination (e.g. Weiner et al., 2013). Other studies have found mixed evidence including e.g. van der Horst (2007), Ansolabehere and Konisky (2009) or Greenberg (2009). The present review focuses on WTP studies for Japan.

To our knowledge, Nomura and Akai (2004) are the first to elicit information on peoples' preferences for renewable energy. They empirically implemented a dichotomous choice elicitation format, collecting data from 300 survey participants in February 2000 about their voluntary monthly contributions to a renewable energy fund that aimed at increasing the generation of electricity from renewable resources. Without further specifying the actual change in the electricity mix, they report a median WTP of ¥ 2000 (about US$16) per month and household for renewable energy.

In another study, Itaoka et al. (2006) implemented a discrete choice experiment to estimate WTP for mortality risk reductions from electric generation, and thereby distinguishing between nuclear and fossil fuels. About 900 respondents from Tokyo and Gifu City participated. They find that the WTP for a reduction of the number of deaths caused by a nuclear power plant disaster is about 60 times higher than that for a coal-fired power plant.

Ida et al. (2015) investigate the trade-off between the aim to reduce the dependence on nuclear fuels and the aim of avoiding electricity price increases. Their investigation is based on a web survey of 2000 Japanese households in February 2013, which included two choice experiments. The first experiment asked respondents to choose between two situations, differing by the dependency on nuclear power generation and electricity rates (prices). The second choice experiment was identical, but with the inclusion of a “none of the two alternatives” option. For the first experiment, Ida et al. (2015) find a WTP of about US$ 0.006 for a 1% reduction in nuclear energy. In the second experiment, the WTP is about 21% higher. Unfortunately, the energy-mix is not further specified, i.e., no information is provided on the shares of renewables or fossil fuels in the electricity mix.

Murakami et al. (2015) conducted a discrete choice experiment in February 2013 using a sample of 4000 Japanese households with the aim of deriving WTP for several attributes of electricity tariffs: the monthly bill, the fuel mix, and pollution emissions (NO_x, SO_2 and CO_2). Respondents were asked to choose between two alternatives. They find that respondents are willing to pay a premium of about US$ 0.31 (US$ 0.72) per month for a 1% increase (decrease) in renewables (nuclear) relative to fossil fuel.

Our study is in the tradition of the aforementioned studies on Japan in the sense that we rely on stated preferences for alternative fuel mixes. Like Murakami et al. (2015), we specify alternative fuel mixes, varying in the percentages of nuclear, fossil, and renewable resources used for electricity generation. However, our study also differs from previous ones on Japan. First, we apply a vignette approach that defines alternative fuel mixes and directly asks the respondents for their WTP. The design is successfully tested in empirical applications (see Section 3.1 for details). Second, we account for spatial dependence of WTP, i.e., distance between the place of residence and Fukushima as well as to the nearest nuclear

[3] In 2014, Japan's government announced an explicit, although vaguely worded, target for renewable power production in the national energy plan, stating that it “pursues the higher levels of introducing renewable energy than the levels which were indicated based on the former Strategic Energy Plans” (Government of Japan, 2014), which in effect means that the share of renewable power will become 13.5% by 2020 and 21.0% by 2030 (Agency for Natural Resources and Energy, 2014b).

[4] An example of those special taxes is the tax on nuclear fuels (the others include the tax on processing radioactive materials, which applies to some nuclear facilities other than reactors. Property taxes are also set very high for nuclear power plants).

[5] Gary King reviews applications in social sciences (http://gking.harvard.edu/vign/eg/), applied to a variety of domains: political corruption, disease risk perceptions and prevention, spousal infidelity, etc. Applications in economics include the role of work disability in the labor market (Kapteyn et al., 2007), household-size economies (Koulovatianos et al., 2005 and 2009), or WTP studies in environmental economics (Grösche and Schröder, 2011). Other examples are Bertoni (2015) who uses vignettes to link early life experiences and future well-being evaluations, and Alesina et al. (2016) who use it to analyze the linkage between intergenerational mobility and preferences for redistribution.

power plant. Such spatial interactions are identified in several previous studies,[6] but there is little evidence for Japan (see e.g. Rehdanz et al., 2015).[7] Third, we investigate the responses using random parameter econometric regression techniques in order to capture preference heterogeneity between respondents (see Grösche and Schröder, 2011).

3. Data on WTP and distance matrix

3.1. Keio electricity module

A new vignette survey was incorporated as an additional module ("electricity module") within a well-known Japanese panel study, the Keio Household Panel Survey (KHPS). KHPS is a two-stage stratified random representative panel survey conducted by Keio University.[8] It is based on a set of pre-tested questionnaires on household- and individual-level characteristics. The first KHPS wave was carried out in 2004, covering about 4000 households. In subsequent waves, the sample size ranges between 3000 and 3500 households. Interviews are carried out in January.

Every year, KHPS provides information on various characteristics of the respondents and their households: age, gender, place of residence, household composition, income, school attendance, etc. In addition to this stable set of core questions, KHPS has a module with questions on specific topics. In 2014, an electricity module was implemented for the first time. It contained a vignette survey asking people on their WTP for different fuel mixes in electricity generation. Their responses are the main ingredient of our empirical investigation.

In the KHPS electricity module, each vignette defines a particular fuel mix (tariff). In total, $T = 14$ tariffs are distinguished. Each tariff $t \in T$ is described by three attributes, i.e., the share of nuclear, s_{nuc}, renewables, s_{ren}, and fossil fuels, s_{fossil}, in the fuel mix with $s_{nuc} + s_{ren} + s_{fossil} = 100\%$. For example, $T(0; 30; 70)$ denotes a tariff with 0% of nuclear, 30% of renewables, and 70% of fossil fuels.

Each respondent was presented five vignettes, each differing in the fuel shares. Each vignette defines a reference and an alternative tariff. The reference tariff is always the same: its fuel mix matches the actual 2014 fuel mix in Japan and should be seen as the real-world anchor. Because all nuclear power plants were switched off in 2014, the nuclear share in the reference tariff is zero, the fossil share is 90%, and the renewable share is 10%. The monthly price of the reference tariff is ¥ 10,000 (about US$ 80).[9] The four alternative tariffs were drawn from the set of 14 alternative tariffs (see Table A1 for details). The shares of the fuels within a sequence of four tariffs are random in order to reduce the possibility of order effects (see Clark and Friesen, 2008).[10] All tariffs were visualized by means of pie charts (see Fig. 1).

Each respondent was asked to state the maximum prices she/he would be willing to pay for four alternative tariffs. Hence, in contrast to most previous approaches, we have refrained from providing predetermined prices. With an open-ended format (no upper/lower limit for WTP assessments) we seek to avoid biasing the response via arbitrary *ex ante* restrictions by the researchers or anchoring effects. This survey design is suggested and tested in earlier works by Menges et al. (2005) and Grösche and Schröder (2011). For more information on the instruction to the respondents see Appendix A.

To infer valid responses from the survey, respondents should demonstrate sufficient understanding of the questions. To test for this aspect of survey effectiveness, we posed a closely related assessment problem using different means of representation in the KHPS electricity module, and then cross-checked for consistency of responses from the vignette survey and the second assessment problem. Specifically, the second assessment problem asked the respondents to provide their opinions on the ideal share of renewables and nuclear in the mix. The wording was,

"*Suppose you could decide about the fuel mix in Japan. What would the mix look like?*
____ *% renewable*; _____ *% fossil;* _____ *% nuclear. Make sure that the percentages add up to 100.*"

We expect a positive correlation between the preferred renewable fuels share and the WTP for renewables, otherwise the wish for a costly greening of the mix is not substantiated by a monetary equivalent. For the ideal nuclear share and the associated WTP, the coefficient need not be positive. This is because people may prefer a high nuclear share if the electricity price is sufficiently low.

3.2. Distance data

A particular interest of our analysis is how WTP for different fuels varies with the distance to Fukushima, and also with the closest nuclear power plant in general. To enrich the KHPS dataset with these distances, we proceed as follows. In a first step, we determine the geographical coordinates (centroids) of each respondent's place of residence (municipality level) and of all nuclear power plants using geographic information systems (GIS).[11] In a second step, we use these centroids to determine the distances between all municipalities and all nuclear power plants. From these distances, we derive two variables. One variable gives the distance between the respondent's place of residence and Fukushima; another to the closest nuclear power plant.

4. Descriptive statistics

A total of 3312 households participated in the 2014 KHPS survey. Our working sample is a subset of 2313 households, smaller than the

[6] This literature is mostly related to the development of wind power (for an overview see Knapp and Ladenburg, 2015). One study focusing on the WTP of Chinese households to avoid the construction of nearby nuclear power plants is Sun et al. (2014).

[7] Based on a quasi-experimental difference-in-differences approach using panel data for Japan, Rehdanz et al. (2015), for example, find evidence for a sizeable effect of the disaster on people's subjective well-being.

[8] KHPS is based on a two-stage stratified random sampling strategy (see Kimura, 2005). In the first sampling stage, Japan is stratified into 24 regions according to a regional and city classification scheme. The number of samples for region is distributed in accordance with basic resident register population ratios. Next, the number of areas to be surveyed within each region is determined, with around ten samples for each survey area, defined by districts according to the Population Census, and a random sampling of the designated number of survey areas is implemented. For survey areas, national census survey districts are used as sampling units. In the second sampling stage, basic resident registers for the selected survey areas are utilized as sampling registers, and approximately ten respondents (five each for KHPS 2007 and KHPS 2012) for each survey area are drawn from the population. Different from other surveys, it is difficult to measure response rate in KHPS. When it is not possible to meet and/or survey an officially selected survey subject because they have moved residence, they are absent for an extended period, or their address is unknown, a pre-selected reserve survey subject will be surveyed instead, thereby maintaining the planned sample size. Reserve survey subjects are randomly selected from candidate subjects who live in the same survey district, are the same gender and are in the same age group as the official survey subject to be replaced. Accordingly, regardless of whether the person responding to the survey is an official survey subject or a reserve survey subject, no bias occurs in the sampling ratios in terms of gender and age categories.

[9] This was the average price for a multi-member household (two to four members) per month in 2013 (Family Income and Expenditure Survey; Statistics Bureau of Ministry of Internal Affairs and Communications). Although there are a number of electric utilities in Japan, within a consumption block the monthly charges for electricity are not significantly different from each other across the country. Therefore, it seems fair to assume that people have similar notions about how much electricity prices are.

[10] The WTP question was included as part of an existing annual household survey (further details are provided below). Since this household survey is paper based, we could not influence the ordering of the four contracts for individual respondents.

[11] There are 1719 municipalities as of January 2014. KHPS covers 445 municipalities for the year 2014.

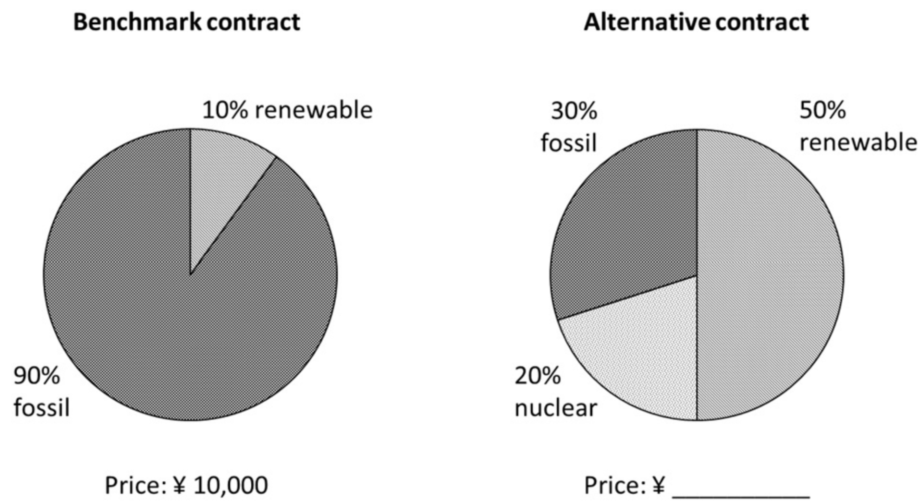

Fig. 1. Stylized survey pie chart. What is the monetary amount that you would be willing to pay at most for the contract shown on the right hand side, given that the price for the benchmark contract with 90% fossil and 10% renewables is ¥ 10,000?

entire KHPS sample due to item non response on questions relevant to our analysis in the regular survey or in the electricity module.[12]

A breakdown of our working sample is provided in Table 1. Altogether, we have roughly equal shares of females and males in our sample. About 23% of the respondents have at least a university degree. The average participating household has a disposable equivalent income[13] of about ¥ 313,500 (about US$ 2500) per month and approximately 2.7 members, of which about 15% are children up to age 15. The average respondent is about 53 years old.

For the not-in-my-backyard analysis, sufficient variation in the distance variables is essential. The distance to Fukushima varies between 44 and 1781 km, and is 487 km on average. The distance to the nearest nuclear-power varies between 2 and 682 km, and is 104 on average. In one specification, one over the distance in km (proximity) will enter the WTP regressions as explanatory variable. In another specification, we include several distance dummies. These dummies determine distances as mutually exclusive radius rings around Fukushima or around nuclear power plants in general.

Descriptive statistics on WTP assessments from the electricity module are provided in Table 2. As explained above, each respondent was asked to assess four alternative fuel mixes. In total, 2502 respondents provided WTPs, but not for all four alternative tariffs, leaving us an unbalanced panel of 9518 observations, and about 680 assessments for each hypothetical contract. The first two columns of Table 2 define the tariff (share of renewables and fossil fuels). The adjacent columns provide the number of WTP assessments, average WTP, standard deviation, and the 10th, 50th, and 90th percentile of the WTP distribution.

Table 2 reveals two regularities. First, WTP rises in the share of renewable fuels in the electricity mix. Take, for example, the tariffs $T(30;0;70)$, $T(50;0;50)$, and $T(90;0;10)$ – tariffs with a rising share of renewable fuels, a declining share of fossil fuels, and a constant share of nuclear fuels of 0%. The mean WTP rises in the share of renewables from ¥ 10,392 over ¥ 10,668 to ¥ 11,140, indicating preferences for renewables in the electricity mix. Hence, respondents are willing to pay a price premium for an increasing share of renewables in the electricity mix. Second, WTP decreases in the share of nuclear in the mix. For example, holding the renewable share constant at 50% but lowering the nuclear share from 40% to 0% (and increasing the share of fossil fuels from 10% to 50%), increases WTP from ¥ 9038 to ¥ 10,668. Hence, respondents demand a price reduction for an increasing share of nuclear in the electricity mix. It should, however, be noted that standard deviations of WTP are sizeable, pointing at substantial preference heterogeneity across respondents.

To assess the survey's effectiveness, we posed the above-mentioned auxiliary question on the perceived ideal mix of renewable and nuclear fuels in electricity generation. The results from this auxiliary question reveal a strong support for renewables: The reported ideal share of renewable fuels, averaged over the participating 2502 responses, is about 59%, the share of nuclear fuels about 30%, the remainder, the ideal fossil-fuel share, is about 11%. These numbers point at a sizeable divide between the ideal fuel mix, according to the Japanese population following the Fukushima accident, and the actual 2014 mix (0% nuclear, 10% renewable, and 90% fossil fuels).

5. Econometric analysis

5.1. Estimation strategy

Standard deviations of WTP in Table 2 indicate substantial preference heterogeneity among respondents. Random parameter techniques offer the required flexibility to cope with the heterogeneity by allowing for the estimation of respondent-specific regression coefficients. In our framework this is possible as each respondent was asked to assess four alternative electricity mixes, so that the data exhibit a panel structure.

The specific coefficient for respondent i, $\beta_{ik} := \beta_k + u_{i,k}$, is the sum of two components: a mean coefficient, β_k, for a particular fuel type k (say, the share of renewables in the electricity mix), and a random respondent-specific deviation, $u_{i,k}$. It is assumed that the respondent-specific deviations are normally distributed in the sample with zero mean and unknown standard deviation.

We model respondents' WTP assessments for the tariffs $T = 1, \ldots, 14$ in linear form as,

$$WTP_{iT} = \alpha + \sum_k (\beta_k + u_{ik}) s_{kT} + (\beta_{int} + u_{i,\, int})(s_{ren,T} \times s_{nuc,T}) + \boldsymbol{\gamma} \mathbf{C}_i + \boldsymbol{\delta} \mathbf{A}_i + \upsilon_i + \varepsilon_{i,T}, \quad (1)$$

[12] Altogether, we have 2936 households with the necessary socioeconomic background variables for the WTP analysis, from which 2313 filled-in the WTP questions of the electricity module. Table A2 in the Appendix provides results of a probit regression to check for potential sample-selection bias; i.e., the probit regression reveals if non-responses in the electricity module can be explained by observables. In general, personal characteristics have little explanatory power to explain participation in the electricity module. For our econometric WTP analysis, bias from sample selection on observables, therefore, should not be an issue. Table A3 in the Appendix provides the sample breakdown for the whole sample and the derived working sample.

[13] Disposable equivalent income is household disposable income divided by the OECD modified equivalence scale.

Table 1
Sample breakdown.

Variable	Definition	Mean	Std.dev.
D_{male}	One if respondent is male, zero otherwise	0.514	
D_{uni}	One if respondent holds a university degree, zero otherwise	0.230	
$Size$	Size of household	2.657	1.447
$s_{children}$	Share of household members of age up to 15	15.377	24.790
Age	Age of the respondent	53.251	13.214
$Income$	Disposable equivalent income per month (in ¥ 1000)	313.596	220.480
I_{ren}	Ideal share of renewable fuels	58.801	22.620
I_{nuc}	Ideal share of nuclear fuels	29.764	18.021
P_{nuc}	Proximity to next operating nuclear power plant (1/km)	0.003	0.002
P_{Fuk}	Proximity to Fukushima I (1/km)	0.015	0.028
R_{1_Fuk}	One if distance from Fukushima I ≤150 km	0.053	
R_{2_Fuk}	One if distance from Fukushima I above 150 km and up to 300 km	0.348	
R_{3_Fuk}	One if distance from Fukushima I >300 km	0.599	
R_{1_nuc}	One if distance from next operating nuclear power plant ≤50 km	0.101	
R_{2_nuc}	One if distance from next operating nuclear power plant above 50 km and up to 100 km	0.428	
R_{3_nuc}	One if distance from next operating nuclear power plant >100 km	0.471	

Note. Own computations. Number of observations is 2313. Database is KHPS 2014. Mean distance to Fukushima is 491 km (Std.dev. is 315 km) and mean distance to the next operating nuclear power plant is 104 km (Std.dev. is 72 km).

with s_{Tk} capturing the share of fuel type k in the electricity mix in contract T. We include the shares of renewables and nuclear fuels, dropping the share of fossil fuels due to multicollinearity. Further, we include the product of the shares of renewable and nuclear fuels to allow for potential interaction effects on WTP. Personal and household characteristics of the respondents are contained in vector $\boldsymbol{C}_i$. Vector $\boldsymbol{A}_i$ contains two interactions: the respondent's ideal share of renewable (nuclear) fuels with the share of renewables (nuclear) in the tariff; $INT(s_{ideal,ren} \times s_{ren,T})$ and $INT(s_{ideal,nuc} \times s_{nuc,T})$. The random effect υ_i serves to shift the regression line up or down according to the individual household's preferences. Finally, $\varepsilon_{i,T}$ is the independent and identically distributed error term. Based on Eq. (1), we specify four different models. SPEC1 is our most flexible specification. We test the sensitivity of the estimates from SPEC1 against less flexible nested specifications. SPEC2 assumes all the random respondent-specific deviations, u_{ix}, are zero. SPEC3 further excludes the assessment vector $\boldsymbol{A}_i$. SPEC4 is the most basic specification with all u_{ix} set to zero, and empty vectors $\boldsymbol{A}_i$ and $\boldsymbol{C}_i$.

We also seek to study the sensitivity of WTP with respect to the proximity to Fukushima and other nuclear-power plants. Hence, we re-estimate SPEC1 including alternative distance measures in the socio-demographics and interactions of the distance measure with the shares of renewables and nuclear in the electricity mix. The first measure is the proximity to Fukushima (or closest nuclear-power plant), defined as 1 over the distance between place of residence and plant in km ($1/km$), most importantly also interacted with the shares of renewables and nuclear in the electricity mix. This functional form presumes that the effect declines with distance in a hyperbolic fashion; WTP is higher for people closer to Fukushima or other nuclear-power plants than for people more distant. This relationship between WTP and proximity need not be supported by the data. To allow for non-linearities, we additionally use radius rings with the furthest distance serving as a benchmark. These radius rings are defined in Table 1. For each radius ring, except the furthest, we include a dummy. It is one if the distance between place of residence and plant falls within the ring; zero otherwise. The radius specification may be viewed as the more flexible one. However, it requires an arbitrary categorization of distances, and this categorization may not be innocuous for the estimates.

Table 2
WTP by contract.

Share of			WTP (¥)		
Renewables	Nuclear	Fossil	Mean	Std.dev.	Obs.
10	80	10	7,756	3,741.66	676
10	60	30	7,460	3,517.13	665
10	40	50	8,221	3,189.56	716
10	20	70	9,130	3,382.93	702
30	60	10	7,611	3,527.39	653
30	40	30	8,654	3,445.61	649
30	20	50	9,090	3,293.65	646
30	0	70	10,392	3,731.87	704
50	40	10	9,038	3,876.47	630
50	20	30	9,604	3,849.97	652
50	0	50	10,668	4,112.32	724
70	20	10	10,116	4,040.80	683
70	0	30	11,215	4,632.77	711
90	0	10	11,140	4,766.27	707

Note. Own computations. Database is KHPS 2014.

5.2. Regression results

The section focuses on WTP estimates and the issue of preference heterogeneity. The issue of spatial heterogeneity of WTP is addressed in Section 5.3.

Table 3
Regression results.

	SPEC1	SPEC2	SPEC3	SPEC4
	Coefficient s.e.	Coefficient s.e.	Coefficient s.e.	Coefficient s.e.
$Constant$	7238.236***	6967.813***	8670.476***	9455.250***
	(414.709)	(419.26)	(223.867)	(109.779)
s_{ren}	11.125***	5.733*	23.042***	22.503***
	(3.688)	(2.936)	(1.662)	(1.598)
s_{nuc}	−25.601***	−22.882***	−27.249***	−27.190***
	(2.768)	(2.684)	(2.107)	(2.029)
$s_{ren} \times s_{nuc}$	−0.271***	−0.293***	−0.295***	−0.292***
	(0.057)	(0.065)	(0.065)	(0.063)
D_{male}	164.084	88.711	74.62	
	(139.203)	(139.07)	(138.385)	
$Size$	84.21	128.109**	118.743**	
	(51.382)	(51.233)	(50.957)	
$s_{children}$	3.831	1.803	−4.458	
	(3.257)	(3.258)	(2.895)	
Age	25.543***	28.857***		
	(5.978)	(5.972)		
$Income$	1.184***	1.433***	1.368***	
	(0.323)	(0.316)	(0.315)	
D_{uni}	252.464	386.977**	312.872*	
	(166.921)	(166.599)	(164.97)	
$s_{ren} \times s_{ideal,ren}$	0.240***	0.295***		
	(0.056)	(0.041)		
$s_{nuc} \times s_{ideal,nuc}$	−0.112*	−0.150***		
	(0.068)	(0.057)		
	Standard deviation for random parameters			
	Std.dev. (s.e.)	Std.dev. (s.e.)	Std.dev. (s.e.)	Std.dev. (s.e.)
$Constant$	2586.023***	2979.080***	2966.394***	2964.640***
	(62.348)	(53.425)	(53.071)	(50.981)
s_{ren}	47.086***			
	(1.184)			
s_{nuc}	39.955***			
	(1.387)			
$s_{ren} \times s_{nuc}$	0.503***			
	(0.104)			
N	8804	8804	8804	9518
$chi2$	1336.886	2061.349	1965.26	2057.424
ll	−82,687.403	−83,406.594	−83,442.359	−90,209.779

Note. Own computations. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Database is KHPS 2014.

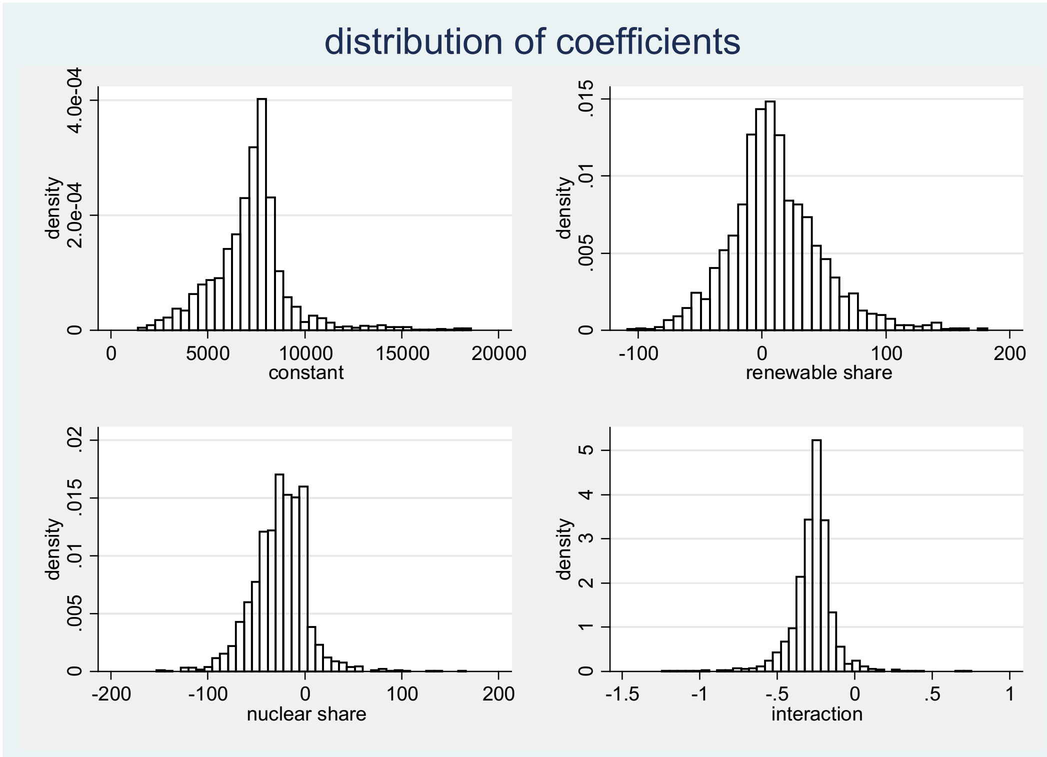

Fig. 2. Histograms of estimated coefficients (SPEC1).
Note. Own computations based on KHPS 2014 database.

Table 3 provides the regression estimates from SPEC1–4. The table is divided into three panels. The top panel provides the regression coefficients and respective standard errors, while in the random parameter model these figures refer to the average coefficients. In this regard, the middle panel reports the standard deviations for the random parameters in the respective models. The bottom panel of the Table provides summary statistics: the number of observations (N), chi-squared ($chi2$) and likelihood-ratio (ll) statistics.

The number of observations underlying SPEC4 (without controls for personal characteristics and attitudes) and SPEC1–3 are different. This is because the vectors $\boldsymbol{C}_i$ and $\boldsymbol{A}_i$ have missing values for some respondents. The regression results from SPEC1 in the main body also include respondents with incomplete information in $\boldsymbol{C}_i$ and $\boldsymbol{A}_i$. Table A4 in the Appendix also provides results from SPEC4 with the sample from specifications SPEC1–3.

Judging on the results of the chi-squared and likelihood-ratio statistics, the flexibility of the random-parameter specification SPEC1 boosts the model fit. The following discussion of the results and also the spatial analysis in the next subsection, will, therefore, concentrate on SPEC1.[14]

The marginal WTP for the share of renewables in the electricity mix is positive, as suggested by the descriptive statistics in Table 2: Compared to the reference tariff with a price of ¥ 10,000 (about US$ 80), a renewable share of 10% and nuclear share of 0%, an increase of the renewable share by 1 percentage points implies a marginal WTP of about ¥ 11 (about US$ 0.09). On the other hand, the same increase of the nuclear share (assuming the renewable share is 0%) implies a decrease of the WTP by about ¥ 26 (about US$ 0.21). Further, the interaction term between renewables and nuclear indicates that the type of fuel substitution matters. Suppose the share of renewables increases by 1 percentage point from 25 to 26% and the nuclear share falls from 25 to 24%. This means an increase of WTP by about ¥ 37 (about US$ 0.30).[15] For the same 1-percentage point increase of renewables at the expense of the fossil share (from 50 to 49%), the WTP is about ¥ 4 (about US$ 0.03).

As can be seen from the middle panel of Table 3, standard deviations of the random parameter distributions are highly significant, indicating substantial heterogeneity in respondents' WTP. This view is supported by Fig. 2, providing histograms of the joint coefficients, $\beta_{ik} := \beta_k + u_{i,k}$, and also of the respondent specific constants, $\alpha + v_i$. In sum, the histograms reconfirm our previous conclusions of a positive (negative) marginal WTP for the renewable (nuclear) share, and substantial preference heterogeneity. Indeed, a non-negligible share of the respondent-specific coefficients for the renewable share is negative. Thus, the mean coefficient for renewable fuels appears positive and statistically significant although a minority of the respondents shares a deviant opinion. Similarly, for a minority of the respondents their regression coefficients suggest a positive WTP for an increase of the nuclear share. Thus, the positive (negative) mean coefficients for the renewable (nuclear) share in all specifications (SPEC1 to SPEC4) should not be interpreted as evidence in favor of a general preference for 'green' and against 'nuclear' fuels.

For the household and personal characteristics of vector $\boldsymbol{C}_i$, we find no significant gender-related difference in WTP. Households with more members and a higher disposable equivalent income have a higher average WTP. Both the share of children among all household members and the presence of a university degree have no significant effect.

Finally, we turn to the effectiveness of the vignettes in the electricity module to provide credible information. To address this issue, we include the information on the ideal fuel mix, $\boldsymbol{A}_i$, from the auxiliary question. As explained above, $\boldsymbol{A}_i$ includes two interactions: (a) the perceived ideal share of renewable fuels (in %), $s_{ideal,ren}$, with the

[14] We also perform likelihood-ratio tests after estimation between any two model specifications. The tests support the more flexible forms. Chi-square test statistics of SPEC4 vs. SPEC3: 61.894; SPEC4 vs. SPEC2: 112.955; SPEC4 vs. SPEC1: 1544.568; SPEC3 vs. SPEC2: 51.061; SPEC2 vs. SPEC1: 1431.613; and SPEC3 vs. SPEC1: 1482.673.

[15] The value of ¥ 37 is computed as: ¥ $11.125 \times (26-25)$ − ¥ $25.601 \times (24-25)$ − ¥ $0.271 \times (26 \times 24 - 25 \times 25)$.

renewable share in the tariff, $s_{ren,T}$: $INT(s_{ideal,ren}\times s_{ren,T})$; and (b) the perceived ideal nuclear share, $s_{ideal,nuc}$, with the nuclear share in the tariff, $INT(s_{ideal,nuc}\times s_{nuc,T})$. The regression coefficient for the first interaction has the expected positive sign: respondents who prefer a high renewable share are also willing to pay more for electricity from renewable fuels. The regression coefficient for the second interaction has the expected negative sign, but the coefficient is not significant at a convenient significance level (5% or 1% level). Respondents who assess a high nuclear share as ideal are not willing to pay more for a higher share of electricity from nuclear fuels. One possible interpretation of the first positive coefficient is that respondents who prefer a high renewable share feel responsible to contribute to a 'greening' of the electricity mix. A possible interpretation of the second insignificant coefficient is that advocates of a high nuclear share expect a compensation for the high nuclear share in terms of lower electricity prices.

5.3. Spatial preference heterogeneity

This section deals with the role of not-in-my-backyard effects for WTP responses. Particularly, we study two types of effects: proximity to Fukushima and proximity to the nearest nuclear-power plant. The analysis builds on the most flexible specification SPEC 1, extended by proximity measures.

The results are presented in Table 4. The first two columns address the variation of WTP with proximity to Fukushima. The two specifications differ with respect to the proximity measure. The first specification includes proximity to Fukushima, defined as 1 over the distance in km ($1/km_{Fuk}$), interacted with the shares of renewables and nuclear in the electricity mix. The second includes proximity to Fukushima measured by the distance dummies, again interacted with the fuel shares. Altogether, three dummies are included, so that the third ring (longest distance) serves as the benchmark. The third (fourth) set includes, again as interactions, proximity (distance dummies) to closest nuclear-power plant.

Most interestingly, proximity to Fukushima turns out to be a factor for the fuel-specific WTP estimates, as seen in the first two columns of Table 4, but significant only at the 10% level of statistical significance. WTP decreases with the nuclear share, and the decrease, in absolute terms, gets larger with proximity to Fukushima. This result holds for both distance measures. Suppose we have equal shares of renewable and nuclear fuels of 25% (see footnote 15 for calculating the WTP). Now, suppose the distance between place of residence and Fukushima increases from 100 to 200 km. According to our estimates for proximity to Fukushima ($1/km_{Fuk}$), WTP increases from about ¥ 6445 (about US$ 51.50) to about ¥ 6592 (about US$ 52.70), a difference of ¥ 147 (about US$ 1.20).[16] For renewables, we find that the WTP is positive and increases with the proximity to Fukushima. Again, the coefficient is only marginally significant and this also holds for the distance-dummy specification.

While proximity to Fukushima matters for WTP estimates, this is not the case for proximity to the closest nuclear-power plant. This can be seen in columns three and four. The proximity variables are defined in analogous manner to the Fukushima-regressions. Hence, not-in-my-backyard effects are only confirmed for the damaged Fukushima reactor but not for nuclear power plants in general. A comparison of the regression coefficients from Table 4 and SPEC1 in Table 3 indicates that coefficients generally are robust to the inclusion of the proximity variables.

Previous studies find evidence that people living in urban environments have less knowledge about the risk of using nuclear fuels (e.g. Kimura et al., 2003). We test WTP stability to urbanization by including a dummy variable for (a) the three mega-city areas Tokyo, Osaka and Nagoya; (b) municipalities with high population density (more than 4000 people per km^2); and (c) cities with more than one million inhabitants. Finally, we classified municipalities according to which power company provides electricity. The Japanese electricity market consists of regional monopolies with small differences between the regions.

Including these variables does not change the results presented above (see Table A6 in the Appendix). Few of the additional variables are significant. Both in cities with more than a million inhabitants and municipalities with high population density, WTP is significantly lower.

6. Concluding remarks

The Japanese government aims at higher levels of renewable fuels in its energy mix. At the same time, nuclear reactors are slowly restarting following the introduction of new post-Fukushima regulatory standards. The present study explores how residents in Japan value fossil, nuclear and renewable fuels in their electricity mix; assessing their valuations by means of fuel-specific WTP. To our knowledge, our study is among the first to provide representative survey evidence on preferences for alternative electricity mixes in Japan, and the first for Japan after Fukushima.

Our findings from a representative vignette survey suggest people in Japan have a positive willingness-to-pay for renewable energies, but a negative one for nuclear, when compared to fossil fuels. As an example, increasing the renewable share from 25 to 26% and lowering the nuclear share from 25 to 24% implies an increase of WTP of about ¥ 37 (about US$ 0.30) per month. We also find evidence of a not-in-my-backyard effect for the Fukushima reactor: the dislike of nuclear fuels turns out to be higher for consumers whose place of residence is closer to Fukushima, but the effect is moderate in size and only marginally significant. For example, if we assume equal shares of renewable and nuclear fuels of 25% and increase the distance between place of residence and Fukushima from 100 to 200 km, people put an extra penalty of ¥ 21 (about US$ 0.20) on the nuclear share in the electricity mix.

Regarding Japan's future energy plan, our results imply a significant WTP for larger shares of renewables in Japan's electricity mix. However, in quantitative terms WTP is small. Increasing the share of renewables from 10% (actual share in 2014) to 50% and reducing the fossil share from 90% (share in 2014) to 50%, respondents would be willing to pay 9% more as compared to the 2014 base tariff.[17] To further put our estimates in perspective, future research could integrate our estimates into a more general cost–benefit framework that includes all economic costs and benefits related to a transformation of Japan's electricity system. Our study should be seen as a first step in this direction.

Whether WTP surveys provide accurate information, of course, is open to debate (see, for example, the critical review in Bertrand and Mullainathan, 2001): framing or ordering effects or the hypothetic nature of the survey, for example, may affect the way people respond to the survey. With a carefully designed questionnaire, however, we hope to have minimized such biases. Most importantly, we implemented a previously tested survey design (see Grösche and Schröder (2011) for details), did not restrict WTP responses to a narrow range, and avoided suggestive language. Further, to avoid interviewer effects and biases from social desirability that arises if respondents want to answer politically correct in front of the interviewer, the survey was carried out in anonymous form. Finally, we also posed a question about perceived ideal electricity mixes in order to assess the effectiveness of the vignettes and did not find conflicting evidence.

Inherent in the nature of surveys, however, is the lack of real monetary incentives, i.e., an incentive-compatibility mechanism that aligns respondents' assessments with immediate financial consequences. If the lack of financial consequences means that respondents

[16] Including the insignificant coefficient for P_{Fuk}, the numbers change slightly; WTP increases from about ¥ 6339 (about US$ 50.70) to about ¥ 6539 (about US$ 52.30), a difference of ¥ 200 (about US$ 1.60).

[17] The relative change of WTP for the base tariff is computed from the estimates from SPEC 4 in Table 3, $WTP = 9455.25 + 22.503\times s_{ren} - 27.190\times s_{nuc} - 0.292\times s_{ren}\times s_{nuc}$, as: $\frac{9455.250+22.503\times50-27.190\times0-0.292\times50\times0}{9455.250+22.503\times10-27.190\times0-0.292\times50\times0} - 1$.

Table 4
Regression results of SPEC1 accounting for spatial heterogeneity.

	Proximity Fukushima	Radius ring Fukushima	Proximity nuclear	Radius ring nuclear
	Coefficient (s.e.)	Coefficient (s.e.)	coefficient (s.e.)	coefficient (s.e.)
Constant	7267.224***	7260.921***	7250.425***	7285.215***
	(−431.169)	(−420.359)	(−417.279)	(−421.818)
s_{ren}	7.621*	9.053**	11.134***	10.815***
	(−4.169)	(−3.864)	(−3.778)	(−4.053)
s_{nuc}	−21.960***	−23.949***	−25.136***	−25.543***
	(−3.334)	(−2.986)	(−2.869)	(−3.121
$s_{ren} \times s_{nuc}$	−0.271***	−0.272***	−0.271***	−0.271***
	(−0.057)	(−0.057)	(−0.057)	(−0.057)
D_{male}	162.732	162.156	163.022	167.539
	(−139.196)	(−139.214)	(−139.195)	(−139.248)
Size	84.4	84.501	83.666	85.764*
	(−51.4)	(−51.394)	(−51.383)	(−51.404)
$s_{children}$	3.869	3.854	3.886	3.873
	(−3.258)	(−3.258)	(−3.258)	(−3.258)
Age	25.587***	25.582***	25.594***	25.764***
	(−5.979)	(−5.98)	(−5.978)	(−5.987)
Income	1.183***	1.181***	1.180***	1.185***
	(−0.323)	(−0.324)	(−0.323)	(−0.323)
D_{uni}	253.523	256.042	250.303	245.601
	(−166.937)	(−167.574)	(−166.932)	(−167.075)
P_{Fuk}	−10,569.477			
	(−37,589.526)			
R_{1_Fuk}		38.184		
		(−386.085)		
R_{2_Fuk}		−80.632		
		(−182.65)		
P_{nuc}			−853.803	
			(−3170.938)	
R_{1_nuc}				−153.361
				(−296.997)
R_{2_nuc}				−113.672
				(−180.775)
$s_{ren} \times s_{ideal,ren}$	0.238***	0.238***	0.240***	0.240***
	(−0.056)	(−0.056)	(−0.056)	(−0.056)
$s_{nuc} \times s_{ideal,nuc}$	−0.112*	−0.111	−0.112*	−0.111
	(−0.068)	(−0.068)	(−0.068)	(−0.068)
$s_{nuc} \times P_{Fuk}$	−1177.353*			
	(−605.098)			
$s_{ren} \times P_{Fuk}$	1181.342*			
	(−647.152)			
$s_{nuc} \times R_{1\_Fuk}$		−12.102*		
		(−6.291)		
$s_{nuc} \times R_{2\_Fuk}$		−2.991		
		(−2.947)		
$s_{ren} \times R_{1\_Fuk}$		6.996		
		(−6.669)		
$s_{ren} \times R_{2\_Fuk}$		5.250*		
		(−3.126)		
$s_{nuc} \times P_{nuc}$			−31.906	
			(−52.166)	
$s_{ren} \times P_{nuc}$			−0.316	
			(−53.462)	
$s_{nuc} \times R_{1\_nuc}$				1.947
				(−4.812)
$s_{nuc} \times R_{2\_nuc}$				−0.667
				(−2.926)
$s_{ren} \times R_{1\_nuc}$				0.713
				(−5.085)
$s_{ren} \times R_{2\_nuc}$				0.535
				(−3.105)
	Standard deviation for random parameters			
	Std.dev. (s.e.)	Std.dev. (s.e.)	Std.dev. (s.e.)	Std.dev. (s.e.)
Constant	2587.700***	2588.073***	2585.688***	2585.267***
	(−62.294)	(−62.299)	(−62.342)	(−62.347)
s_{ren}	46.982***	46.977***	47.094***	47.093***
	(−1.184)	(−1.184)	(−1.184)	(−1.184)
s_{nuc}	39.836***	39.857***	39.936***	39.938***
	(−1.387)	(−1.387)	(−1.388)	(−1.388)

(continued on next page)

Table 4 (*continued*)

	Standard deviation for random parameters			
	Std.dev. (s.e.)	Std.dev. (s.e.)	Std.dev. (s.e.)	Std.dev. (s.e.)
$s_{ren} \times s_{nuc}$	0.501*** (−0.104)	0.500*** (−0.104)	0.503*** (−0.104)	0.503*** (−0.104)
N	8804	8804	8804	8804
chi2	1352.059	1351.965	1337.996	1338.195
Ll	−82,681.958	−82,681.898	−82,686.986	−82,686.874

Note. Own computations. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Standard errors in parentheses. Database is KHPS 2014.

de-emphasize the attribute price (Goett et al., 2000:27), our WTP estimates should be seen as an upper bound of true WTP. However, this is still an open issue.[18]

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements

The data analysis in this paper utilizes Keio Household Panel Survey (KHPS) data provided by the Panel Data Research Center at Keio University.

Okubo acknowledges financial support from the Japan Society for the Promotion of Science through the Grant-in-Aid for Scientific Research (16K03652).

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.eneco.2017.04.026.

References

Agency for Natural Resources and Energy, 2014a. Enerugii Hakusho 2014 ("White Paper of Energy 2014") (in Japanese).

Agency for Natural Resources and Energy, 2014b. Saisei enerugii wo meguru genjou to kadai June 17, 2014. http://www.meti.go.jp/committee/sougouenergy/shoene_shinene/shin_ene/pdf/001_03_00.pdf.

Ajzen, I., Brown, T.C., Rosenthal, L.H., 1996. Information bias in contingency valuation: effects of personal relevance, quality of information, and motivational orientation. J. Environ. Econ. Manag. 30, 43–57.

Alesina, A., Stantcheva, S., Teso, E., 2016. Intergenerational Mobility and Preferences for Redistribution, Mimeo. University, Harvard.

Ansolabehere, A., Konisky, D.M., 2009. Public Attitudes toward Construction of new Power Plants. Public Opin. Q. 73 (3), 566–577.

Bertoni, M., 2015. Hungry today, unhappy tomorrow? Childhood hunger and subjective wellbeing later in life. J. Health Econ. 40, 40–53.

Bertrand, M., Mullainathan, S., 2001. Do people mean what they say? Implications for subjective survey data. Am. Econo. Rev. 91, 67–72.

Clark, J., Friesen, L., 2008. The causes of order effects in contingent valuation surveys: an experimental investigation. J. Environ. Econ. Manag. 56, 195–206.

Cummings, R.G., Taylor, L.O., 1999. Unbiased value estimates for environmental goods: a cheap talk design for the contingent valuation method. Am. Econ. Rev. 89, 649–666.

Diamond, P., 1996. Testing the internal consistency of contingent valuation surveys. J. Environ. Econ. Manag. 30, 337–347.

Diamond, P.A., Hausman, J.A., 1994. Contingent valuation: is some number better than no number? J. Econ. Perspect. 8, 45–64.

Ertor-Akyazi, P., Adaman, F., Ozkaynak, B., Zenginobuz, U., 2012. Citizens' preferences on nuclear and renewable energy sources: evidence from Turkey. Energy Policy 47, 309–320.

Goett, A.A., Hudson, K., Train, K.E., 2000. Customers' Choice among Retail Energy Suppliers: The Willingness-to-pay for Service Attributes. The Energy 21, 1–28.

Government of Japan (2014) Strategic Energy Plan, Cabinet Decision Made on April 11, 2014, 2014.

Greenberg, M.R., 2009. NIMBY, CLAMP, and the location of new nuclear-related facilities: U.S. National and 11 site-specific surveys. Risk Anal. 29, 1242–1254.

Grösche, P., Schröder, C., 2011. Eliciting public support for greening the electricity mix using random parameter techniques. Energy J. 33, 363–370.

Ida, T., Takemura, K., Sato, M., 2015. Inner conflict between nuclear power generation and electricity rates: a Japanese case study. Energy Econ. 48, 61–69.

Itaoka, K., Saito, A., Krupnick, A., Adamowicz, W., Taniguchi, T., 2006. The effect of risk characteristics on the willingness to pay for mortality risk reductions from electric power generation. Environ. Resour. Econ. 33, 371–398.

Kapteyn, A., Smith, J.P., van Soest, A., 2007. Vignettes and self-reports of work disability in the United States and the Netherlands. Am. Econ. Rev. 97, 461–473.

Kimura, M., 2005. The sample characteristics of the 2004 Keio household panel survey (2004nen Keio Gijuku Kakei Paneru Chosa no Hyohon Tokusei), Chapter 1. In: Higuchi, Y. (Ed.), Dynamism of Household Behavior in Japan [I] (Nihon no Kakei Kodo no Dainamizumu [I]). Keio University Press, Tokyo, pp. 13–41 (in Japanese).

Kimura, H., Furuta, K., Suzuki, A., 2003. Psychological factors affecting public acceptance of nuclear energy: comparative analysis focusing on regional characteristics and degree of knowledge. Trans. At. Energy Soc. Jpn. 2 (4), 379–388 (in Japanese).

Knapp, L., Ladenburg, J., 2015. How spatial relationships influence economic preferences for wind power — a review. Energies 8, 6177–6201.

Koulovatianos, C., Schröder, C., Schmidt, U., 2005. On the income dependence of equivalence scales. J. Public Econ. 89, 967–996.

Koulovatianos, C., Schröder, C., Schmidt, U., 2009. Nonmarket household time and the cost of children. J. Bus. Econ. Stat. 27, 42–51.

Kraft, M.E., Clary, B.B., 1991. Citizen Participation and the NIMBY Syndrome: Public Response to Radioactive Waste Disposal. The Western Political Quarterly 44, 299–328.

Krueger, A.B., Stone, A.A., 2014. Progress in measuring subjective well-being. Science 346 (6205), 42–43.

List, J.A., 2001. Do explicit warnings eliminate the hypothetical bias in elicitation procedures? Evidence from field auction experiments. Am. Econ. Rev. 91, 1498–1507.

Loomis, J., Brown, T., Lucero, B., Peterson, G., 1997. Evaluating the validity of the dichotomous choice question format in contingent valuation. Environ. Resour. Econ. 10, 09–123.

Menges, R., Schroeder, C., Traub, S., 2005. Altruism, warm glow and the willingness-to-donate for green electricity: an artefactual field experiment. Environ. Resour. Econ. 31, 431–458.

Murakami, K., Ida, T., Tanaka, M., Friedman, L., 2015. Consumers' willingness to pay for renewable and nuclear energy: a comparative analysis between the US and Japan. Energy Econ. 50, 178–189.

Neill, H.R., Cummings, R.G., Ganderton, P.T., Harrison, G.W., McGuckin, T., 1994. Hypothetical surveys and real economic commitments. Land Econ. 70, 145–154.

Nomura, N., Akai, M., 2004. Willingness to pay for green electricity in Japan as estimated through contingent valuation method. Appl. Energy 78, 453–463.

Rehdanz, K., Welsch, H., Narita, D., Okubo, T., 2015. Well-being effects of a major negative externality: the case of Fukushima. J. Econ. Behav. Organ. 116, 500–517.

Smith, V.K., Osborne, L.L., 1996. Do contingent valuation estimates pass a 'Scope' test. J. Environ. Econ. Manag. 31, 287–301.

Sun, C., Lyu, N., Ouyang, X., 2014. Chinese public willingness to pay to avoid having nuclear power plants in the neighborhood. Sustainability 16, 7197–7223.

Sundt, S., Rehdanz, K., 2015. Consumers' willingness to pay for green electricity: a meta-analysis of the literature. Energy Econ. 51, 1–8.

van der Horst, D., 2007. NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. Energy Policy 35 (5), 2705–2714.

Weiner, M.D., MacKinnon, T.D., Greenberg, M.R., 2013. Exploring the gender gap and the impact of residential location on environmental risk tolerance. J. Environ. Psychol. 36, 190–201.

[18] See the general discussion in Diamond and Hausman (1994), Ajzen et al. (1996), Diamond (1996), and Smith and Osborne (1996), and case studies such as Cummings and Taylor (1999), List (2001), Loomis et al. (1997) or Neill et al. (1994).