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"Local Citizens' Preferences for Offshore Wind Turbine Development: An Empirical Evidence from Four Prospective Prefectures in Japan"

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Title

Local Citizens' Preferences for Offshore Wind Turbine Development: An Empirical Evidence from Four Prospective Prefectures in Japan

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Abstract

The purpose of this study is to investigate local citizens' recognition of offshore wind power and to evaluate their preferences for offshore wind turbines in four prefectures in Japan, namely, Akita, Chiba, Fukuoka, and Nagasaki, where is promoted areas of offshore wind power. Although the development of offshore wind power is an important measure for Japan to achieve a decarbonized society by 2050, local opposition is one of the main barriers to promoting offshore wind power. This study conducts an online survey and choice experiment with 2400 respondents from the four prefectures. The survey reveals that 55% of respondents agree with the promotion of offshore wind power. Those who opposes the offshore wind power concerns about the durability of turbines and future removal plans. Moreover, the mixed logit model shows that people prefer a greater distance from turbines, a larger number of turbines but not too many, and less impact on marine ecosystems. The model also shows the heterogeneous preferences among individuals and prefectures. Furthermore, the ordered logit model demonstrates that those who recognize the possible contributions of offshore wind turbines are likely to accept the development of offshore wind turbines while those who are concerned about the negative impact of turbines on the marine landscape and removal plans seem to oppose the turbines. The study highlights the importance of tailoring offshore wind farm strategies to local concerns to effectively build consensus among stakeholders.

Keywords

Social acceptance; Offshore wind power; Preference heterogeneity; Choice experiment; Carbon neutral

1. Introduction

The average global temperature has increased by about 0.5°C over the past 100 years. The main cause of climate change is greenhouse gases emitted from the use of fossil fuels. Global average temperatures are projected to increase by 0.8°C to 3.5°C by 2100 without immediate action to reduce carbon dioxide emissions (IPCC, 2019). Ensuring sustainable energy has long been required to address climate change, which is one of the most pressing challenges facing humanity (Yergin, 2012). The United Nations has set ambitious sustainable development goals for sustainable energy that is economically rational and reliable (United Nations, 2015). An important approach to mitigate climate change is the rapid expansion of low-carbon energy alternatives to fossil fuel energy. Various pathways have been proposed for the transition from fossil fuels to renewable energy.

Offshore wind energy plays an important role in the transition to renewable energy in several countries, including Japan, with wide coastal areas (Foxon et al., 2010; Green & Vasilakos, 2011; Jacobson & Delucchi, 2011). Offshore wind energy can be implemented on a large scale, which realize cost-effective energy generation. This is one of the greatest advantages of offshore wind power generation from an economic perspective. Offshore wind power is the most promising renewable energy source in Japan (Public-Private Council on Enhancement of Industrial Competitiveness for Offshore Wind Power Generation, 2020). The Japanese government is working to achieve a goal by the 'Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities' from April 2019. To promote the development of offshore wind farms, the Japanese government has designated several potential areas for the construction of turbines based on various conditions in each local area, such as geographic formation, availability of ports and harbors, low impact on fisheries, identifiability of stakeholders, and so on. As of 2023, 24 locations

(12 prefectures) have been identified as candidates for offshore wind. For example, Hibiki-nada in Fukuoka Prefecture is one of the proposed areas for the construction of offshore wind turbines (see also Figure 1).

The development of large offshore wind turbines often leads to local opposition movements. For example, Nippon Hoso Kyokai (a Japanese public broadcaster referred to as NHK) reported that local opposition to the construction of offshore wind turbines has been raised in several areas in Japan (NHK, 2023). The local protests against offshore wind turbines occur for several reasons: protecting the marine landscape, preventing the degradation of marine ecosystems, and avoiding the negative impact on local fisheries (Haggett, 2011; Iwata et al., 2023; Joalland & Mahieu, 2023; Shimada et al., 2022). The campaign against the construction of offshore wind energy is not only taking place in Japan, but also in a large part of the world (Devine-Wright & Howes, 2010; Joalland & Mahieu, 2023; Jones & Richard Eiser, 2010; H. J. Kim et al., 2019). The local opposition cannot be ignored by the government and the power company to develop offshore wind power systems because an agreement with the local residents is required to develop offshore wind power systems. Therefore, it is essential to investigate the local citizens' preferences for offshore wind farms in order to build stakeholder consensus.

Previous studies have explored people's preferences for offshore wind turbines. Quantitative assessments of preferences for offshore wind are often based on surveys of the general public, local residents, and tourists. Choice experiments and cost-benefit analysis are used to assess the impact of an offshore wind energy development project on Korean citizens (H. J. Kim et al., 2019). The results suggest that the project is not beneficial to the public. Various characteristics are identified that influence whether Korean citizens accept a large-scale offshore wind energy installation (H. Kim et al., 2020). Korean public's preference for offshore wind farms in general (J. H. Kim et al., 2021). Preferences for wind energy development in Ireland are explored by a questionnaire survey from the perspective of intermittency that affects the stability of the electricity system (Brennan & van Rensburg, 2023). As a result, heterogeneous preferences are observed with respect to intermittency solutions. Discrete choice experiments with a national sample in France investigates the impact of large-scale offshore wind energy projects on marine activities (Joalland & Mahieu, 2023). The results show that employment in the marine economy, the impact on the supply of fresh seafood, and the availability of recreational activities are also important perspectives to consider for public acceptance. This is in contrast to previous literature, which has mainly focused on the visibility of wind farms and their impact on marine biodiversity.

Other studies have identified the characteristics of local residents and tourists who are receptive to offshore wind facilities. The adaptability of offshore wind are discussed based on a literature review of onshore wind, resulting that the common factors that influence people's responses are identified (Haggett, 2011). The impact of offshore wind farms on coastal tourism in Languedoc-Rousillon (southern France) are evaluated by choice experiments (Westerberg et al., 2013). The results reveal that age, nationality, vacation activities, and loyalty to the destination influenced attitudes toward compensation policies. Desired compensation strategies are studied by a survey with recreational users in the Bay of Saint-Brieuc, where an offshore wind farm is planned (Kermagoret et al., 2016). The study concludes that compensation schemes based on strong sustainability principles, including ecosystem restoration for the benefit of the entire population, would be more acceptable for the uses. The impact of wind farms on their rental decisions are assessed (Lutzeyer et al., 2018), showing that renters could lose up to 10% of their rental value if their views were degraded by wind farms within 8 miles of the coast.

The social acceptance of wind power in Japan has also been examined in the previous literature. The influence of citizen initiatives on the social acceptance of renewable energy and social change through the study of local citizen-operated wind power systems (Maruyama et al., 2007). Most Japanese people have a negative attitude toward the development of new wind turbines, while they are receptive to existing local wind turbines (Motosu & Maruyama, 2016). The differences in citizens' preferences for renewable energy between eastern and western Japan are investigated (Nakano et al., 2018). Several key factors that affect the social acceptance of renewable energy in Japan are identified by incorporating spatial data on renewable and non-renewable power plants, natural and productive capital, and renewable energy potential (Keeley et al., 2022).

However, local residents' recognition of and preferences for offshore wind power projects in areas where offshore wind turbines are to be built have yet to be investigated. Exploring local people's perceptions and preferences for offshore wind energy provides an effective strategy for gaining local consent. It is necessary to better understand the perceptions and preferences of local residents and avoid conflicts with them for the further development of offshore wind power and the achievement of a carbon-neutral society in the future. In addition, there are no baselines for examining how people's perceptions and preferences change as offshore wind turbines become operational in the future (Rand & Hoen, 2017). By identifying baselines, it is possible to assess the long-term impact of offshore wind turbines on people's perceptions and preferences.

This study conducts an online survey in the four candidate prefectures for offshore wind farms in Japan (Akita, Chiba, Fukuoka, and Nagasaki prefectures) and choice experiments to assess local preferences for turbines ($N = 2400$). In this study, a study sample is collected from not only the closest areas to turbines but also the entire area of candidate prefectures.

The remainder of this paper is organized as follows. Section 2 shows the materials and the methodology of this study. Section 3 reports the results of the data analysis. Section 4 discusses the interpretation of the results and concludes the study.

2. Material and Method

2.1. Study Sites

Study sites of this study are the four prefectures in Japan: Akita, Chiba, Fukuoka, and Nagasaki (Figure 1). They have been designated as potential sites for the development of offshore wind facilities by the Japanese government, and in some areas the construction is already implemented. For example, in Fukuoka Prefecture, Hibiki-nada (Figure 1(d)) has been designated as an area for promoting offshore wind power development, and the government, municipality, and construction companies develop plans to build large-scale offshore wind turbines. In the plan, twenty-five wind turbines will be built and each turbine will reach 200 meter above sea level (Yomiuri Shinbun, 2023).

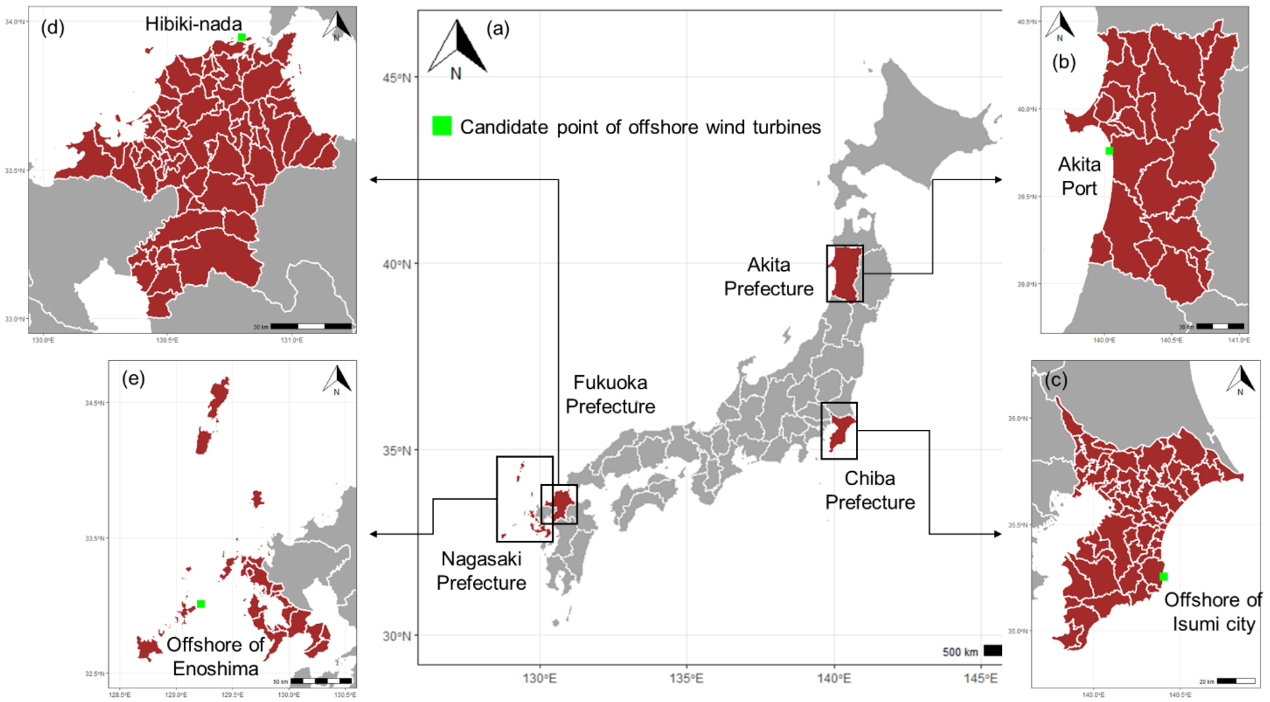

Figure 1. Four candidate prefectures for offshore wind turbines in Japan.

2.2. Survey Design and Choice Experiments

An online survey is conducted from February 2 to February 8, 2023 among a representative sample of 2400 people in the four prefectures (i.e., 600 respondents each in Akita, Chiba, Fukuoka, and Nagasaki prefectures). The main purpose of the survey is to investigate residents' perceptions and preferences for offshore wind power to be built in their prefecture. The questionnaire includes the following items: an interest in the environment and energy sources; individual relevance to the sea; knowledge and opinions about offshore wind power; choice experiments; socio-economic characteristics. The survey instrument of this study is provided in supplementary material.

Choice experiments are used to assess residents' preferences for the construction of an offshore wind farm along their coastline. Choice experiments are one form of conjoint analysis and a widely used environmental evaluation method that elicits respondents' preferences for objects represented by multiple attributes (Louviere et al., 2000). Respondents repeatedly choose their preferred options from several options that have different attribute levels. This experimental method evaluates respondents' preferences from different attributes of options that influence their decisions. In addition, the use of a monetary attribute allows us to assess the monetary value of the marginal change in the attributes.

Five attributes are employed in the choice experiments of this study to describe a hypothetical offshore wind turbine: *distance* (distance between offshore wind turbine and the coast); *number* (the number of turbines in the construction area); *species* (the percentage of marine species that affected by the construction of the turbine); *carbon* (the percentage of reducing carbon dioxide in a year by offshore wind turbine); and *payment* (annual payment for conduct offshore wind power generation). The level of each attribute is summarized in Table 1.

Table 1. Choice experiment attributes and their levels.

Attribute	**Symbol**	**Level**
Geographic distance between offshore wind turbine and the coast	*distance*	1, 5, and 20 km
The number of turbines in the construction area	*number*	20, 40, and 60 turbines
The percentage of marine species that affected by the construction of the turbine	*species*	0, 10, and 30 percent
The percentage of reducing carbon dioxide in a year by offshore wind turbine	*carbon*	5, 15, and 30 percent
Annual payment for conduct offshore wind power generation	*payment*	0, 1000, 3000, 7000, 10000 JPY per year

The procedure for designing choice experiments is as follows. 54 hypothetical offshore wind turbines (*option*) are generated by combining the attribute levels. Three hypothetical options constitute one choice experimental task without duplication, and thus, 18 tasks are generated. Three groups are generated and each group have six tasks without duplication. The respondents of this study are randomly divided into the three groups, and each respondent faces only six choice tasks. When designing choice experiments, D-efficiency is considered. A D-efficient choice design provides more statistically efficient results compared to the standard orthogonal design (Huber & Zwerina, 1996). Note that the choice tasks in the study do not include a status quo option. This is because the residents of the four prefectures have realistic difficulties in choosing the status quo option because the four prefectures are potential sites for the construction of offshore wind farms. The example of choice experiment tasks is presented in Table 2.

Table 2. Example of choice experiment task.

Attribute	Option 1	Option 2	Option 3
Geographic distance between offshore wind turbine and the coast	20 km	1 km	5 km
The number of turbines in the construction area	40 turbines	60 turbines	20 turbines
The percentage of marine species that affected by the construction of the turbine	10 percent	0 percent	30 percent
The percentage of reducing carbon dioxide in a year by offshore wind turbine	15 percent	30 percent	5 percent
Annual payment for conduct offshore wind power generation	1000 JPY	7000 JPY	0 JPY
Please choose the most preferred option	☐	☐	☐

Note: The original task is provided to the respondents in Japanese. The Japanese version is presented in supplementary material. To visualize the geographic distance to turbines, participants are presented with three images of turbines of different sizes representing the distance (Figure A1, A2, and A3 in Appendix).

2.3. Estimation Strategy

This study applies a mixed logit model and an ordered logit model to investigate local citizens' recognition and preferences for offshore wind turbines. The mixed logit model is used to estimate individual preference parameters of each attribute describing offshore wind turbines and to calculate individual WTP for the attributes.

Mixed logit model represents a flexible and practical model assuming the preference heterogeneity among individuals (McFadden & Train, 2000; Train, 2009). Estimation model assumes that the random utility model represents individual choice behavior. The utility, U_{njt}, which an individual receives based on his/her choice, is defined as follows:

$$U_{njt} = V_{njt} + \varepsilon_{njt} = \beta_n' x_{njt} + \varepsilon_{njt}, \tag{1}$$

where V_{njt} is the observable utility; $n \in (1, 2, \ldots, N)$, and $j \in (1, 2, \ldots, J)$, and $t \in (1,2, \ldots, T)$ are the indexes of the individuals, alternatives, and tasks in the choice experiments, respectively; β_n' is the taste parameter of individual n; and ε_{njt} is a random draw from a type I extreme value distribution. The choice probability of the series of choices, y_n, made by respondent n is expressed as a conditional logit model as follows:

$$P_{ni}(\beta) = \prod_{t=1}^{T} \left[\frac{\exp\,(\beta' x_{nit})}{\sum_j \exp\,(\beta' x_{njt})} \right]. \tag{2}$$

The conditional logit model assumes that the taste parameters are identical across individuals, which is an unrealistic assumption. In contrast, the mixed logit model assumes that the preferences are heterogeneous across individuals, which allows individuals to have different taste parameters. Mixed logit probabilities are obtained by integrating the conditional logit probabilities with the distribution of β since the individual taste parameter, β_n, is unknown. Thus, mixed logit probability is described by the following form:

$$P_{nit}(\theta) = \int \prod_{t=1}^{T} \left[\frac{\exp(\beta' x_{nit})}{\sum_j \exp(\beta' x_{njt})} \right] g(\beta|\theta) d\beta\,, \tag{3}$$

where $g(\beta|\theta)$ is the probability density function of β with the parameter θ. Here, it is assumed that $g(\beta|\theta)$ is a normal distribution with an estimated mean and a standard deviation for all attributes used in the choice experiments except for *payment*. Note that it is difficult to algebraically perform the integral calculation using equation (3). Therefore, a simulation method is used to maximize simulated log-likelihood and obtain the taste parameters.

The individual marginal WTP for attribute k ($MWTP_{k,i}$) except for *payment* is calculated for all individuals as follows:

$$MWTP_{k,i} = -\beta_{k,i} / \beta_{payment,i} \quad (4)$$

where β_k denotes the parameter of attribute k and $\beta_{payment}$ is the parameter of *payment*.

Ordered logit model is adopted to evaluate how independent variables influence a dependent variable (Train, 2009). This model estimates the probability of each categorical outcome from more than two discrete choices, in which the log odds of the outcomes are modeled as a linear combination of independent variables. An underlying score is estimated as a linear function of the independent variables and a set of cut points. The probability of observing outcome i corresponds to the probability that the estimated linear function, together with the random error, lie within the range of the cut points computed for the outcome:

$$\Pr(y_i = i) = \Pr(k_{i-1} < \beta' x + \varepsilon < k_i), \quad (5)$$

assuming that ε is logistically distributed in ordered logit. Then we can estimate the coefficients $\beta_1, \beta_2, \dots, \beta_k$ together with the cut points $k_1, k_2, \dots, k_{k-1}$. k is interpreted as the number of possible outcomes, with k_0 being $-\infty$ and k_k being $+\infty$.

3. Results

3.1. Survey Results

Table 3 summarizes the key socio-economic characteristics of the respondents. The questionnaire asks whether Japan should promote offshore wind power generation using a 5-point Likert scale (i.e., 5: Should promote; 4: Should promote somewhat; 3: Neutral; 2: Should not promote somewhat; 1: Definitely should not promote). As a result, 1331 respondents (55.5% of respondents) demand promotion of offshore wind firms (that is, they chose 5 or 4), 895 respondents (37.3%) are still neutral (that is, they gave 3 as an answer), and the remaining 174 respondents (7.2%) oppose to offshore wind (that is, they told 2 or 1). About half of the respondents are still ambivalent about the construction of offshore wind power.

Table 3. Results of socio-economic characteristics and other factors.

Variables	Description	Mean	SD	Min	Max
age	Age in years	49.40	11.58	18	69
female	= 1 if a respondent is female, = 0 otherwise	0.43	0.50	0	1
income	Household annual income: = 1 if < 2 million, = 2 > 2 million and < 4 million …, = 6 > 10 million and < 15 million, = 7 > 15 million and < 20 million, = 8 > 20 million, = 9 "I do not know"	4.28	2.60	1	9
stability	5-point Likert scale: = 1 if a respondent does not interest in energy stability at all, …, = 5 if a respondent strongly interests in it	3.95	1.03	1	5
landscape	5-point Likert scale: = 1 if respondent does not interest in landscape conservation at all, …, = 5 if a respondent strongly interests in it	3.75	1.03	1	5
biodiversity	5-point Likert scale: = 1 if a respondent does not interest in biodiversity conservation at all, …, = 5 if a respondent strongly interests in it	3.52	1.08	1	5

sea.visible	= 1 if sea is visible from a respondent's house, = 0 otherwise	0.23	0.42	0	1
sea.visit	5-point Likert scale: = 1 if a respondent visits sea once in these 10 years, = 2 few times in these 10 years, = 3 a few times in a year, = 4 1–3 times in a month, = 5 more than 1 time in a week	2.98	1.06	1	5
knowledge	4-point Likert scale: = 1 if a respondent does not know about offshore wind power generation, …, = 4 if a respondent knows well	2.33	0.85	1	4
clean.energy	5-point Likert scale: = 1 if a respondent does not interest in cleaner energy at all, …, = 5 if a respondent strongly interests in it	3.76	1.06	1	5
distance.promote	Geographic distance (km) between the proposed offshore wind turbine development site in each prefecture and each respondent's location, as indicated by the respondent's zip code	47.59	24.45	0.02	178.94
akita	Respondent in Akita prefecture	0.25		0	1
chiba	Respondent in Chiba prefecture	0.25		0	1
nagasaki	Respondent in Nagasaki prefecture	0.25		0	1
fukuoka	Respondent in Fukuoka prefecture	0.25		0	1

Table 4 provides the summarized results of respondents' hopes and concerns for offshore wind project. The results indicate that respondents highly evaluate the potential contribution of offshore wind projects on securing an internal energy source, new industry creation, and prioritized power supply in the case of emergency compared to other contributions.

Table 4. Recognitions of potential contributions and concerns for offshore wind projects.

Variables	Description	Mean	SD
Potential contributions			
cc_expect	The degree of hopes for climate change countermeasures (Dummy variable: 1 hope for the contribution; 0 do not hope)	0.64	0.48

es_expect	The degree of hopes for energy sources that do not rely on imports (Dummy variable: 1 hope for the contribution; 0 do not hope)	0.75	0.44
ic_expect	The degree of hopes for the creation of new industries (Dummy variable: 1 hope for the contribution; 0 do not hope)	0.70	0.46
lc_expect	The degree of hopes for local job creation (Dummy variable: 1 hope for the contribution; 0 do not hope)	0.62	0.49
si_expect	The degree of hopes for the creation of new tourism resources (Dummy variable: 1 hope for the contribution; 0 do not hope)	0.45	0.50
nl_expect	The degree of hopes for the creation of new landscapes (Dummy variable: 1 hope for the contribution; 0 do not hope)	0.42	0.49
pe_expect	The degree of hopes for priority power supply in times of emergency (Dummy variable: 1 hope for the contribution; 0 do not hope)	0.68	0.46
Potential impacts			
hr_concern	The degree of concerns about health hazards due to noise, vibration, and infrasound (Dummy variable: 1 concern about the impact; 0 do not concern)	0.54	0.50
ll_concern	The degree of concerns about loss of existing landscape (Dummy variable: 1 concern about the impact; 0 do not concern)	0.52	0.50
im_concern	The degree of concerns about the impact on marine ecosystems (Dummy variable: 1 concern about the impact; 0 do not concern)	0.67	0.47
if_concern	The degree of concerns about the impact on local industries such as fishing (Dummy variable: 1 concern about the impact; 0 do not concern)	0.67	0.47
du_concern	The degree of concerns about durability against natural disasters (Dummy variable: 1 concern about the impact; 0 do not concern)	0.70	0.46
rt_concern	The degree of concerns about the removal of wind turbines after the project is completed (Dummy variable: 1 concern about the impact; 0 do not concern)	0.68	0.47
de_concern	The degree of concerns about unstable power supply (Dummy variable: 1 concern about the impact; 0 do not concern)	0.63	0.48

Note: Each dummy variables are generated using a 5-point Likert scale variable. For the dummy variables of respondents' hopes, the answer 'Highly hope' or 'Hope' is set to 1 'hope for the contribution' and the answer 'do not hope', 'do not hope at all', or 'I do not know' is set to 0 'do not hope'. In the same manner, the dummy variables of respondents' concerns are created. The answer ‘very concern’ or ‘concern’ is set to 1 ‘concern about the impact’ and the answer ‘do not concern’, ‘do not concern at all’, and ‘I do not know’ is set to 0 ‘do not concern’.

Figure 2 illustrates the results of local residents' expectations of potential benefits from offshore wind farms for the three groups of respondents. Overall, the results suggest that those with neutral or negative attitudes towards offshore wind farms are less likely to expect potential benefits from offshore wind farms than those with positive attitudes. This point is the large difference between the three groups. In particular, the contribution of offshore wind to climate change mitigation, the creation of new job opportunities, and new landscape creation are not expected by those who do not support offshore wind. From these perspectives, heterogeneity in people's attitudes towards offshore wind farms may be generated. It should also be noted that the rate of "I do not know" is higher in groups that are indifferent to offshore wind and do not support it. Policy makers and developers need to provide sufficient information to local people about the benefits of offshore wind energy to gain local understanding and support.

Figure 3 describes the concerns of local people about several potential problems caused by offshore wind development for the three groups. It is interesting to note that there is no significant difference in concerns about offshore wind between those who are supportive and those who are neutral. The potential negative impacts of offshore wind development may already be shared by local people, regardless of their attitudes toward offshore wind. It should also be noted that the proportion of "I don't know" is higher in the sample that is neutral towards offshore wind. This suggests that they may have less knowledge about it and therefore cannot decide their own attitudes towards offshore wind farms. The results also show that local people who are opposed to offshore wind have relatively strong concerns about it. This result is intuitive. In addition, the results show that they are concerned about the durability of the turbines against natural disasters and the removal of the turbines. Concerns about the robustness of wind farms make sense given that Japan is a country where natural disasters are frequent and increasing in intensity. In addition, local people are concerned about the negative impact of offshore wind turbines on marine species and local fisheries. Policy makers and developers should present the information about their concerns and dissolve their anxiety about the development of offshore wind turbines.

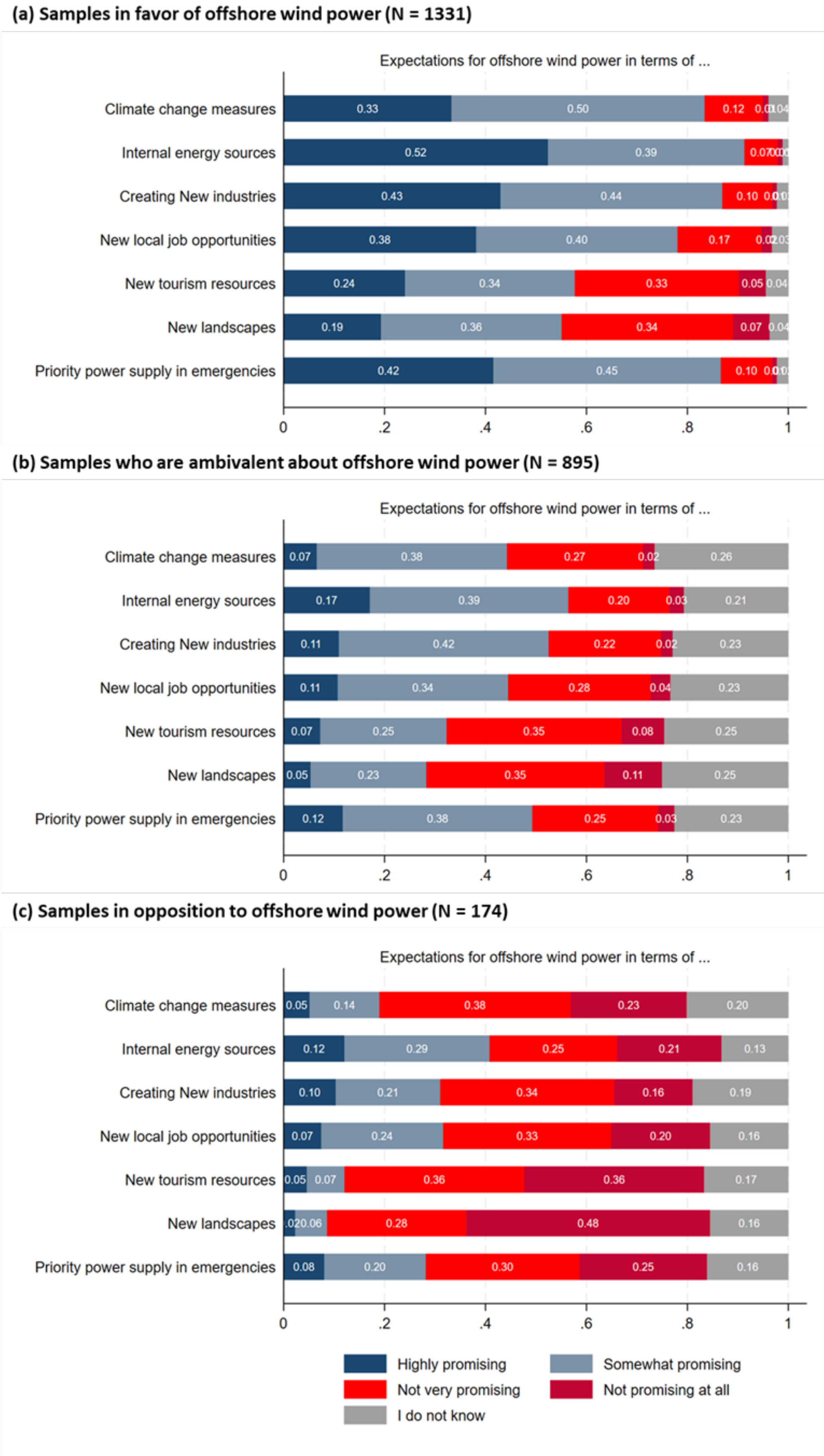

Figure 2. Expectations for several potential benefits of offshore wind farms.

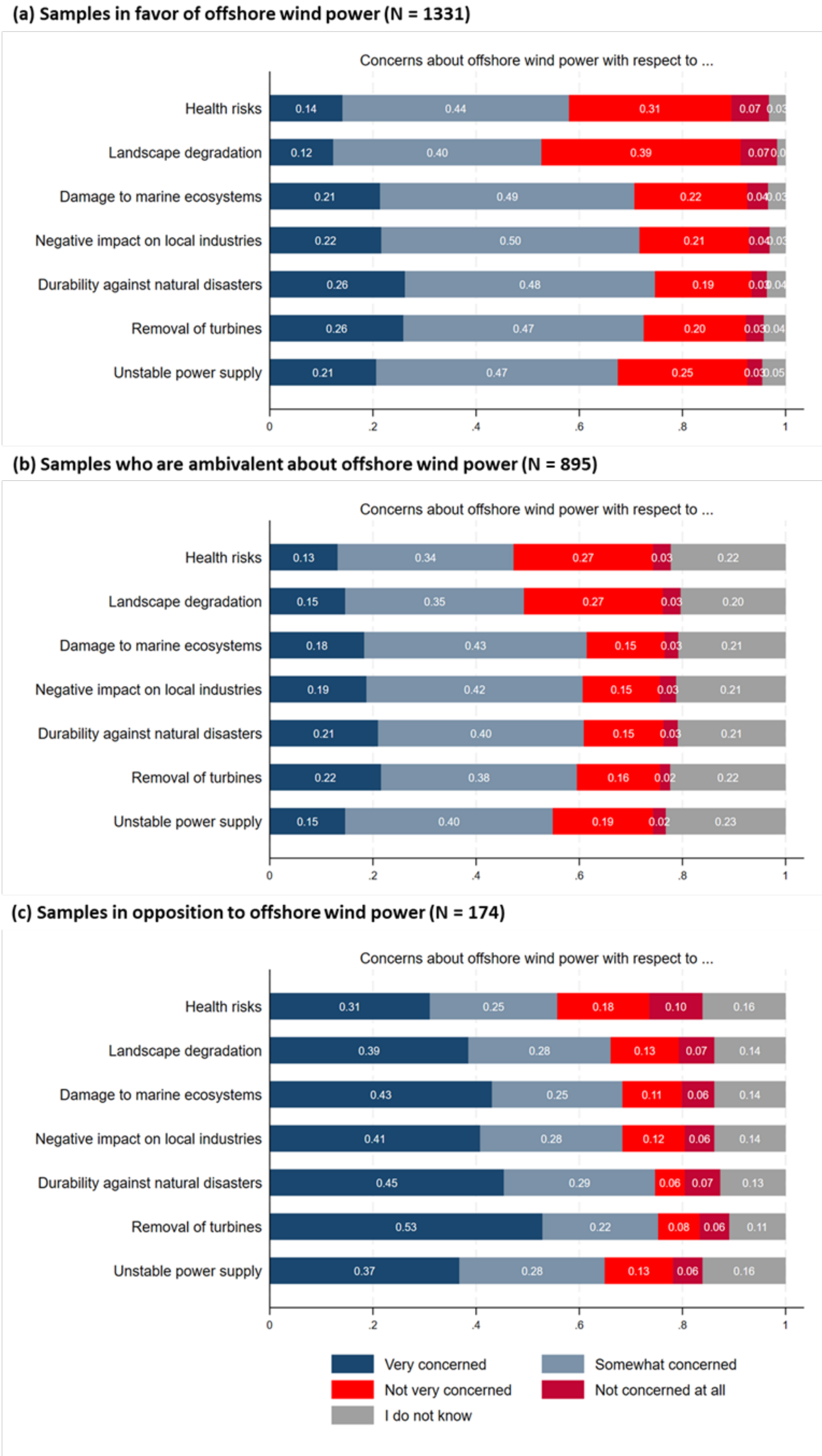

Figure 3. Concerns for several potential issues occurred by offshore wind farms.

3.2. Choice Model Results

Table 5 shows the estimation results of the mixed logit model with a pooled sample. Model 1 is the base model, and Model 2 includes a squared number of turbines (*sq_nturbine*) and other choice experiment attributes. Model 2 accounts for the nonlinear effects of *nturbine* by *sq_nturbine*. The results of model 1 show that the coefficients for *payment* are negative with statistical significance. This is consistent with economic theory. The coefficient and standard deviation of distance is statistically significant above zero on average. This means that respondents prefer a greater distance between turbines and a coast and have heterogeneous preferences. The coefficient of *species* is negative and statistically significant, which means that participants do not welcome an increase in the number of marine species affected by wind turbines. The standard deviation of *species* is statistically significant, which means respondents have heterogeneous preferences. On the contrary, the coefficients of *nturbine* and *carbon* are on average not statistically significantly different from zero. The standard deviation of *carbon* is statistically significant. In model 2, as in model 1, *payment* and *species* have negative coefficients, and *distance* has a positive coefficient on average with statistical significance. The result of standard deviations is similar to those of model 1. In contrast to Model 1, the coefficient of *nturbine* is above zero and the coefficient of *sq_nturbine* is below zero on average with statistical significance. This means that although participants prefer a large number of turbines, the increase in utility is non-linear and decreases as the number of turbines increases.

Table 5 also provides calculated WTP values based on model 2. The average WTP for distance is 281.1 JPY per year per household. This means that each household would pay 281.1 JPY for an additional kilometer to the turbines from the coast. WTP for *nturbine* and *sq_nturbine* is 504.4 and -7.2 JPY on average, respectively. This suggests that households would make payment for additional turbines, but the amount of additional payment would be decreased as the number of additional turbines increase. Households show a negative WTP for an increase in the proportion of marine species affected by turbines. On average, households would pay -289.9 JPY for each one percent increase in the proportion.

Table 5. Results of Mixed Logit Model with Pooled Sample.

	Model 1		Model 2		
Variables	**Coefficient**	**SD**	**Coefficient**	**SD**	**WTP (JPY/year/household)**
payment	-0.123***		-0.140***		
(1000 JPY)	(0.0161)		(0.0162)		
distance	0.0282*	0.0520***	0.0394**	0.0522***	281.1
	(0.0162)	(0.00227)	(0.0161)	(0.00229)	[118.4 – 445.9]
nturbine	-0.00395	-0.000602	0.0705***	0.000933	504.4
	(0.00911)	(0.00360)	(0.0138)	(0.00412)	[232.0 – 776.8]
sq_nturbine			-0.00100***		-7.2
			(0.000141)		[-9.6 – -4.8]
species	-0.0317***	0.0336***	-0.0405***	-0.0343***	-289.9
	(0.00968)	(0.00150)	(0.00966)	(0.00151)	[-361.7 – -218.2]
Carbon	0.00508	-0.0222***	0.0105	-0.0233***	75.2
	(0.00657)	(0.00176)	(0.00656)	(0.00175)	[-0.3 – 150.7]
Observations	43,200		43,200		
Log-likelihood	-14398		-14373		

Note: Coefficient is the mean value among respondents. Standard errors are presented in parentheses. *** p<0.01, ** p<0.05, and * p<0.10. Square brackets provide 95% interval of calculated WTP values.

Table 6 shows the results of the mixed logit model using split samples. The results indicate the diverse preferences among prefectures. The coefficients of *payment* are different among the samples in each prefecture. The coefficient has the smallest value in the Akita sub-sample and the largest value in the Fukuoka sub-sample. This variation may be due to differences in the average incomes of the prefectures. The coefficient of *distance* is positive and statistically significant in Akita, while it is insignificant in the other subsamples. The coefficient of *species* is negative and statistically significant in the Akita, Chiba, and Nagasaki subsamples. The coefficient of *carbon* is statistically significantly positive only with the Akita subsample.

Table 6. Results of Mixed Logit Model with Divided Samples.

	Akita		Chiba		Fukuoka		Nagasaki	
Variables	**Coefficient**	**SD**	**Coefficient**	**SD**	**Coefficient**	**SD**	**Coefficient**	**SD**
payment	-0.204***		-0.130***		-0.0814**		-0.143***	
(1000 JPY)	(0.0329)		(0.0321)		(0.0325)		(0.0321)	
sq_nturbine	-0.0012***		-0.0009***		-0.0010***		-0.0009***	
	(0.000284)		(0.000281)		(0.000289)		(0.000278)	
distance	0.0935***	0.0547***	0.0282	0.0502***	-0.0126	0.0551***	0.0469	0.0501***
	(0.0327)	(0.00457)	(0.0320)	(0.00451)	(0.0326)	(0.00477)	(0.0319)	(0.00443)
nturbine	0.0537*	0.00483	0.0678**	0.000645	0.107***	-0.00428	0.0582**	0.00000
	(0.0280)	(0.00864)	(0.0276)	(0.00563)	(0.0282)	(0.00882)	(0.0273)	(0.00799)
species	-0.0712***	-0.0373***	-0.0374*	-0.0317***	-0.00847	-0.0368***	-0.0440**	-0.0323***
	(0.0196)	(0.00304)	(0.0192)	(0.00303)	(0.0195)	(0.00310)	(0.0191)	(0.00301)
carbon	0.0307**	-0.0196***	0.00805	-0.0225***	-0.0112	-0.0301***	0.0141	-0.0218***
	(0.0133)	(0.00391)	(0.0130)	(0.00346)	(0.0133)	(0.00330)	(0.0130)	(0.00352)
Observations	10,800		10,800		10,800		10,800	
Log-likelihood	-3545		-3598		-3589		-3624	

Note: Coefficient is the mean value among respondents. Standard errors are presented in parentheses. *** $p<0.01$, ** $p<0.05$, and * $p<0.10$.

3.3. Estimation Results of Ordered Logit Model

The ordered logit model can be applied to an ordinal dependent variable like a Likert scale. In this study, the dependent variable indicates respondents' acceptance of promoting offshore wind projects ranging from "*oppose promoting*" to "*should promote*", that is, 5-point Likert scale. Table 7 presents the estimation results of the ordered logit model. Based on the log-likelihood ratio test, the estimated equations are statistically significant (the test statistic and the corresponding *p*-values are 1018 and 0.00, respectively).

Table 7. Results of estimating the ordered logit model.

Variables	Coefficient	Standard Error	95% Confidential Interval
age	0.007**	0.004	[0.000 – 0.015]
female	-0.334***	0.090	[-0.510 – -0.159]
income	-0.031*	0.017	[-0.065 – 0.003]
elecuse	-0.009	0.013	[-0.036 – 0.017]
see_sea	0.052	0.103	[-0.150 – 0.254]
visit_sea	0.053	0.042	[-0.030 – 0.135]
know_owp	0.445***	0.059	[0.329 – 0.561]
akita	-0.150	0.121	[-0.387 – 0.087]
chiba	0.071	0.119	[-0.162 – 0.303]
fukuoka	0.101	0.115	[-0.125 – 0.327]
cc_expect	1.067***	0.114	[0.843 – 1.292]
es_expect	0.498***	0.139	[0.225 – 0.771]
ic_expect	0.433***	0.138	[0.162 – 0.705]
lc_expect	0.192	0.123	[-0.048 – 0.432]
si_expect	-0.063	0.122	[-0.302 – 0.176]
nl_expect	0.418***	0.117	[0.189 – 0.648]
pe_expect	0.902***	0.126	[0.655 – 1.150]
hr_concern	0.064	0.100	[-0.132 – 0.260]
ll_concern	-0.578***	0.103	[-0.779 – -0.377]
im_concern	-0.228	0.141	[-0.504 – 0.048]
if_concern	-0.082	0.141	[-0.359 – 0.194]
du_concern	-0.003	0.119	[-0.235 – 0.230]
rt_concern	-0.209*	0.108	[-0.421 – 0.003]
de_concern	-0.164	0.103	[-0.367 – 0.038]
Observations	2400		
Pseudo R^2	0.167		
Log-likelihood	-2537		
Log-likelihood ratio test statistics (*p*-value)	1018 (0.00)		

Note: *** p<0.01 and ** p<0.05.

The results show that socio-economic characteristics have an impact on supportive attitudes towards offshore wind projects. The estimated coefficient on the variable *know_owp* has a positive sign with statistical significance at the 1% level. This implies that those with more knowledge about offshore wind are more supportive of the project than those with less knowledge. The estimated coefficient of *female* has a negative sign with statistical significance at the 1% level. This suggests that men are more supportive of offshore wind projects than women. Furthermore, 47.3% of males and 73.3% of females are unaware of offshore wind power, suggesting that differences in awareness of offshore wind power between males and females have an impact on attitudes (see Table 8). The *age* estimates are statistically positively significant. This indicates that those who are older tend to have more favorable attitudes towards offshore wind projects than those who are younger. Contrary to expectations, however, *income* estimates are negatively significant. In other words, we see that households with higher incomes tend to be less favorable towards the project. The estimates of the coefficients on *elecuse, see_sea*, and *visit_sea* are not statistically significant. This is an interesting finding since these variables are often thought to influence project acceptance in Japan.

Table 8. Gender differences in perceptions of offshore wind energy.

know_owp	**Male**	**Female**	**Total**
Not at all	143	257	400
	(10.48)	(24.83)	(16.67)
Do not know much	502	502	1,004
	(36.78)	(48.5)	(41.83)
Slightly aware	561	235	796
	(41.10)	(22.71)	(33.17)
Very familiar	159	41	200
	(11.65)	(3.96)	(8.33)
Total	1,365	1,035	2,400
	(100)	(100)	(100)

Note: The percentages of responses within each gender are shown in parentheses.

The coefficient estimates for *Akita*, *Chiba*, and *Fukuoka* are not statistically significant. It is not yet clear whether this is a regional (prefectural level) effect on whether one supports or does not support offshore wind power.

People's recognition of the potential contributions of offshore wind projects to the local and global has an effect on the attitude towards the projects. The estimated coefficients of *cc_expect*, *es_expect*, *ic_expect*, *nl_expect*, and *pe_expect* variables are above zero with statistical significance. This means that those who expect the project to combat climate change, create energy sources that do not rely on imports, create new industries, create new landscapes, and provide priority power supply in case of emergencies are more supportive of the project than others. The estimated coefficients of *ll_concern* and *rt_concern* variables have negative signs with statistical significance. This implies that those concerned about the loss of existing landscape, and the removal of the turbines after the project completion are less favorable to the project than others.

4. Discussion and Conclusion

4.1. Interpretation of Results

The results reveal that more than a half of local residents (55.5 %) in the four prefectures where the development of offshore wind turbines is promoted encourage the development. This is consistent with the results of a previous study (Rand & Hoen, 2017). Such inhabitants recognize the potential contribution of offshore wind to the securement of internal energy sources and prioritized power supply in the case of emergency. This result is consistent with previous study (Devine-Wright & Wiersma, 2020; Firestone et al., 2012). On the contrary, those who are indifference (37.3%) or opponent (7.2%) concern about durability of turbines and removal plans of the turbines in the future.

The results also highlight that offshore wind may not be a recreational facility, but only an energy source for local people. For all three groups, the potential benefit of offshore wind as a domestic energy source is the most promising. In Japan, improving energy self-sufficiency rate are one of the urgent issues (Ministry of Economy, Trade and Industry Agency for Natural Resources and Energy, 2021) and the recent sharp rise in energy prices triggered by the Russia-Ukraine crisis. As a result of these facts, citizens may be more motivated to improve the country's energy vulnerability. This result is in line with the previous study (Firestone et al., 2012; Liebe et al., 2017). Further, they expect priority power supply in case of emergency, which is reasonable given the frequency of natural disasters in Japan. The results also suggest that people may not view the construction of offshore wind turbines as a recreational opportunity, such as a new place to visit and a new landscape.

Local residents recognize the impact of offshore wind turbine on local environment such as potential changes in the marine landscapes and marine ecosystems from the diverse perspectives. Regarding the distance to turbines, the negative impacts on marine species, and the contribution of carbon emissions reduction, preference heterogeneity among individuals and the four prefectures are revealed. These results are consistent with previous study (Firestone & Kempton, 2007; Firestone et al., 2012; Iwata et al., 2023). In contrast to other attributes, local people show less importance of the contribution of offshore wind power on climate change mitigation. This result implies that local residents would not perceive the offshore wind power as global public goods.

Based on the results of the ordered logit model, the higher level of awareness of offshore wind, the more likely the respondents support offshore wind projects. Females has the more negative impression of project promotion compared to males, which may also be explained by differences in the level of awareness. Therefore, it is important to accurately publicize the new technology of offshore wind power especially to women.

The coefficient of *age* is statistically positively significant. This may be due to the relatively low level of awareness among the younger generations, just as the difference in awareness between genders affects attitudes towards offshore wind projects. The government needs to make efforts to increase awareness of offshore wind among the younger generation, partly because it is a new technology and is expected to become the next generation energy source. The reason that people with lower income are more supportive of projects may be interpreted as a relatively higher expectations of new job creation among people with lower income. However, there are still many unclear points that require further elaboration.

The amount of electricity consumption does not affect attitudes towards project support. Although the variables would be expected to be positive for economic incentive reasons, the results show statistical insignificance. This may be because few people believe that the spread of renewable energy sources such as offshore wind power in Japan will lead to lower electricity prices, and in fact, a certain percentage of the population believe that electricity prices will become higher. The coefficients of *see_sea* and *visit_sea* are not statistically significant. These variables do not affect attitudes towards the project among those who have high/low involvement with the sea. Although these variables would be expected to be negative due to concerns about possible changes to the familiar coastal landscape, the results are not statistically significant.

There are notable differences between supporters and opponents in their recognition of the potential contributions and concerns of offshore wind projects. Compared to those who oppose, those who support offshore wind projects are more likely to see the potential contribution of projects to climate change mitigation, the creation of indigenous energy sources, the creation of new industries, the creation of new landscapes, and priority power supply in the case of an emergency. However, those opposed to the project are more concerned about the loss of existing landscapes and the removal of wind turbines once the project is completed. Therefore, policymakers and developers need to pay particular attention to these two concerns as they move forward with their plans. Furthermore, differences in the recognition would cause or exacerbate conflicts among people. Simply emphasizing the benefits of offshore wind projects and seeking to change people's perceptions will not resolve this conflict. Rather, policymakers should address the perception discrepancy by developing an appropriate disclosure process regarding the issues that people are concerned about.

4.2. Policy Implications for Increasing Social Acceptance Levels

For increasing social acceptance levels, policymakers and developers should understand locals' recognition of and preferences for offshore wind turbines. Based on the survey results, approximately a half of people would be neutral or disagree to the development of offshore wind power. This could be a source of opposition movements. The results also suggest that those who disapprove of offshore wind turbines concern the removal of turbines in the future in particular. Policymakers and developers would benefit from provisioning information of the development and future removal plan to local stakeholders.

Based on the results, desired construction plans of offshore wind turbines are pointed out in general. Turbines should be constructed distant from the coast to avoid degrading the landscape. The number of turbines should be increased but not too many. The results suggest

35 turbines would be the best. Influencing marine ecosystem should be avoided. The electricity generated should be used preferentially by the local community. Naturally, however, each areas have unique conditions and context such as the gradient of submarine, existing marine species, available resources, the number of fisheries, decision-making processes, local culture and history. These factors could produce local oppositions. Local development plans of offshore wind projects must be compatible with local situations to accomplish social acceptance, which is strongly echoed by Haggett (2011).

4.3. Limitations and Future Work

Although these contributions of this study, three limitations and corresponding future work should be acknowledged. First, certain local stakeholders such as fisheries are excluded from the respondents. This is because this study uses an online-based survey that collects responses broadly, but may omit a particular individual from the sample. Future work should investigate the recognition and preferences of local fisheries through semi-structured interview surveys, for example. Second, this study does not identify causal relationships between local awareness and attitudes. Future studies should explore causal relationships to provide more robust evidence for policy implications. Experimental approaches may be useful. Third, this study addresses social acceptance from the dimension of *community acceptance* by identifying local public recognition and preferences (Wüstenhagen et al., 2007). Future study should be expanded to examine other key factors of community acceptance: *procedural justice*, *distributional justice*, and *trust*.

4.4. Conclusion Remarks

This study investigates the local public's awareness and preferences for offshore wind turbines. The online survey and choice experiments are conducted in the four prefectures of

Japan, and the mixed logit and ordered logit models are applied to the choice data. The main findings are threefold. First, a majority of residents in the four prefectures support the promotion of offshore wind projects. 55.5% of the respondents are in favor of the development of offshore wind turbines in their own area. It should be noted that 37.3% are still neutral and 7.2% are against. Second, the preferences of local residents for offshore wind turbines are assessed. In general, locals prefer a greater distance from turbines, a large number of turbines but not too many, and less negative impact on marine ecosystems. They are not interested in the carbon reduction potential of offshore wind. People's preferences are heterogeneous across individuals and prefectures. Third, those who recognize the potential contribution of offshore wind to climate change mitigation and emergency power supply are more likely to accept the development of offshore wind. On the contrary, those who are concerned about the negative impact of turbines on the landscape and plans for turbine removal are likely to oppose offshore wind.

The findings of this study should be effectively integrated into a strategy to achieve community and social acceptance. Currently, there are still no conceptual golden rules and even no tailor-made measures to increase the local acceptance level (Haggett, 2011; Wiersma & Devine-Wright, 2014), resulting in the oppositions that is emerging at the local level. This would be due to less understanding of the heterogeneous recognition and preferences of local citizens between areas. Considering the different conditions of the areas, valid approaches have to be developed to realize social acceptance for offshore wind turbines at the local level.

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