

An estimation of the social costs of landfill siting using a choice experiment

Toshiaki Sasao*

Faculty of Humanities and Social Sciences, Iwate University, 18-34, 3-Chome Ueda,
Morioka, Iwate, 020-8550, Japan

Abstract

This paper examines public preferences on siting landfills using a choice experiment. A choice experiment is a method that elicits public preferences directly through questionnaires. This paper focuses on possible negative effects of a hypothetical landfill siting on residents who are assumed to live around the landfill. The results of this analysis clearly show that the residents evaluate accepting waste originating from outside their community quite negatively, especially industrial waste originating from the Tokyo Metropolitan Area. Large external costs also are seen for siting landfills near areas that are sources of drinking water. In addition, the results show that the NIMBY syndrome of the residents weakens as the hypothetical landfill site is farther away. Considering three hypothetical siting plans, external costs based on public preferences are estimated. The social costs, which are the sum of the private costs and external costs, are then calculated. The results of the case study indicate that the option with the lowest private cost it is not always the option with the lowest social cost.

Keywords: Landfill siting, Social costs, Choice experiments, Public preferences, NIMBY

1.Introduction

Landfill shortage is a serious problem in most developed countries, including Japan. Nevertheless, the risk of contamination and pollution resulting from landfills and the lack of information given to the public create a NIMBY (not in my backyard) syndrome

* Corresponding author. Tel & Fax: +81-19-621-6751
E-mail address: tsasao@iwate-u.ac.jp

concerning siting of landfills. The NIMBY syndrome happens when the public refuses to have landfills sited near their houses although they admit the necessity for them, and it makes siting new landfills difficult. During consultation on siting landfills the public will often comment that waste management policy makers should provide more information. The negative effects caused by landfill siting can be expressed in monetary terms, which are often called external costs. The external costs of siting landfills are a kind of welfare loss that the managers of landfills do not pay but that the residents who live around them are obliged to bear. It is important for the policy makers and the managers of landfills to reduce the external costs from the perspective of social efficiency.

This paper examines public preferences on siting a landfill using a choice experiment (CE). This method is a type of stated preference technique that elicits public preferences directly through questionnaires. In the questionnaires, respondents are assumed to be residents who live around a landfill site. This study focuses on three possible negative effects of landfill siting. The first is how the residents evaluate the acceptance of waste originating from outside their community. The second is how the NIMBY phenomenon is observed in the surrounding area of the landfill. The third is how the public evaluates siting a landfill near areas that are sources of drinking water or residential areas. Using empirical results, the paper then examines the external costs and private costs (land costs, development costs, and so on) for three hypothetical landfill plans.

This paper proceeds as follows. Section 2 overviews some existing studies about plans for siting waste disposal facilities that include landfills, and about environmental valuations for the facilities. Section 3 explains the theoretical model in the background of CE. Section 4 outlines the questionnaire used for this experiment. Section 5 shows the empirical results. Section 6 examines the external costs and the social costs of the hypothetical landfill siting. Section 7 summarizes the main results.

2. Background

There are socio-economical studies and environmental valuations that relate to siting waste disposal facilities. First, an overview of some of the socio-economical studies is provided. O'Hare et al. (1983) took up the issue of the NIMBY problems caused by siting waste disposal facilities and pointed out the necessity for a compensation scheme. Mitchell and Carson (1986) also recommended a compensation

scheme subject to a clarification of property rights. As for the method of the compensation scheme, Kunreuther and Kleindorfer (1986), Kunreuther et al. (1987) and Minehart and Neeman (2002) created a low-bid auction model. In the model, each community submits a sealed bid indicating the minimum amount it would require to accept the facility. The community submitting the lowest bid accepts the facility and receives compensation sufficient to cover its bid. Swallow et al. (1992) suggested a three-stage approach to site selection including not only technical choice based on expert advice, but also social choice based on public preferences.

Environmental valuation methods, that include contingent valuation (CV), pair-wise rating, choice experiment (CE) and a hedonic method, have been used to examine public concerns over environmental resources or environmental management. CV, pair-wise rating and CE elicit public preferences for environmental issues using survey questions by finding out what they would be willing to pay for specified improvements (Bateman et al. 2002, Freeman et al. 1993, Mitchell and Carson 1989). The hedonic method is a model to examine the monetary values of non-market amenities and disamenities (Freeman et al. 1993).

Environmental valuation methods are also useful for examining the siting of waste disposal facilities. Regarding environmental valuations applied to waste disposal facilities, Roberts et al. (1991) and Groothuis and Miller (1994) conducted experiments using the CV method. Opaluch et al. (1993) conducted an experiment using pair-wise rating to examine impacts from a noxious facility, and the results were adopted for an actual siting plan in the U.S. Garrod and Willis (1998) conducted a CE and has examined marginal willingness to pay (MWTP) to reduce noise, odor and dust from a landfill. Hirshfeld et al. (1992), Nelson et al. (1992) and Kohlhose (1991) examined to what extent the negative effects of a landfill can fall on the residents who live around it using the hedonic method, and Smith and Desvousges (1986) examined this using the CV and hedonic methods.

These studies show that landfills generate negative effects on surrounding areas and are NIMBY facilities. Moreover, some of them examine public preferences on siting waste disposal facilities using various methods. To gain detailed knowledge of public preferences, pair-wise rating and CE are useful because these methods are multi-attribute preference-elicitation techniques. In particular, CE is more similar to consumers' choice-behavior in the real economy, and it is easier for respondents to answer than pair-wise rating. However, there are only a few studies that apply CE to the evaluation of siting landfills. There are no studies using CE that examine how the residents evaluate the acceptance of waste originating from outside their community

and the siting of a landfill near their own houses. In addition, there are no studies that examine the external costs and the social costs of siting landfills using CE. Therefore, this paper examines the public preferences on siting landfills using CE, including the above issues.

3. Model

In this paper, a CE is applied to elicit public preferences on siting a landfill. To conduct the CE, data collected through a questionnaire survey were used. In the questionnaires, three sets of alternatives (plans) consisting of five attributes relating to a landfill site are shown, and the respondent is asked to select the one they most prefer. An example of the questionnaires used in this survey is shown in Figure 1. The collected data are then analyzed econometrically using the following conditional logit model or multinomial logit model in the background of the CE. This clarifies the utility parameter of each attribute that shows public preference weights on siting a landfill. The marginal willingness to pay (MWTP) of each attribute is calculated. The MWTP shows how much the public are willing to pay maximally for one-unit change of an attribute (for instance, 1 km further away from the landfill site). In this way, it shows the public valuation of each attribute in monetary terms. In this section, the theoretical model for the CE is first shown, followed by how to calculate MWTP.

Please select your preferred plan, considering the balance between each attribute in each plan. Then, please mark the plan at the bottom line.

	Plan 1	Plan 2	Plan 3	
Cost (Special Tax)	3,000 yen	1,000 yen	8,000 yen	
Range of accepting waste	Only MSW in Iwate Prefecture	Including industrial waste in the Metropolitan Area	Only MSW in Morioka City	
Number of houses	100 houses	400 houses	100 houses	
Drinking water source exists	Exist	Doesn't exist	Doesn't exist	
Distance from your house	1 km	6 km	3 km	None
Check the preferred plan				

*If you prefer neither, please select "None."

Figure 1 : A sample question used in the study.

3.1 CE structure

First, every respondent is assumed to be rational in that they make choices to maximize their perceived utility subject to constraints on expenditure. However, there are many errors in the maximization because of imperfect perception, optimization and because the analyst cannot measure exactly all the relevant variables. Hence, every respondent is assumed to have a random utility function (Ben-Akiva and Lerman 1985, Louviere et al. 2000 and Maddala 1983). In the random utility function, each utility is assumed to have two components: a systematic component or observable component by the analyst, and a random component or unobservable component by the analyst. That is, the random utility function is shown as follows:

$$U_{iq} = V_{iq}(X_{iq}) + \varepsilon_{iq} \quad (1)$$

where U is the total utility, V is the observable component of the total utility, ε is the unobservable component, X is the vector of the attributes, the i attached to each symbol is the number of alternatives, generally called profiles, and q is the number of respondents. Parameters of the observable utility function V are estimated using the following conditional logit model.

If $U_{iq} > U_{jq}$ ($j \neq i$), individuals will select alternative i . Hence, the probability of choosing alternative i in the set of all possible alternatives $C=\{1,2,\dots,J\}$ by individual q is as follows:

$$\begin{aligned} P_{iq} &= \Pr(U_{iq} > U_{jq}, \forall j \in C, j \neq i) \\ &= \Pr(V_{iq} - V_{jq} > \varepsilon_{jq} - \varepsilon_{iq}, \forall j \in C, j \neq i) \end{aligned} \quad (2)$$

Like McFadden (1974), the error terms ε_{jq} and ε_{iq} are assumed to be independently and identically distributed with a Gumbel distribution (a type 1 extreme value distribution), and probability P_{iq} is as follows:

$$P_{iq} = \frac{e^{\lambda V_{iq}}}{\sum_{j=1}^J e^{\lambda V_{jq}}} \quad (3)$$

where λ is the scale parameter, conventionally normalized to 1. The Gumbel distribution is used for analytic convenience, and is imposed in many similar models.

The log likelihood function for the maximum likelihood estimate is,

$$\ln L = \sum_{q=1}^Q \sum_{j=1}^J d_{jq} \ln P_{jq} \quad (4)$$

where Q is the number of respondents (strictly, the number of completely answered samples), d_{jq} is the dummy variable, $d_{jq}=1$ when individual q selects alternative j , and $d_{jq}=0$ when individual q selects any other alternative, except for alternative j . The utility parameters that maximize Equation (4) are then calculated.

3.2 Calculating MWTP

When the parameters of the utility function are estimated using the conditional logit model as explained above, the MWTP of each attribute can be obtained. Assuming additive separability for the utility function, the utility function can be written as:

$$V(X, p) = \sum_n \beta_n x_n + \beta_p p \quad (5)$$

where X is the vector of n attributes, $X=(x_1, x_2, \dots, x_n)$, p is the price of the alternative, β_n is the marginal utility of each attribute, and β_p is the marginal utility of income. The number of respondents and alternatives i, j and q are omitted here for simplification. Although many individuals do not have additive utility functions for environmental quality, the assumption is commonly made (Louviere et al. 2000). The total differential of (5) is as follows:

$$dV = \sum_n \frac{\partial V}{\partial x_n} dx_n + \frac{\partial V}{\partial p} dp \quad (6)$$

Utility is assumed to be held constant ($dV=0$), and all attributes except for x_1 ($dx_i=0, i \neq 1$) including all non-measured attributes that the respondents perceive are assumed to be unchanged. Thus, the marginal willingness to pay (MWTP), that is the monetary measure for 1 unit change of x_1 , is as follows:

$$MWTP_{x_1} = \frac{dp}{dx_1} = - \frac{\partial V}{\partial x_1} / \frac{\partial V}{\partial p} = \frac{\beta_1}{\beta_p} \quad (7)$$

4. Survey design

A questionnaire on siting a hypothetical landfill in Morioka City, Iwate Prefecture in Northern Japan, was conducted on the citizens to collect data for the study. A map of each location is shown in Figure 2. After a pilot survey conducted through home visits, a final survey of the general public was conducted by post in February 2002. Questionnaires were sent to 600 households selected randomly from a database of telephone numbers, and 302 households responded. A translated version of the questionnaire used in this survey can be obtained from the author upon request. The landfill assumed in the questionnaire was as large as an existing municipal landfill in Morioka City, with the following specifications:

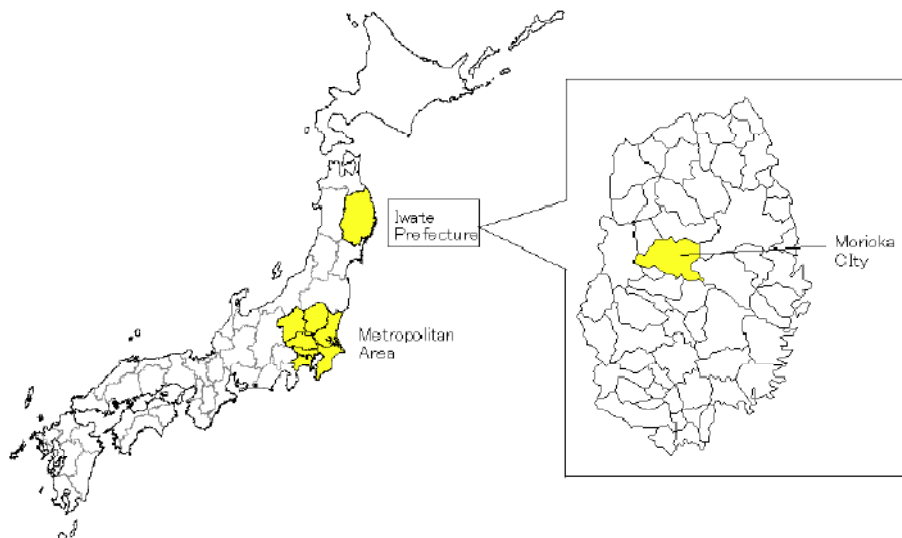


Figure 2: Map

- Construction type: municipal landfill with drainage
- Operating period: 15 years
- Size: 9 ha
- Capacity: 1 million m³

- Waste types accepted: municipal solid waste (MSW) incinerator ash, un-recycled glass, and non-toxic construction waste from industry.

In the questionnaire, the necessity for the new landfill in the city was first explained, and then the scenario where the landfill was sited somewhere in Morioka City was presented. Public knowledge and attitudes toward landfills were also investigated. Then, eight CE questions containing three alternatives (plans) such as in Figure 1 were given in the questionnaire. For each question, the respondents were asked to select their preferred plan considering the balance between each attribute in each plan. The respondents were asked to select “none” when they did not like any of the alternatives. Although the collection of 2,416(=302 × 8) samples was expected, complete samples numbered 2,218 due to 198 blanks in the collected responses.

Five attributes related to the external costs of siting a landfill were analyzed in the CE questions. The definition and levels of each attribute are provided in Table 1. Although there are other attributes for siting a landfill, these five attributes were considered representative of typical concerns, while also reducing confusion among respondents. The rationale of each attribute is as follows.

Table 1: Explanation of the attributes analyzed in the CE questions

1. Cost
This attribute considers a special tax levied on each household in the city only once. There are four levels: ¥1,000, ¥3,000, ¥8,000, ¥15,000.
2. Range of waste accepted
This attribute considers the range of waste accepted. There are four levels: only MSW in Morioka City; MSW in Morioka City and a part of this from other cities in Iwate Prefecture; MSW in Morioka City and a part of the industrial waste in Iwate Prefecture, as well as MSW in Iwate Prefecture; all of this waste and a part of the industrial waste in the Tokyo Metropolitan Area.
3. Number of houses near the landfill site
This attribute considers the number of houses within a radius of 1 km from the center of the landfill. There are four levels: 0 houses, 100 houses, 400 houses and 1,200 houses.
4. Whether there is a drinking water source
This attribute considers whether there is a drinking water source within 1 km of the landfill. There are two levels: there is a water source or there is no water source.
5. Distance from respondent's house
This attribute considers the distance between the border of the landfill and each respondent's house. There are four levels: 0.5 km, 1 km, 3 km and 6 km.

The cost attribute is used to evaluate each of the other four attributes in monetary terms. It is assumed to be the extra costs that residents would be required to pay for each plan. Another attribute examines the public perception of accepting waste originating from outside of Morioka City. This attribute allows an analysis of whether residents would be willing to pay more in the form of extra costs to ensure that MSW or industrial waste from outside of Morioka City is excluded. The attribute has four levels to explore a wide range of conditions. For this questionnaire, the fraction of outside waste in the landfill is not defined. In addition,

shortened management due to expanding the range of waste acceptance is not considered. The third attribute examines the public perception of siting a landfill near a residential area. The levels are selected considering the population density and the average number of people per household in Morioka City. The fourth attribute examines whether there is a drinking water source within 1 km or not. The presence of a nearby drinking water source is used as a representative attribute for contamination from landfills. Water and soil contamination are important problems with landfills, and 63% of the respondents in this survey selected this as their main concern. The fifth attribute examines the public perception of siting a landfill near the respondent's house.

As shown in Table 1, since there are two levels of drinking water source attributes and four levels of other attributes, the number of profile combinations (alternatives) is $4^4 \times 2 = 512$. However, it is difficult to use all these profiles. Therefore, 16 profiles were produced by the orthogonal main effects method, which increases statistical efficiency by avoiding factors such as multicollinearity (Louviere et al. 2000). Cases in which the number of houses is 0 and in which the distance from the residents' house is 0.5 km were omitted. Four booklets, each containing 8 CE questions, were prepared.

5 Estimation of public preferences

5.1 Estimation method

Assuming the additive utility function as Equation (5), utility parameters are estimated using the conditional logit model. The parameters are estimated including the "none" choices, which numbered 672 of 2,218 complete samples in this survey. Some of the respondents selected "none" in all the questions. The "none" responses seem to indicate one of the following: the respondents are indifferent to all of the presented plans; none of the plans is supported; or they are resistance-responses that show opposition to the siting plan itself.

Considering recent public distrust of siting landfills, the "none" responses should not be excluded but should be included to determine more suitable public preferences. This study considered the "none" responses as a fourth alternative, and the alternative specific constants (ASC) utility function was estimated. When ASC is positive, it means that it is preferable for the respondents to select neither than to select any plan. On the other hand, when ASC is negative, it means that it is preferable for them to select any

plan than to select none. It should be noted that there were 298 of 600 households who did not return the survey. Some of them may have selected the “not-returning” option because they were against landfill siting itself and/or the survey instrument. For these reasons, it is difficult to determine perfect public preferences even if the “none” responses are also included in the estimation.

The linear model used is:

$$V = ASC + \beta_1 COST + \beta_2 MNCPRF + \beta_3 IDSPRF + \beta_4 METRO + \beta_5 HOUSE + \beta_6 WATER + \beta_7 DIST \quad (8)$$

where ASC is a parameter of the “none” choice; COST is the cost levied on residents; MNCPRF is a dummy variable that shows acceptance of all the MSW in Morioka City and a part of that from other cities in Iwate Prefecture; IDSPRF is a dummy variable that shows the acceptance of all the MSW in Morioka City and a part of the industrial waste in Iwate Prefecture, as well as a part of the MSW in the prefecture; METRO is a dummy variable that shows acceptance of all of the above waste and a part of the industrial waste in the Metropolitan; HOUSE is the number of houses within a 1-km radius of the center of the landfill; WATER is a dummy variable that means there is a drinking water source within 1 km of the landfill; and DIST is the distance from the respondent’s house to the landfill site.

The utility for the distance from the respondent's house is expected to increase at a decreasing rate, as the landfill site is farther away. Therefore, not only a linear model, but also a root model and two dummy models are estimated. In dummy model 1, $\beta_7 DIST$ is replaced with $\beta_7 DIST1 + \beta_8 DIST3 + \beta_9 DIST6$, and it is replaced with $\beta_7 DIST05 + \beta_8 DIST1 + \beta_9 DIST3$ in dummy model 2. Each dummy model indicates the distance the landfill site is from the respondent’s house in km (eg, DIST3 is the dummy variable representing the effect of the landfill being 3 km from the respondent’s house).

5.2 Estimation results

The estimations for the four distance models were performed using TSP, a software program for econometric analysis. The estimation results are shown in Table 2. All attributes were significant at the 1% level except for ASC in root and dummy model 1.

Table 2: Estimation results

N=2,218

Variables	Linear model		Root model		Dummy model 1		Dummy model 2	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Cost (10,000 yen)	-0.7149	-9.92	-0.6779	-9.38	-0.6740	-8.87	-0.6740	-8.87
Including MSW in Iwate Prefecture	-0.3328	-3.92	-0.2909	-3.41	-0.2524	-2.88	-0.2524	-2.88
Including industrial waste in Iwate Prefecture	-0.4707	-5.38	-0.4690	-5.37	-0.5413	-6.13	-0.5413	-6.13
Including industrial waste in the Metropolitan Area	-1.8619	-16.37	-1.8148	-16.15	-1.6778	-14.71	-1.6778	-14.71
Number of houses (100 houses)	-0.0447	-5.38	-0.0458	-5.72	-0.0481	-5.97	-0.0481	-5.97
Drinking water source exists	-1.2573	-18.46	-1.2170	-17.84	-1.1310	-15.91	-1.1310	-15.91
Distance from respondent's house: Linear (km)	0.1937	12.35	—	—	—	—	—	—
Root (km)	—	—	0.6657	12.73	—	—	—	—
Dummy 0.5 km	—	—	—	—	—	—	-1.4375	-13.03
Dummy 1 km	—	—	—	—	0.7701	6.76	-0.6674	-7.33
Dummy 3 km	—	—	—	—	1.1268	9.39	-0.3107	-3.43
Dummy 6 km	—	—	—	—	1.4375	13.03	—	—
ASC	-0.5650	-5.75	-0.0421*	-0.34	-0.1204*	-0.95	-1.5579	-16.52
Log likelihood	-2450.70		-2442.82		-2427.90		-2427.90	
Akaike Information Criterion (AIC)	2458.70		2450.82		2437.90		2437.90	
Correct predictions (%)	52.98		52.98		53.79		53.92	

*Not statistically significant. Other coefficients are statistically significant at the 1% level.

Each coefficient (utility parameter) in the table stands for the valuation weights of each attribute. For dummy model 1 or dummy model 2, for example, the estimation results show that a cost increase of 10,000 yen causes a 0.6740 decrease in utility on average, and the acceptance of waste originating from other municipalities in Iwate Prefecture causes an average 0.2524 decrease in utility. Although the utility levels themselves are shown as absolute numbers, they have no specific meaning in themselves and are only meaningful for comparing between attributes. For instance, the negative effect of the acceptance of waste including industrial waste in the Metropolitan Area is about 1.5 times greater than that of siting a landfill near a drinking water source.

To evaluate the relative performance of the four distance models, three performance measures are used. Log likelihood is the value evaluated at the mean of the estimated utility parameters, and the equation is provided in Equation (4). The larger the value of the Log likelihood is, the better the fit of the model to the observed data is. Akaike Information Criterion (AIC) allows us to compare the fit of different models. The smaller the value of the AIC is, the better the fit of the model to the observed data is. Correct predictions mean the proportion of successful predictions (that is, expected selection coincides with observed one) for each alternative in the questionnaires (Louviere et al.2000 and Maddala 1983). As shown in Table 2, dummy models 1 and 2 are the most suitable. They have the largest log likelihood, the smallest AIC and are highest in correct predictions.

5.3 Marginal Willingness to Pay

As shown in Equations (5) through (7), the valuation weights or the utility parameters can be converted into monetary terms as MWTP. Through converting these parameters into MWTP, they can be evaluated in common monetary terms. Moreover, the external costs of siting landfills can be calculated using the MWTP. The MWTP of each attribute is obtained by dividing the coefficient of a given attribute by the coefficient on COST as shown in Table 3, which shows the MWTP values when using dummy model 2 to represent the effect of the distance from the landfill. As recognized in Equation (8), the following base of the MWTP of each attribute was set as 0 yen: the residents in Morioka City accept only MSW in the city; there are 0 houses in the area located within a 1-km radius of the center of the landfill; there is no drinking water source; the distance from the respondent's house to the landfill is 6 km in dummy model 2.

Table 3: MWTP of each attribute when using Dummy Model 2 to describe the distance to landfill.

Attributes	MWTP Yen (US\$)*	95% confidential intervals** Yen (US\$)
Including MSW in Iwate Prefecture	-3,717 (-29.74)	-1,584 ~ -6,036 (-12.67 ~ -48.29)
Including industrial waste in Iwate Prefecture	-8,030 (-64.24)	-5,625 ~ -11,133 (-45.00 ~ -89.06)
Including industrial waste in the Metropolitan Area	-24,848 (-198.78)	-20,446 ~ -30,643 (-163.37 ~ -245.14)
Number of houses (100 houses)	-713 (-5.70)	-486 ~ -1,014 (-3.89 ~ -8.11)
Drinking water source exists	-16,752 (-134.02)	-13,657 ~ -20,913 (-109.26 ~ -167.30)
0.5 km distant from the landfill site	-21,284 (-170.27)	-16,855 ~ -26,685 (-134.84 ~ -213.48)
1 km distant from the landfill site	-9,799 (-78.39)	-7,175 ~ -13,215 (-57.40 ~ -105.72)
3 km distant from the landfill site	-4,516 (-36.13)	-2,422 ~ -6,949 (-19.38 ~ -55.59)

* Yen is converted into dollars assuming an exchange rate of \$1=¥125 that is the average rate in 2002.

**95% confidential intervals are obtained by the method of Krinsky and Robb (1986), and based on 1,999 random draws.

The results in Table 3 permit a number of interpretations. First, accepting MSW partly from other cities in Iwate Prefecture was evaluated by the respondents as -3,717 yen (-29.74 dollars) on average. Such a negative valuation can be regarded as external costs or welfare loss due to siting the landfill. Including industrial waste in the prefecture, the respondents' valuation was -8,030 yen (-64.24 dollars). These results indicate that the public considers industrial waste more harmful than MSW. For accepting industrial waste in the Metropolitan Area in addition to municipal and

industrial waste in the prefecture, the respondents' valuation was -24,848 yen (-198.78 dollars). These results indicate that the public strongly oppose accepting industrial waste in the Metropolitan Area. This may be connected to the illegal dumping discovered at the northern boundary in Iwate Prefecture in 1998. The dumped waste included industrial waste from the Metropolitan Area.

Next, regarding the number of houses around the landfill site, the public displays less concern over the number of houses than for other attributes. However, the estimation results also show that the public does not like siting landfills near residential areas.

Siting a landfill within 1 km of a drinking water source was evaluated by the respondents as -16,752 yen (-134.02 dollars), regardless of whether the users are the respondents themselves or other people. In questions asked before the CE questions, 93% of the respondents were opposed to siting a landfill within 1 km of a drinking water source even if the respondents themselves did not utilize the water source. These preliminary results are consistent with the estimation results. Opaluch et al. (1993) show that the public feels that there are undesirable effects when siting a landfill in an area where the groundwater is of high quality.

The distance from the landfill site was evaluated more negatively by the respondents the nearer the respondent's house was to the landfill. The WTP (not MWTP in dummy model) of 3 km away from the boundary of the landfill site was about -4,516 yen (-36.13 dollars), that of 1 km away from it was about -9,799 yen (-78.39 dollars) and that of 0.5 km away from it was about -21,284 yen (-170.27 dollars) on average.

In the questions asked before the CE questions, 68% of the respondents admitted that a certain amount of additional landfill is inevitable, and 8% insisted that many more landfills are necessary. Nevertheless, as mentioned above, the respondents felt that there are negative effects when siting the landfill near their own houses. These results help to clarify the so called NIMBY syndrome.

5.4 Estimation of the range of negative effects

There are no existing studies that analyze the range of the negative effects of siting landfills using CE. The fit results for the root, linear, and dummy 1 distance models are shown in Figure 3. Dummy model 1 only allows an estimation of utility levels at 1 km, 3 km and 6 km from the landfill site. This study does not examine a utility change beyond 6 km, limiting the ability to examine the effect of distance on residents. The better fit for the root and dummy models compared to the linear model

indicates that the utility level increases at a decreasing rate as the landfill site is farther away. In other words, the NIMBY syndrome of the residents in the surrounding area of the landfill is observed to weaken at a decreasing rate, as the landfill site is farther away.

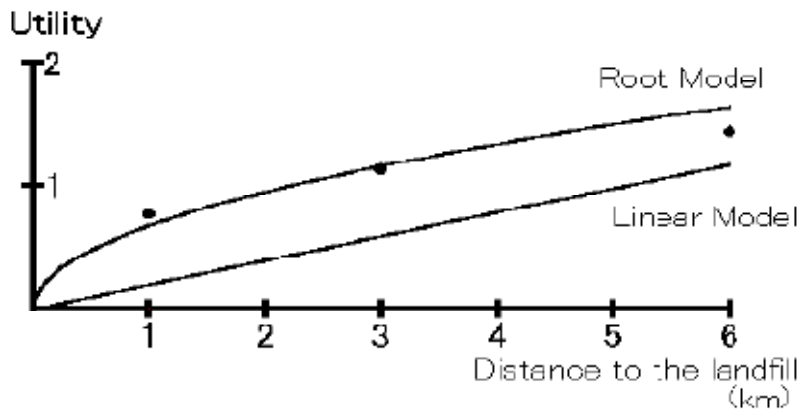


Figure 3: Model estimates for the effect of distance to landfill on residents' utility

6. Case study: estimation of the social costs on landfill siting

In most actual siting plans, although private costs such as land costs and developing costs are considered, the external costs, that is the negative effects on residents of landfill siting evaluated in monetary terms, have been ignored. It is important to consider social costs that consist of private costs and external costs in siting plans in order to site disposal facilities from the perspective of social efficiency. In this section, the external costs and the social costs are calculated using MWTP estimated in the previous section.

In this section, three hypothetical siting plans are presented to calculate the social costs when a landfill as large as the landfill assumed in this survey is sited in Morioka City. The contents of the three plans are shown in Table 4. The external costs of each plan are calculated using the four MWTP estimated in the previous section, and multiplying each by the number of households in Morioka City (114,177 as of March 2002). For instance, in Plan A, the external costs are

$-3,717 \times 114,177 - 713/100 \times (20+130) \times 114,177 = -424,396,979$ yen ($-3,395,176$ dollars). The effect of the distance from the landfill site can be calculated by multiplying the MWTP at each distance from the landfill site by the number of households at that distance. In this case study, the MWTP for 0 to 0.5 km from the landfill site is assumed to be same as that of 0.5 km from it, the MWTP in 0.5 to 1 km from the landfill site is assumed to be same as that of 1 km from it, and the MWTP in 1 to 3 km from the landfill site is assumed to be same as that of 3 km from it. For instance, in Plan A, the costs are $-21,284 \times 20 - 9,799 \times 130 - 4,516 \times 2000 = -10,731,550$ yen ($-85,852$ dollars). It follows from this that the external costs of Plan A are calculated as $-424,396,979 - 10,731,550 = -435,128,529$ yen ($-3,481,028$ dollars). In the same way, the external costs of Plan B and Plan C are $-2,342,210,170$ yen ($-18,737,681$ dollars) and $-922,452,773$ yen ($-7,379,622$ dollars), respectively. It should be noted that the external costs must be taken over the life of the landfill (15 years), because a tax is levied on each household in the city only once. while the operating period is assumed to be 15 years.

Table 4: Hypothetical siting plans

Attributes	Plan A	Plan B	Plan C
Range of accepting waste	Including MSW in Iwate Prefecture	Including MSW in Iwate Prefecture	Including industrial waste in Iwate Prefecture
Number of houses			
0 to 0.5 km from the site	20	10	10
0.5 to 1 km from the site	130	40	90
1 to 3 km from the site	2,000	1,000	1,000
Drinking water source exists	Doesn't exist	Exist	Doesn't exist
Private Costs (Land costs and developing costs) (1,000 yen)	2,500,000 (\$20,000,000)	1,500,000 (\$12,000,000)	1,800,000 (\$14,400,000)

The private costs (land costs and developing costs) in each plan are also shown in Table 4. The minimum private costs are for Plan B at 1,500 million yen (12 million dollars). However, when considering the external costs shown in Figure 4, the minimum overall costs (social costs) are for Plan C at 2,722 million yen (21.8 million dollars). The results indicate that the most socially efficient choice in landfill siting will not always be the one with the lowest private costs.

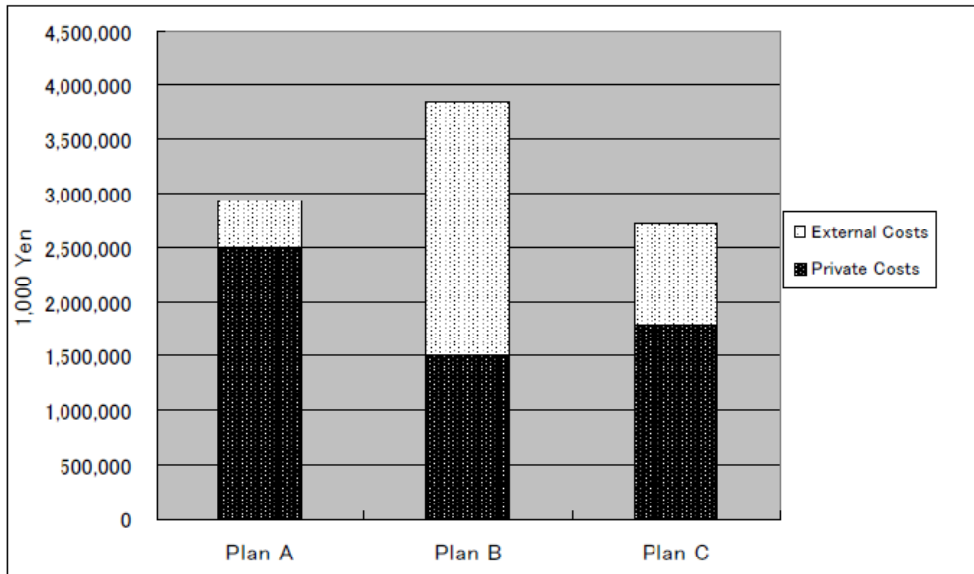


Figure 4: Social costs of hypothetical siting plan.

7. Conclusions

This paper examines public preferences on siting a landfill using a CE. The results of this analysis clearly show that the residents evaluate quite negatively accepting waste originating from outside their community, especially industrial waste originating from the Tokyo Metropolitan Area, and siting a landfill near areas that are sources of drinking water. In addition, the results also show that NIMBY syndrome of the residents in the surrounding area of the landfill is observed to weaken at a decreasing rate, as the landfill site is farther away. These results clarify the NIMBY syndrome concerning landfills.

Solid waste managers should look to reduce the external costs in order to site socially acceptable landfills. They should offer proper information to the public and accurately recognize public preferences for landfill siting. They should then mitigate the negative impact on the environment or the risks that are identified by public preference (Baldasano et al., 2003). When the external costs remain in spite of the above efforts, compensation can be paid to the residents affected by landfills or the host community. The method of calculating the external costs using CE in this paper is useful for determining this compensation or the bid each community should make in a Kunreuther-type low-bid auction. Compensation does not necessarily have to be monetary. As Frey et al. (1996) point out, monetary compensation is not always

supported by the public. In some cases, in kind compensation may be suitable for addressing the external costs.

One limitation of this study is that limited information was provided to the respondents because of the need to elicit public preference with a postal questionnaire. When more time and resources are available, deliberative-participatory approaches and citizens' juries (CJ) are more desirable than postal questionnaires (Kenyon et al. 2001). Further research is needed on the use of these more intensive techniques to identify external costs.

A second limitation is that additional expense paid by communities for their own solid waste disposal because of restrictions on landfill siting is not considered for simplicity. Ley et al.(2002) shows that interstate trade restrictions reduce public welfare through raising disposal fees. If the residents perceive an increase in disposal costs by trade restrictions, public preferences may differ from the results of this survey. This issue also merits further research.

The study of external costs can be improved by the use of new data analysis techniques (eg, Geographic Information Systems), and by extending the analysis to include non landfill aspects of the solid waste management system.

Acknowledgements

I thank the editor and four anonymous referees for their helpful comments on an earlier version of this paper. I am solely responsible for any remaining errors in this paper. This study is funded by a Grant-in-Aid for the Encouragement of Young Scientists by the Japan Society for the Promotion of Science and the Asahi Glass Foundation.

References

- Baldasano, J.M., Gasso, G., Perez C., 2003. Environmental performance review and cost analysis of MSW landfilling by baling-wrapping technology versus conventional system. *Waste Management* 23, 795-806.
- Bateman I.J. et al., 2002. *Economic Valuation with Stated Preference Techniques*. Edward Elgar Publishing.

- Ben A. and Lerman S.R., 1985. *Discrete Choice Analysis: Theory and Application to Travel Demand*. MIT Press.
- Frey.B.S., Oberholzer-Gee,F and Eichenberger, R.,1996. The Old Lady Visits Your Backyard: A Tale of Morals and Markets. *Journal of Public Economics* 104(6), 1297-1313.
- Freeman A.M. et al., 1993. *The Measurement of Environmental and Resource Values –Theory and Methods*. Resource for the Future.
- Garrod,G., Willis, K., 1998. Estimating lost amenity due to landfill waste disposal. *Resources, Conservation and Recycling* 22, 83-95.
- Groothuis, P.A., Miller, G., 1994. Locating hazardous waste facilities: The influence of NIMBY beliefs. *American Journal of Economics and Sociology* 53(3), 335-46.
- Hirshfeld S., Vesilind, P.A., Pas, E.I, 1992. Assessing the true cost of landfills. *Waste Management & Research* 10, 471-84.
- Kenyon, W., Hanley, N., Nevin, C., 2001. Citizen's juries: an aid to environmental valuation?. *Environment and Planning C: Government and Policy* 19,557-66.
- Kohlhase, J.E., 1991. The impacts of toxic waste sites on housing values. *Journal of Urban Economics* 30, 1-26.
- Krinsky, I., Robb A.L., 1986. On approximating the statistical properties of elasticities. *Review of Economics and Statistics* 68,715-19.
- Kunreuther, H., Kleindorfer, P.R., 1986. A sealed-bid auction mechanism for siting noxious facilities. *American Economic Review Papers and Proceedings* 76, 295-99.
- Kunreuther,H.,Kleindorfer,P.,Knez, P.J., Yaksick, R., 1987. A compensation mechanism for siting noxious facilities: Theory and experimental design. *Journal of Environmental Economics and Management* 14, 371-83.

- Ley, E., Macauley, M.K. and Salant, S.W., 2002. Spatially and Intertemporally Efficient Waste Management: The Costs of Interstate Trade Restrictions. *Journal of Environmental Economics and Management*
- Louviere, J.J., Hensher, D.A., Swait, J.D., 2000. *Stated Choice Methods: Analysis and Application*. Cambridge University Press.
- Maddala G.S., 1983. *Limited-dependent and Qualitative Variables in Econometrics*. Cambridge University Press.
- McFadden, D., 1974. Conditional logit analysis of qualitative choice behavior. In: Zarembka P, editor. *Frontiers of Econometrics*. Academic Press.
- Minehart, D., Neeman, Z., 2002. Effective Siting of Waste Treatment Facilities. *Journal of Environmental Economics and Management* 43, 303-24.
- Mitchell, R.C., Carson, R.T., 1986. Property rights, protest, and the siting of hazardous waste facilities. *American Economics Review Papers and Proceedings* 76, 285-90.
- Nelson, A.C., Genereux, J., Genereux, M., 1992. Price effects of landfills on house values. *Land Economics* 68(4), 359-65.
- O'hare, M., Bascow, L., Sanderson, D., 1983. *Facility Siting and Public Opposition*. Van Nostrand – Reinhold.
- Opaluch, J.J., Swallow, S.K., Weaver, T., Wessells, C.W., Wichelns, D., 1993. Evaluating impacts from noxious facilities: Including public preferences in current siting mechanisms. *Journal of Environmental Economics and Management* 24, 41-59.
- Roberts, R.K., Douglas, P.V., Park, W.M., 1991. Estimating external costs of municipal landfill siting through contingent valuation analysis: A case study. *South Journal Agricultural Economics* December, 155-165.
- Smith, V.K., Desvousges, W.H., 1986. The value of avoiding a LULU: Hazardous waste disposal sites. *The Review of Economics and Statistics* 68 (2), 293–299.

Swallow, S.K., Opaluch, J.J., Weaver, T.F., 1992. Siting noxious facilities: An approach that integrates technical, economics, and political consideration. *Land Economics* 68 (3), 283-301.