An estimation of the residential utility for the local waste management services in Kagoshima

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Abstract

The municipal government tried to reduce waste disposals and increase recycling rates in Japan. It is difficult to get full cooperation from the residents. Using choice experiments, the cost measure for each characteristics of waste collection services. The estimation result reveals that the trade-offs between the risk, costs and handling costs. The marginal utility loss for the increase in the number of separation is almost 200yen and the increase in recycling rate by 1% raises 53yen of utility. The estimation result also shows that the needs of risk communications between municipal authorities and residents.

JEL Classification: Q51, Q53

Keywords: Solid Waste management, Choice experiment, Multi Nominal Model

1. Introduction

Waste management policy is one of the important issues for municipal governments in Japan. The Japanese Government's waste management policy has changed dramatically since the introduction of the Basic Law for Establishing a Recycling-Based Society in 2002. In addition, local waste management systems have changed to accommodate this law. The system varies between the local governments in Japan. Among the waste management policies, waste collection methods are a big concern and sometimes a burden for residents. Recently, local authorities have made great efforts to obtain the cooperation of residents by attempting to introduce a policy that achieves the desired results but imposes a lesser burden on residents. Using choice experiments, this paper reveals the utility differences between waste collection policies.

Prior to the introduction of the new policy, governments usually held meetings to obtain the residents' views on waste management policy. However, it is very difficult to establish the optimum system based on residents' opinions. Usually, local residents do not know what kinds of methods are feasible or what will be the results of those methods. It is clear that most residents would prefer smaller payments and handling costs, a better recycling rate, and a more ecologically friendly method of waste management. Usually, these properties of a waste management system cannot be achieved simultaneously.

Among the various waste collection methods available, a unit-based method of charging is widely employed in Japan via a system of selling waste bags for a fee. The waste bags are sold for 37.9 yen on average for Japan (Usui 2003), and 15-30 yen for a 40-liter bag in Kagoshima Prefecture (Sakata 2001). The Japanese Government is trying to oblige local governments to introduce user charges in 2005. At the same time, it is increasing the types of waste and recyclable goods that must be separated by residents. In some small cities, such as Minamata and Kamikatsu, the residents must separate over 20 types of garbage and recyclable goods. The local government provides thorough explanations of the methods required using the city papers and meetings, hundreds of which must be held in each small district.

Local authorities should design their waste management systems considering these trade-offs and technology restrictions. If they know the residents' preferences for the characteristics of waste collection, they can design the most preferred system subject to the technology restrictions.

In this paper, we try to evaluate waste collection methods using Conjoint Analysis (CA). CA was originally developed in mathematical psychology (Luce and Tukey 1964) and marketing research (Actio and Jain 1980, Green and Srinivasan 1990). In the 1990s, CA has been widely used in environmental economics to evaluate non-market goods and the choice of transportation (Bilbao 2004, Haefele 2001, Hensher 1994, Louviere 1988, Louviere, Hensher, and Swait 2000, and Takeuchi, Kuriyama, and Washida 1999). Recently, the application of CA methods has been extended to various areas such as health economics (Miguel 2000), and waste management (Sasao 2002).

Using CA, we can evaluate the preferences relating to the properties of each policy. Sasao (2002) evaluated the location preference for a waste dump in Akita, in northeast Japan. This paper attempts to apply CA to the evaluation of non-market goods, especially such goods supplied as public services. In particular, we have applied CA to the residential demand for the waste collection service supplied by the local authorities.

The following section explains the model of CA used in this paper. In CA, the willingness to pay (WTP) for a provided policy is estimated using an econometric method. Sakata (2003) estimated the result using the Multinomial Logit Model (MNL). MNL is often criticized because it requires the assumption of independence from irrelevant alternatives (IIA). The IIA assumption is a very strong restriction when using CA in policy studies. The solutions to reduce this restriction are the nested logit model (e.g. Tsuge 2001) and the Multinomial Probit Model (MNP). In this paper, we have used MNP to estimate the residents' utility for each policy characteristic.

The following section illustrates the estimation model. In section 3, the research objective and method are explained. In section 4, the estimated result is presented. Section 5 concludes the paper.

2. The Model

Suppose the consumer's utility can be divided by the characteristics of goods. Then, we can define individual t's utility function as follows (Lancaster 1966):

$U_t = U_t(x_1, x_2, \ldots, x_n)$

U_t : t's Utility

x_i : i'th characteristics of goods x

Using this utility function, we can define our estimation model based on random utility theory (Luce and Tukey 1964, McFadden 1973). The respondents show their utility through their responses. We can observe it by analyzing the differences in each response to policy profiles. Individual i's utility is defined for a policy profile described by question j as follows:

$$U_{tj} = V_{tj}(x) + \varepsilon_{tj}$$
$$= \beta' x_{tj} + \varepsilon_{tj} \cdots\cdots\cdots(1)$$

U_{tj} : t's Utility for choice j

V_{tj} : t's choice for question J

x_{tj} : properies for choice j of t's question J

β : weight vector for properties

ε_{tj} : error term

We assume that t's utility is maximized when he or she chooses choice j from question j. Thus, the probability model is restricted to the following condition:

$$\Pr ob(U_{tj} \succ U_{tk})$$
$$j \neq k,$$

To estimate this model, we assume the error term ε_{tj} is normally distributed, with a mean of zero, and a variation equal to one. Then, we obtain the probability that choice j is selected from the profiles:

$$\Pr ob(Y_i = j) = \Phi(\frac{\alpha_k - dVt}{\sigma})$$

dV_t : the utility difference of individual t between choice j and k.

$$dV_t = V_{tj}(x_j) - V_{tk}(x_k)$$

where Y_i is the random variable for selection, Φ is the normal distribution function, α_k is the threshold variable, and $\sigma$is the scale parameter. In this paper, we define σ=1 for simplicity.

The log likelihood function is:

$$\ln L_0 = \sum_{i=0}^{n} \sum_{j=0}^{J} d_{ij} \ln prob(Y_i = j).$$

We obtain the marginal utility of each property as follows:

$$\delta_k = \frac{\partial P_j}{\partial x_j} = P_j \left[\beta_j - \sum_{k=0}^{J} P_k \beta_k \right] = P_j \left[\beta_j - \bar{\beta} \right]$$

3. Research Outline

3.1. About Kagoshima City

Kagoshima City is the capital of Kagoshima Prefecture and it has a population of almost 600,000 people.

Kagoshima City has two waste management facilities. The northern one has an incinerator, a recycling plant, and a waste dump, whereas the southern one has an incinerator and a thermal recovery system that generates electricity supply to almost 300 households.

In 2002, the cost of waste management was about 16,000 yen per person in a year. This included costs such as collection fees and maintenance costs, but excluded the labor cost of office workers.

In Kagoshima Prefecture, many municipal governments recover their waste management costs by charging customers for a special bag and including user costs in its price. Although Kagoshima City charges offices for waste management in this manner, they have not introduced such a system for residents.

Between 1995 and 2003, the recycling rate of Kagoshima improved from about 2.7% to 14.3%. This improvement was achieved by a new recycling scheme that was introduced in 1996 and completed in 2001, and that involves collecting packaging waste as a recycling material. The recycling rate is quite high in large cities, averaging about 12%.

Table 1. Separation of waste in Kagoshima City

1	Combustibles
2	Large waste
3	Magazines
4	Cans
5	PET Bottles
6	Bulbs and fluorescents
7	Non-combustibles
8	Newspapers
9	Cloths
10	Bottles
11	Plastic packages

Kagoshima City gradually subdivided their collection methods so that the types of waste collected increased from five to 11. The final scheme started in 2000. Currently, residents separate their waste into 11 categories, as shown in Table 1. The waste collection schedule is also shown in the table. Some residents claim that the separation and collection schedule is too complex.

3.2. Research Methodology

We carried out our research in Kagoshima City in September 2002. It involved 10 researchers visiting houses to interview residents and collecting 500 samples from the northern part of Kagoshima City, which includes the central and Ishiki areas. The samples were chosen randomly from 10 regions. The sample areas were chosen on the basis of population weight and picked randomly.

Interviews were carried out using question sheets and manuals. Researchers completed the same training to avoid interviewer bias. Each question sheet had five parts. These related to face, general knowledge of environmental problems, knowledge of waste policy, preferences for waste policy in Kagoshima, and eight choice experiment cards. We designed very simple questions so that interviewees could focus on the choice cards.

3.3. Profile Design

There are five categories each with three levels in the research profile. If we make profiles with those combinations, it is difficult to use 3^8 combinations (125) of profiles in the questions and so we reduced the profiles to 12 using orthogonal design. However, using such techniques creates an unrealistic profile list and therefore, instead of removing those profiles, we explained the method in interviews.

Each choice set consists of three randomly chosen profiles and there are 220 (${}_{12}C_3 = 220$) patterns of question cards. The interviewer showed the interviewee eight randomly chosen cards, and the interviewee then chose the most desirable profile from each card. A sample card is shown in Figure 1.[1]

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[1] It is difficult to eliminate some unrealistic profiles in the profile list using orthogonal design, so those unrealistic profiles were left in our list. To avoid the undesirable effect caused by those profiles, the interviewer spent a lot of time explaining to respondents that the profiles were included because of the requirements of the analytical method.

Figure 1. Sample Choice sheet

Rate of Recycling	12 %	22%	70%
Charge Method	2 stage	Flat (using Tax)	Waste Bag
Separation	3	11	3
Amount of Dioxin	Close to 0	Old Guideline	New Guideline
Cost of MSWM*	32000 yen/year twice from current level	16,000 yen/year	32000 yen/year twice from current level
Answer: Choose 1			

* MSMW: Municipal Solid Waste Management

3.4. Attributes

We have five attributes, each consisting of three levels. They were chosen based on the actual variations in waste management systems implemented in Japanese municipal areas. We can make most of the real collecting system mixing those properties (Table 2).

We chose to focus on separation categories 3, 11, and 21. Category 3 is combustible goods, non-combustible goods, and large goods. Category 11, which has been adopted in Kagoshima City, is shown in Figure 1. Category 21 has been implemented in Kawanabe town and Aira town. With 21 or more separation systems, the recycled wastes are collected once or twice a month at a specific corner of each district.

The second property is the percentage of recycling. In 2000, the latest data available at the time of research, the recycling rate of Kagoshima was 8%. The second target, at 22%, represents the recycling rate of Nagoya City, which has just started its recycling plan. The third target is 70%, which is desirable. San Francisco aims to increase its recycling rate to 75% by 2010.

There are three charging methods: flat rate, two-stage collection, and waste bags. Under the flat rate system, residents pay the same amount of money regardless of their income or the amount of waste they produce. If the fee is included in their residential tax, we can consider that this method is free of charge. The two-stage system is the same as the flat rate for most residents provided they do not exceed regulatory restrictions on the amount of waste produced. However, once residents produce a larger amount of waste than the city council regulations permit, they pay for waste collecting services by paying for each waste bag required. The Waste Bag system collects fees according to the amount of waste.

We have chosen the amount of dioxin as a proxy of waste management security. In Japan, the hazard of dioxin is widely known. We explained that 'the old guideline' meant that ‘There are some risks for human health’, whereas 'the new guideline' meant that ‘There are some risks for natural ecosystems’. Finally, by ‘close to 0’, we meant that ‘There is almost no risk for natural ecosystems’.

The cost of the Waste Management System (MSWM) was based on current waste management costs. In Kagoshima, the local government charges those fees as a part of residential taxes for each household. Therefore, we define the current cost as the total cost divided by the number of households.

Table 2. Attributes of Profiles

	1	2	3
Separation	3	11	21
% of Recycling	8% (Current Kagoshima)	22%	70%
Charge Method	Flat (using Tax)	Two stage (free for up to 100 waste bags)	Waste Bag
Amount of Dioxin	Old Guideline	New Guideline	Close to 0
Cost of MSWM	16,000 yen/year	24000 yen/year (x 1.5 from current level)	32000 yen/year (x 2 from current level)

4. Estimation and Results

The observable utility V shown in (1) is estimated by using the Multinomial Probit Model. The estimation model is as follows:

$$V = \beta_1\left(Rate_i - Rate_j\right) + \beta_2\left(Charge_i - Charge_j\right) + \beta_3\left(Separate_i - Separate_2\right) + \beta_4\left(Dioxin_i - Dioxin_j\right) + \beta_5\left(Cost_i - Cost_j\right),$$

where Rate is the Recycling rate, Charge is a dummy for the charging method, Separate is the number of separation categories for recycling work, Dioxin is the risk dummy for emissions of dioxin from incinerators, and Cost is the waste management cost per person.

Table 3 shows the estimation results. It shows every parameter is significant and their signs are compatible with our assumptions. The result displays residents' utilities for individual variables. The parameters show the marginal utility of each variable, but parameters for the charging method and dioxin cannot be used directly because they use dummy variables.

The right column of Table 3 shows the marginal effects divided by the marginal effect of cost. In other words, it shows the utility of each variable evaluated in terms of their money cost. The 1% increase in the recycling rate provides 53 yen (almost US$0.5) of utility, whereas the introduction of a charging system results in a 9403 yen loss of utility. The increase in the number of separation categories reduces utility by 203 yen. When the emissions of dioxin change, a loss of 3978 yen in utility occurs.

As the number of separation categories increases, residential utility declines by 203 yen. The increase in separation categories directly increases the handling cost of waste disposal for residents. This result might be underestimated because the increase in separation categories would contribute to recycling, which might increase residential utility.

This result can be used to analyze the change in utility resulting from the policy change. For example, the utility loss caused by increasing the number of separation categories would be compensated for by the 4% increase in the recycling rate. Table 3 shows that the charging system reduces residents' utility to such an extent that it seems it will be very difficult for residents to accept it. However, we can find a policy choice that would not cause a decline in residents' utility. If the charging system reduces the emissions of dioxin dramatically and increases the recycling rate, the system may be accepted. For instance, the charging system would reduce utility by 9403 yen, but this would be offset by the reduction in dioxin emissions by two ranks, which would increase utility by 7956 yen. Moreover, if the recycling rate increased by 30%, the total utility change is positive (9452 - 9403 = 49 yen).

Table 3. Estimation Results

Variable	Coefficient	Standard Error	b/St.Er.	Marginal Effect (by cost)
Recycling Rate	0.0038	0.0010	3.872	53.78851637
Charging Method	-0.6645	0.0461	-14.428	-9403.530896
Separation	-0.0144	0.0033	-4.403	-203.1465163
Dioxin	0.2811	0.0271	10.391	3978.129872
Cost per Person	-0.0001	0.0000	-20.617	-1

5. Conclusions

In this paper, the residential utilities for waste management services are revealed. We obtain three implications from the analysis, which are as follows: (1) user charging is not popular as it reduces utility substantially, (2) residents tend to prefer working rather than making direct monetary payments, and (3) residents react strongly to environmental risks.

We should carefully scrutinize the second implication. It is considered that direct payments should not be avoided. On the other hand, residents can reduce handling costs for separation by sometimes ignoring separation rules.

The third implication shows the importance of risk communications for public services. Risk communication can reduce residents' utility loss more cost effectively than does reducing emissions to close to zero. In Japan, risk communication activities have just been introduced and most are undertaken by private companies. Municipal governments have not implemented them yet.

In this paper, we applied CA to local waste management services. This helps policy makers to choose the most preferred policy among policies that have the same results. In addition, CA can be used for most public services when the residential demand is known. Actually, the diversion of residents' preferences varies greatly these days, so CA could be a supplemental method for voting.

In this paper, we have not considered the actual technology restrictions faced by a local authority. Taking into account the technology options employed in the real world, we can show the optimum and realistic waste management services corresponding to residents' preferences for each municipal government.

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