Economic Evaluation of Residential Environment Change Associated with Global Warming, Approached by Conjoint Analysis

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Abstract

In economic evaluation of the impacts of global warming on non-marketed goods or services, generally the Hedonic Price Method, Travel Cost Method or Contingent Valuation Method are used. However, because of the huge costs involved in applying these methods, utilization of the results of established research is recommendable on the basis of consideration of benefit transfer. There is no guarantee at all, however, of adjustability between individual values and overall values in measuring the economic value of plural impact items, because the economic value of each impact item is measured individually in the results of established research. This research aims to calculate a control total for managing adjustability between individual values and overall values in each field, and attempts to classify residential environments into four large fields and sixteen sub-fields and apply a conjoint analysis based on a questionnaire survey.

Key words: conjoint analysis, economic evaluation, global warming, non-marketed goods, residential environment change

1. Introduction

In recent years, global warming has been recognized as an urgent international problem. It is said that the effects span various fields in addition to the socio-economic and are serious enough to lead to expectations of some countries suffering obliteration. In order to defend humanity from such a situation, we must study the influence of global warming and frame various mitigation and/or adaptation measures.

In this case, there will be a need to implement economic evaluations of residential environment changes associated with global warming and the effects of mitigation and/or adaptation measures for avoiding the influence of global warming. This is necessary for the same reason that economic efficiency is required in general public works. In order to meet this demand, residential environment changes associated with global warming must be evaluated in monetary terms.

In the U.K. which is tackling economic evaluation of the influence of global warming in a progressive manner, the UKCIP (United Kingdom Climate Impacts Programme) has received financial assistance from the DEFRA (Department for Environment, Food and Rural Affairs). In 2004 it published guidelines called "costing the impacts of climate change" (Metroeconomica, 2004a & 2004b) and started consulting on "prediction of damage costs of future climate change" and "cost-benefit analyses of adaptation measures against climate change" according to the demand of each city or corporation in the U.K. In these guidelines, economic evaluation of impacts due to climate change is classified in the following manner.

1) Impacts on marketed goods or services can be valued according to changes in inputs or outputs, for instance, using a "change in productivity" approach. For impacts on man-made assets, cost-based methods, such as the "replacement cost" and "avertive expenditure" techniques, are appropriate.
2) Impacts on non-marketed goods or services can be valued using economic techniques, such as the HPM (Hedonic Price Method), TCM (Travel Cost Method), CVM (Contingent Valuation Method) or others. However, because of the huge cost involved in applying these methods, utilization of the results of established research is recommended in consideration of benefit transfer.

These guidelines have also indicated some data-

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bases on benefit transfer, for instance, the Green Book, the Environmental Valuation Reference Inventory and the Environment Agency's Register of Environmental Values. There is no guarantee at all, however, of adjustability between individual values and overall values in measuring the economic value of plural impact items, because the economic value of each impact item is measured individually in the results of established research.

The present research aims to calculate a control total for managing adjustability between individual values and overall values in each field, and attempts to classify residential environments into four large fields and sixteen sub-fields and apply a conjoint analysis based on a questionnaire survey.

2. Established Evaluation Methods

For economic evaluation of the environment, some methods such as HPM, TCM, CVM and so on have been proposed (Ohno, 2000). In particular, CVM studies have been amassing rapidly in recent years, and guidelines have been provided by NOAA (National Oceanic and Atomospheric Administration) (Arrow *et al.*, 1993; NOAA, 1994).

CVM originated from the ideas of Ciriacy-Wantrups (1947) and was initially applied to measurement of recreational benefits of the rivers in Delaware in 1958. After that, CVM was further developed in the field of environmental economics through the definition of consumer surpluses based on the discrete choice theory espoused by Small and Rosen (1981) and Hanemann (1984). CVM is a method for measuring environmental values, by having people specify their WTP (Willingness To Pay) or WTA (Willingness To Accept compensation) for the environment, based on definitions of ES (Equivalent Surplus) and CS (Compensating Surplus) in economics. It has been indicated, however, that various biases are included in the amounts expressed by people in response to the questionnaire (Mitchell & Carson, 1989). This bias problem means that the evaluation results differ according to the survey method, and gives CVM low reliability.

Conjoint analysis has begun to replace CVM. Conjoint analysis is an economic evaluation method, developed in the field of psychometrics and market research, based on questionnaire surveys like CVM (Kuriyama, 2000). First, defining the utility function of people in terms of the function of their policy attributes, environmental situations, policy costs, income and so on, we estimate the function from the results of chosen behavior of people. Second, by applying definitions of ES and CS to the utility function thus estimated, we can measure the benefits of policies that bring about environmental change. Or, by calculating the ratio of the unit change of the policy cost to the unit change at the environment level, we can determine the marginal willingness to pay for the environment.

One characteristic of conjoint analysis is that we can evaluate plural attributes simultaneously, whereas CVM is limited to the evaluation of single attributes. Furthermore, it is expected that the various biases that are pointed out with CVM will be mitigated appreciably, because people choose "goods" or "policies" in conjoint surveys, i.e., daily behavior, rather than "amounts" as in CVM surveys. The present study has adopted conjoint analysis as the evaluation method, because it involves economic evaluation of residential environment changes in many fields associated with global warming.

3. Classification of Residential Environment Fields

In 1961, the WHO (World Health Organization) defined a healthy residential environment as a fundamental human need and classified it into four fields (safety, health, convenience and amenity). In Japan, residential environment standards were presented on the basis of this classification in 1981, and residential environment development became official policy in this country (Sato & Asami, 2001). These four fields are summarized in the following manner:

1) Safety

Safety is divided into safety in everyday life and safety in the case of disasters. The former consists of crime-prevention, traffic safety and domestic environment safety. The latter indicates protection from natural disasters and/or man-made disasters.

2) Health

Health is an important condition in leading a fulfilling life. Environmental factors that influence health are divided into the physical environment, the chemical environment, the biological environment and the social environment.

3) Convenience

Convenience is an important condition for efficiency of life among residents and is divided into ease in carrying out daily activities, ease in using various institutions, ease in using transportation facilities, and ease in using social services.

4) Amenity

Amenity is divided into elements related to space performance, elements related to space constitution, elements related to coexistence with nature, elements related to the historical significance of the area, and elements related to residing there.

Global warming exerts an influence on all residential environments classified into the above four fields. The present study attempts to classify the residential environment into four large fields and sixteen sub-fields as follows.

1) Safety of residential environments

① Fires: increase in risk of the forest fires due to

drying
<Countermeasures: land control, fire prevention measures, etc.>

② Water shortages: reduced available water resources due to decreases in precipitation
<Countermeasures: evaporation and transpiration control, development of technology that decreases losses through leakage, application of drainage, etc.>

③ Floods: more frequent flood disasters in coastal areas and the river valleys due to increases in sea level and precipitation
<Countermeasures: development of embankment facilities, adjustment of river flows, etc.>

④ Storm damage: greater frequency of damage from typhoons and gusts
<Countermeasures: development of protection facilities against wind, etc.>

2) Health of residential environments

① Illness due to heat: outbreaks of heat stress and heat stroke
<Countermeasures: load reduction through air conditioning and tree planting in cities, etc.>

② Allergies: large volumes of pollen scattered as a result of changes in the natural environment (animals and plants)
<Countermeasures: information on pollen, anti-allergy inoculations, etc.>

③ Infections: influence of infections on human body through contact and ingestion
<Countermeasures: stronger quarantines, inoculation campaigns, improvement of water supply systems, etc.>

④ Illness due to air pollution: influence of air pollution on human body through photochemical reactions
<Countermeasures: reduction of greenhouse gases and air pollutants, etc.>

3) Convenience of residential environments

① Energy use: energy shortage due to excessive use of air conditioners
<Countermeasures: controlling power demand, providing information (electric power forecasts), etc.>

② Automobile use: influence of abnormal weather and photochemical smog on automobile use
<Countermeasures: travel demand management, introduction of low-pollution cars, use of bicycles, etc.>

③ Electronic device use: influence of lightning on use of electronic devices
<Countermeasures: introduction of the lightning-resistance devices, etc.>

④ Use of various facilities: influence of changing geographical features and weather on the use of various institutions
<Countermeasures: management of facilities, snowfall measures in winter, etc.>

4) Amenity of residential environments

① Culture: influence on scenery, food, customs, etc.
<Countermeasures: preservation and transmission of unique cultural items, etc.>

② Natural symbiosis: influence on local climates and natural environments
<Countermeasures: land control, management of scenery, use of materials compatible with living things, etc.>

③ Living behavior: influence on the timing and actions of human behavior
<Countermeasures: increase in exercise time for health control, introduction of labor standards that consider influences on health, etc.>

④ Food: influence of climate change and insect pest outbreaks on agricultural products
<Countermeasures: changing importation partner countries, regulation of price fluctuations, etc.>

4. Data Collection

4.1 Questionnaire survey

In 2006 March, a questionnaire survey of adult men and women in Japan was carried out using the Internet. Three types of models (open style, closed style and semi-closed style) were used in the Internet survey for quantitative analysis (Japan Marketing Organization, 2000). The survey this time was the closed style. Because the respondents were members of the general public who had registered in an Internet survey company, we could get a picture of various private attributes and it was easy to predict a number of respondents. Furthermore, it was highly likely that even people with little interest in this field would reply, because the survey company paid compensation to people who responded.

In this survey, 1,077 replies were obtained. It took about 43 hours 15 minutes to get all the replies. At that time, I controlled the survey by computer program so that none of the votes would be spoiled. In other words, when there was a lack or contradiction in a reply, the respondent would see a warning sentence displayed on the screen and be unable to advance to the next screen. Therefore, all of the 1,077 replies were effective. Also, the questionnaires were distributed so as to avoid biases in respondent attributes, and their responses were received. The attribute distributions (sex, age, job, annual income) were as follows.

<Sex>
Male: 54.7%,
Female: 45.3%.
<Age>
20-29: 18.2%, 30-39: 19.0%,
40-49: 19.7%, 50-59: 20.0%,
60 or over: 23.1%.

<Job>
Wage earner: 43.9%,
Family-operated business: 9.4%,
Liberal profession: 4.2%,
Housekeeping spouse: 23.7%,
Student: 3.8%,
Jobless: 11.8%,
Others: 3.2%.

<Annual income>
Less than 2 million yen: 7.6%,
2 - 3.99 million yen: 19.2%,
4 - 5.99 million yen: 23.5%,
6 - 7.99 million yen: 15.0%,
8 - 9.99 million yen: 10.8%,
10 million yen and more: 10.6%
Unknown: 13.3%.

4.2 Contents of the questionnaire survey

The title of the survey was the "Questionnaire survey regarding the influence of global warming," and the contents of survey sheet were as follows.

Questions 1 and 2 were positioned as the introduction to this survey, and asked about the respondent's interest in the global warming issue. Question 1 was a question on the global warming issue overall. Question 2 focused in particular on the sea-level-rise issue.

<Question 1>

In recent years, global warming has advanced rapidly, and some concerns have been raised accordingly; the occurrence of abnormal weather, destruction of forest ecosystems, increases in vector-borne infections and heat disorders, expanding areas of affected food production, sea-level-rise, etc. Are you interested in such problems of global warming? Regarding your degree of interest, please choose the closest matching level from the following six levels (0 points=no concern, 20 points, 40 points, 60 points, 80 points, 100 points=highest concern).

1. 0 points 2. 20 points 3. 40 points
4. 60 points 5. 80 points 6. 100 points

(Average: 69.6 points)

<Question 2>

The IPCC (Inter-governmental Panel on Climate Change) predicts about 88 cm of sea-level-rise globally within 100 years from now. According to circumstances, industries and populations in coastal area may inevitably need to move to other areas, and industrial structures and population distributions might change, even in Japan. Specifically, if the sea level goes up 1 m, in Japan, 861 km^2 of land and 150 trillion yen of property will disappear and 17.3 million people will be influenced. Are you interested in such problems of sea-level-rise? Regarding your degree of interest, please choose the closest matching level from the following six levels (0 points=no concern, 20 points, 40 points, 60 points, 80 points, 100 points=highest concern).

1. 0 points 2. 20 points 3. 40 points
4. 60 points 5. 80 points 6. 100 points

(Average: 71.8 points)

Questions 3 and 4 constituted the main part of this survey, i.e., questions regarding the global warming issue as environmental policy. Question 3 was a question asking about the degree of urgency of these problems and countermeasures for residential environment items (the 16 sub-fields) that are classified in Chapter 3. Here the first four sub-fields are shown. Question 4 is a typical question in conjoint analysis, and asks about desirable policy alternatives, by making each respondent choose among alternatives which have different levels of elements (safety, health, convenience, amenity and cost) the nearest to his way of thinking. In this survey, five questions were presented to each respondent, who was to choose one alternative out of three alternatives for each question. Four different questionnaires were prepared. One alternative in each question was a common "standard case," with a total of 41 alternatives set up in this survey. The "standard case" was that of existing measures being maintained against global warming, with the result that the residential environment quality ten years later would decrease 20% from the present level. Here the first question is shown.

<Question 3>

In Japan, various measures are being considered for avoiding influences on "safety," "health," "convenience" and "amenity" of residential environments from global warming. How much importance do you give to problems and measures regarding "safety," "health," "convenience" and "amenity" in your life? Regarding the degree of your concern, please choose the nearest to your thinking of the following six levels (0 points = no concern, 20 points, 40 points, 60 points, 80 points, 100 points = highest concern).

1) Safety of residential environments

① <Problems> fires: increased risk of forest fires due to drying
<Countermeasures> land control, fire prevention measures, etc.
1. 0 points 2. 20 points 3. 40 points
4. 60 points 5. 80 points 6. 100 points
(Average: 56.0 points)

② <Problems> water shortages: reduced available water resources due to decreases in precipitation
<Countermeasures> evaporation and transpiration control, development of technology that decreases losses through leakage, application of drainage, etc.
1. 0 points 2. 20 points 3. 40 points
4. 60 points 5. 80 points 6. 100 points
(Average: 67.9 points)

③ <Problems> floods: more frequent flood disasters in coastal areas and the river valleys due to increases in sea level and precipitation
<Countermeasures> development of embankment facilities, adjustment of river flows, etc.
1. 0 points 2. 20 points 3. 40 points
4. 60 points 5. 80 points 6. 100 points
(Average: 69.9 points)

④ <Problems> greater frequency of damage from typhoons and gusts
<Countermeasures> development of protection facilities against wind, etc.
1. 0 points 2. 20 points 3. 40 points
4. 60 points 5. 80 points 6. 100 points
(Average: 67.9 points)

<Question 4>

Below we present three policy alternatives, which place different levels of importance on different elements (safety, health, convenience, amenity, cost). Please choose the nearest to your way of thinking out of the three alternatives.

1. Policy A 2. Policy B 3. Policy C

Policy	Change in residential environment level due to policy				Cost [yen/household/month]
	Saf.	Hea.	Con.	Ame.	
A	20% down	50% down	20% down	50% down	65,000
B	20% down	No change	No change	50% down	80,000
C	20% down	20% down	20% down	20% down	70,000

Notes)
- "No change": enough measures are carried out against global warming such that the residential environment level ten years later will not change from the present level.
- "20% down": existing measures are maintained against global warming, resulting in a 20% decrease in the residential environment level ten years later from the present level.
- "50% down": no measures are carried out against global warming, resulting in a 50% decrease in the residential environment level ten years later from the present level.
- "Cost": the amount spent for measures to realize the policy every month, where its fund is the tax that you paid.
- "70,000 yen/household/month": the amount used for measures to continue the existing policy every month. Please pay attention. If you choose the policy that requires a higher (or cheaper) cost than 70,000 yen, the amount that you are able to use usually decreases (or increases) by the difference from 70,000 yen.

5. Economic Evaluation Model

5.1 Definition of the utility function

In conjoint analysis, defining utility functions of people in terms of the function of their policy attributes, environmental situations, policy costs, income and so on, we estimate the function from the results of chosen behavior of people. This study defines the utility function as follows.

<Model 1>

$$V = \sum_{k=1}^{4} \alpha_k x_k + \gamma \cdot p \tag{1}$$

<Model 2>

$$V = \sum_{k=1}^{4} \left(\sum_{j=1}^{4} \beta_{kj} y_{kj} \right) x_k + \gamma \cdot p \tag{2}$$

$$y_{kj} = \frac{z_{kj}}{\sum_{j=1}^{4} z_{kj}} \tag{3}$$

where V: partial utility of the residential environment,
x_k: level of the k-th residential environment (four large items) [%; present level = 100%],
y_{kj}: relative degree of concern for the j-th residential environment (four sub-fields) in the k-th residential environment (four large fields),
z_{kj}: absolute degree of concern for the j-th residential environment (four sub-fields) in the k-th residential environment (four large fields),
p: cost [yen / month], and
α_k, β_{kj}, γ: unknown parameters.

5.2 Method of economic evaluation

This study measures the marginal willingness to pay for residential environment change. By differentiating utility functions (1) and (2), the following equations are obtained.

<Model 1>

$$dV = \sum_{k=1}^{4} \alpha_k dx_k + \gamma \cdot dp \tag{4}$$

<Model 2>

$$dV = \sum_{k=1}^{4} \sum_{j=1}^{4} \beta_{kj} (y_{kj} dx_k + x_k dy_{kj}) + \gamma \cdot dp \tag{5}$$

where I set $dy_{kj} = 0$, because the only controllable variables in utility function V are x_k and p.

In equations (4) and (5), I set $dV = 0$ and $dx_{k'} = 0\ (k' \neq k)$, in order to obtain the change in cost dp so as to cancel the change in utility dV due to the change in the residential environment dx_k. Then the ratio of the change in cost dp to the change in the residential environment dx_k is obtained as follows.

<Model 1>

$$\frac{dp}{dx_k} = -\frac{\alpha_k}{\gamma} \tag{6}$$

<Model 2>

$$\frac{dp}{dx_k} = -\frac{\sum_{k=1}^{4} \beta_{kj} y_{kj}}{\gamma} \tag{7}$$

Equations (6) and (7) indicate the marginal willingness to pay. Moreover, equation (7) implies that the overall value is given by the total of the individual values of each residential environment field. Therefore, the economic value of each field is given as follows.

$$M_k = -\frac{\alpha_k}{\gamma} = -\frac{\sum_{k=1}^{4} \beta_{kj} y_{kj}}{\gamma} \tag{8}$$

$$M_{kj} = -\frac{\beta_{kj} y_{kj}}{\gamma} \tag{9}$$

where M_k: economic value of the k-th residential environment (four large fields),
M_{kj}: economic value of the j-th residential environment (four sub-fields) in the

k -th residential environment (four large fields),

The economic values M_k and M_{kj} indicate the economic impact (benefit or damage) on the residential environment, when the level ten years later changes (increases or decreases) 1% from the present level. A 1% change in the residential environment level due to global warming is defined by a 1% change in the physical level. It is difficult, however, to define a 1% change in each level, because each residential environment field in this study contains plural physical quantities that change independently. For instance, each item ("fires," "water shortages," "floods," "storm damage") in the "safety" of the residential environment has at least two physical quantities, "frequency of occurrence" and "strength of occurrence." In order to define a 1% change in each item, we have to make a new index, integrating frequency and strength. This is a big problem which differs among each of the sixteen sub-fields, and I would like to solve this problem in a future study, but this problem appears not to ruin the modeling of this study.

6. Results of Economic Evaluation

The parameters of equations (1) and (2) were estimated using data collected in the questionnaire survey in this study. By applying these estimated parameters to equations (7) and (9), the marginal willingness to pay (MWTP) for residential environment change was obtained. The result is shown in Tables 1-4.

Table 1 Estimated values (Model 1: Case 1).

Variables	Estimated parameters (t-value)	MWTP [yen/household/month]
Safety	2.782E-02 (21.531)	472
Health	2.736E-02 (17.492)	464
Conven.	1.525E-02 (9.463)	259
Amenity	1.679E-02 (11.939)	285
Cost	–5.891E-05 (–11.420)	

Note) "Case 1": using all samples.

Table 2 Estimated values (Model 2: Case 1).

Variables	Estimated parameters (t-value)	Relative degree of concern	MWTP [yen/household/month]
Safety			(473)
①	1.877E-02 (1.461)	0.214	68
②	3.129E-02 (2.529)	0.260	138
③	6.130E-02 (4.769)	0.267	278
④	–2.338E-03 (– 0.189)	0.259	–10
Health			(463)
①	–2.019E-03 (– 0.133)	0.240	–8
②	3.973E-03 (0.264)	0.237	16
③	5.472E-02 (3.144)	0.260	241
④	4.804E-02 (2.867)	0.263	214
Conven.			(260)
①	1.280E-02 (0.958)	0.280	61
②	2.237E-02 (1.443)	0.275	104
③	6.794E-03 (0.400)	0.218	25
④	4.804E-02 (1.018)	0.227	69
Amenity			(284)
①	1.535E-02 (1.124)	0.230	60
②	9.846E-03 (0.703)	0.255	43
③	6.707E-03 (0.424)	0.241	27
④	3.322E-02 (2.958)	0.274	154
Cost	–5.899E-05 (–11.473)		

Note) "Case 1": using all samples.

Table 3 Estimated values (Model 1: Case 2).

Variable	Estimated parameters (t-value)	MWTP [yen/household/month]
Safety	2.875E-02 (19.631)	537
Health	2.954E-02 (16.556)	552
Conven.	1.634E-02 (8.926)	305
Amenity	1.663E-02 (10.422)	311
Cost	–5.355E-05 (–9.204)	

Note) "Case 2": excluding samples of people who had low interest in the global warming issue.

Table 4 Estimated values (Model 2: Case 2).

Variables	Estimated parameters (t-value)	Relative degree of concern	MWTP [yen/household/month]
Safety			(532)
①	7.485E-03 (0.476)	0.214	30
②	5.674E-02 (3.517)	0.260	272
③	4.377E-02 (2.917)	0.267	216
④	3.205E-03 (0.211)	0.259	15
Health			(546)
①	–2.087E-02 (–1.187)	0.240	–92
②	2.161E-04 (0.011)	0.237	1
③	8.628E-02 (3.808)	0.260	414
④	4.598E-02 (2.258)	0.263	223
Conven.			(304)
①	1.060E-02 (0.633)	0.280	55
②	1.981E-02 (1.077)	0.275	101
③	1.335E-02 (0.627)	0.218	54
④	2.278E-02 (1.020)	0.227	95
Amenity			(312)
①	1.843E-02 (1.024)	0.230	78
②	4.250E-03 (0.260)	0.255	20
③	3.715E-02 (1.854)	0.241	165
④	9.634E-03 (0.677)	0.274	49
Cost	–5.419E-05 (–9.293)		

Note) "Case 2": excluding samples of people who had low interest in the global warming issue.

Tables 1 and 2 show the results estimated using all samples obtained in the questionnaire survey. Here, the number of valid replies was 1,077, and the number of samples used to estimate parameters was 5,385 because each respondent answered the comparative questions five times. Table 1 indicates that the MWTPs for "safety," "health," "convenience" and "amenity" were 472, 464, 259 and 285 yen/household/month, respectively.

Considering the number of households on March 31, 2005, in Japan was about 50.38 million, the total economic damage to the residential environment in the standard case (when existing measures are maintained against global warming and the residential environment level ten years later decreases 20% from the present level) can be calculated as 17.91 trillion yen/year. The ratio of the total economic loss to the GDP (Gross Domestic Product) in 2004 was 3.61%. Now, the standard case, which is defined as "the case in which the residential environment level ten years later decreases 20% from the present level" in this study, is a hypothesis with no particular scientific backing. Therefore, I invite future discussion of this hypothesis in order to evaluate the accuracy of "3.61%."

By comparing Table 1 and Table 2, it can be said that the estimated values of MWTP for the four large fields are almost equal, and that there is adjustability between Model 1 and Model 2. However, Table 2 indicates that there are many parameters whose t-value is low, and it is difficult to tell if the results of Model 2 have sufficient statistical significance.

Tables 3 and 4 indicate the results estimated by excluding samples of people who had low interest in the global warming issue. The excluded sample is the sample of people who select 40 points or less on Question 1 or 2, and the number of samples used in estimating parameters was 4,245. Table 3 indicates that the MWTPs for "safety," "health," "convenience" and "amenity" were 537, 552, 305 and 311 yen/household/month, respectively. The order of values in Table 3 was the same as that of Table 1, and each value in Table 3 was greater than the respective one in Table 1. Also, by comparing Table 3 and Table 4, it can be said that there is adjustability between Model 1 and Model 2. However, from Table 4, it is also difficult to tell if the results of Model 2 have sufficient statistical significance.

7. Conclusion

This research aimed to calculate the control total for managing adjustability between individual values and overall values in each field, and has tried to classify the residential environment into four large fields and sixteen sub-fields and apply a conjoint analysis based on a questionnaire survey.

The results indicate that the marginal willingness to pay for four large fields ("safety," "health," "convenience" and "amenity") of the residential environment is 472, 464, 259 and 285 yen/household/month, respectively. These values indicate economic impact (benefit or damage) on the residential environment, when the level ten years later changes (increases or decreases) 1% from the present level. If we assume that existing measures are maintained against global warming and the residential environment level ten years later decreases 20% from the present level, the total economic damage can be calculated as 17.91 trillion yen/year.

The values for the sixteen sub-fields of the residential environment were also estimated. However, the model has many parameters whose t-value is low, and it is difficult to say that the results have sufficient statistical significance. Reconstruction of the economic evaluation model will be a future subject of this study.

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