Measurement of value of a statistical life based on happiness survey

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Abstract: Happiness survey aims at clarifying determinants of subjective degree of happiness. In this survey, we prepare about subjective degree of happiness and some attribute questions (household income level, individual preference and customs, and so on). In recent years, the happiness index has been drawing attention internationally, and its knowledge is accumulating in each country. Based on the data obtained by the happiness survey, some of studies has been made to estimate the degree of the relative risk aversion representing the attitude toward people's risk. They suggest that the economic evaluation of various mortality risks can be carried out based on the happiness survey. First, we conducted the happiness survey that we set many items which may have an influence on individual's happiness. In addition, we conducted the internet-based survey in March 2016, which was targeted for the several thousand adults of both sexes (ages 20-69) living in japan. Second, we estimated parameters by applying ordered response model to the data obtained from this survey. Finally, we tried to measure the value of a statistical life (VSL) by multi-attribute based on the estimation result of these parameter. The findings in this study are as follows; Case of single attribute (when measured by age): VSL rose in direct proportion to age until 50s, but turned to a decrease in 60s. Case of multi-attribute (when measured with other attributes taken into account in addition to age): Although the estimated value of VSL increased or decreased, the same tendency as the case of single attribute was shown. However, some of them (e.g., smoking habit) showed a different tendency from the case of single attributes.

JEL classification: C35, I15, I31

Keywords: *value of a statistical life, happiness survey, ordered response model*

1. Introduction

The value of a statistical life (VSL) has been used in research fields related to economic evaluation of changes in the risk of death from environmental problems, climate change impacts,

traffic accidents, disasters, diseases, and so on.

According to Hammitt (2000), VSL is defined as monetary transaction against minute changes in mortality at a certain time, it can be expressed as a marginal substitution rate between the wealth of an individual and the risk of death. For example, if the mortality rate that can be reduced in one year is set to one hundred thousandths and the amount considered to be the maximum amount to be paid at that time is 2,000 JPY, the value of VSL for an individual will be 200 million JPY. In addition, Hammitt (2000) says that attention is necessary because there is no meaning to pay 200 million yen to avoid any death, or accept some sort of death in exchange for 200 million yen.

Since VSL is not constant, it can take different values for each age.

Aldy and Viscusi (2007) focused on the discussion of Senior discount on VSL regarding whether the risk reduction benefit for older people is lower than that of the younger generation, especially the elderly VSL needs to be discounted. Among them, for example, Canada estimates the VSL of those 65 years of age and over 25% lower than the VSL of those under the age of 65 in 2000, and European Commission It introduced in 2001 that it recommended to Member States to use VSL which will decline with age. Thus, when a certain age is exceeded, it can be seen that there are countries where the VSL is discounted and evaluated. Then, Aldy and Viscusi (2007) is, in relation to the VSL and age, VSL indicates that the inverted U-shape with respect to age.

On the other hand, VSL may take different values not only for age but for various personal attributes. For example, various personal attributes such as a family environment such as the presence or absence of a child and the presence or absence of a child, the place of residence, the presence or absence of smoking and past and present health conditions can be considered. In this way, when there are different VSLs according to various individual attributes, it can be considered that it is possible to make appropriate benefit assessment according to each project in public works projects aiming at reducing any risk not uniformly . For example, public works projects in areas with relatively child-rearing households may have higher benefits than projects in areas where there are not many parenting households. Sharing such differences in VSL and differences in benefits from projects between policy makers in each region and local residents is also important as risk communication in public projects for risk reduction is there.

In this study, we conducted a Web-based happiness survey with a number of items considered to possibly affect individual's happiness level for adults and males between 20 and 69 living in Japan. Furthermore, parameter estimation is performed by applying an order response model to the data obtained from the survey, and the value of statistical life (VSL: Value of Statistical Life) by multiple attributes is attempted.

2. The value of a statistical life

(1) Economic interpretation of the VSL

The value of statistical life (VSL) is defined as monetary transaction against a minute change in mortality rate at a certain time according to Hammitt (2000).

This can be expressed as the marginal substitution rate of an individual's wealth and mortality risk. In Figure 1, the horizontal axis represents the survival probability p (same as 1 minus mortality rate), the vertical axis represents individual wealth, and the convex curve at the origin represents indifference curve. If the combination of wealth and death rate of an individual is point X, the slope of the indifference curve of point X, that is, the limit substitution rate between wealth and death rate is VSL. This means that the maximum amount you can pay to lower the death rate by Δp is Δw. Also, VSL can be expressed as $\Delta w/\Delta p \approx dw/dp = VSL$ for a minute change Δp in mortality rate. Although the relationship between VSL and WTP (Willingness to pay) and WTA (Willingness to accept compensation) is also shown in Figure 1, its explanation is omitted because of paper limitation, and details are described in Hammitt and Robinson (2011).

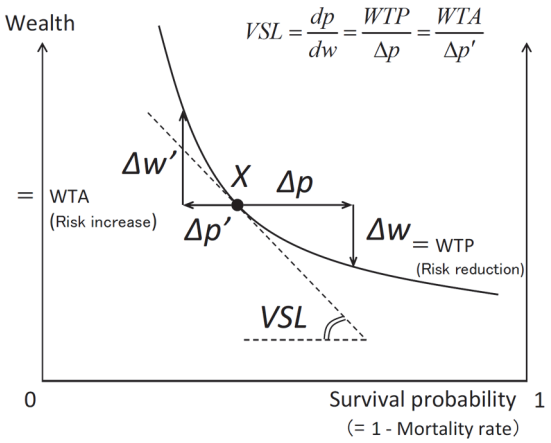

Figure 1: Economic interpretation of the value of a statistical life

(2) Case studies in estimated by the VSL

Kuriyama et al. (2007) stated that the value of VSL in empirical studies is generally substituted by WTP divided by the risk reduction width. Also, as can be seen from Table 1, in estimating VSL, CVM (Contingent Valuation Method) is used in many studies. However, in the case of estimation by CVM, basically, only VSL corresponding to the value of the risk reduction width shown in the questionnaire survey form can be estimated. For this reason, a method of estimating VSL that does not depend on the risk reduction range presented is expected and its development is currently proceeding. Boardman et al. (2006) mentioned several representative

studies that measured VSL and organized the estimates of VSL. Although the values of VSL estimated by many studies are largely different from each other, it is concluded from the results of these existing studies that the estimated value of VSL in the United States is US $ 4 million there. On the other hand, Ohno et al. (2011) has arranged an existing study on VSL estimation in Japan. Here, 19 studies (11 traffic accidents, 5 cases of illness (water quality, air pollution · heat stroke), 3 cases of water accidents and occupational accidents), VSL estimate is 0.5 billion JPY (minimum (Maximum value) (from Table 1). Similarly to the results of Boardman et al. (2006), although the range of estimates of VSL in Japan is wide, the value of VSL for the risk of death of a traffic accident estimated by the Cabinet Office (226.07 million JPY) it is the standard value of life value in Japan now about on February 2017.

Table 1: Estimated value of a statistical life in Japan

mortality risk	analytical method	estimate of VSL
traffic accident	CVM	1.03～1.4 billion JPY
	standard gambling method	0.15 billion JPY
	wage risk method	0.79～0.99 billion JPY
water quality	CVM	2.24～3.55 billion JPY
air pollution	CVM	0.14 billion JPY / 3.14～4.59million USD
heatstroke	CVM	0.0902～0.1055 billion JPY
water accident	CVM	0.054～0.097 billion JPY
industrial accident	wage risk method	0.82～8.12 billion JPY

Source: Created by the authors based on Chen (2011)

3. Relationship with the happiness survey and the VSL

(1) Estimation method comparison for VSL

As mentioned above, CVM is often used to measure the value of statistical life. It is also possible to measure the value of statistical life by the hedonic wage law. In both cases, it is possible to measure the value of statistical life by individual attribute, but let's see the characteristics of each.

In the case of CVM, the value of statistical life is measured by asking in a questionnaire a willingness to pay for a given risk reduction range and dividing the willingness to pay estimated by analyzing it by the risk reduction width. While there is a merit that it can respond flexibly to various risks, the measurement result of the value of statistical life by CVM may depend on the risk reduction range assumed at the questionnaire. In general, it is known that in order for the value of statistical life by CVM to be independent of the range of risk reduction, the willingness to pay should be near proportional to the risk reduction range.

Measurement of the value of statistical life by the hedonic wage method has an advantage that it uses explicit preference data, and has higher reliability than CVM using assertion preference data. Also, since it is possible to measure the willingness to pay for marginal mortality risk reduction, there is no problem that the value of statistical life depends on the range of risk reduction like CVM. However, since the target is only the risk in labor, there remains a question as to whether it can be dealt with in the same way as the risk of death from illness or the like and risk of occupational accidents.

Therefore, in this study, we try to measure the value of statistical life by estimating the happiness function. Happiness functions can be related to utility functions by making some assumptions. Assuming this relationship, by estimating the happiness degree function, the parameter of the utility function is estimated, and the value of statistical life can be measured using this parameter. In this method, since the utility function is directly estimated, the value of statistical life in a marginal sense for general mortality risk is easily obtained, and various personal attributes to be asked in the happiness survey there is also the merit that you can aggregate the value of statistical life separately.

(2) Happiness function and the estimation

The experience utility u_i of the individual i depends on the income y_i of the individual i and the attribute vector x_i and is expressed as follows.

$$u_i = \alpha + \gamma g(y_i) + x_i'\beta + \varepsilon_i \tag{1}$$

Here, α and γ are scalars, β is a coefficient vector, ε_i is a random variable different among individuals. The function g is common (homogeneous) among individuals and is represented by the utility function of Constant Relative Risk Aversion. In other words, ρ is the relative risk aversion.

$$g(y_i) = \begin{cases} \dfrac{y^{1-\rho} - 1}{1-\rho} & \text{if } \rho \neq 1 \\ \ln y & \text{if } \rho = 1 \end{cases} \tag{2}$$

Furthermore, the degree of happiness h_i responded by the individual i by the happiness survey is a monotonically increasing function of the experience utility u_i of the individual i and is expressed as $h_i = f(u_i)$. For simplicity, it is assumed that the function f is common among homes (homogeneous). In this study, we ask respondents in the happiness survey 11 levels of happiness degree from 0 to 10. Therefore, it is assumed that the function f is a step function as follows.

$$f(u_i)=\begin{cases}0 & \text{if } u_i \le \mu_0 \\ 1 & \text{if } \mu_0 < u_i \le \mu_1 \\ 2 & \text{if } \mu_1 < u_i \le \mu_2 \\ \vdots & \vdots \\ 10 & \text{if } \mu_9 < u_i \end{cases} \tag{3}$$

In this study, parameters were estimated using data obtained from the happiness survey. Specifically, an ordered logit model assuming a logistic distribution was applied to ε_i. However, this time, for the sake of simplicity, the relative risk aversion degree is assumed to be 1 and analyzed.

(3) Definition of the VSL and the measuring method

Experience utility can be enjoyed when surviving, but it is considered that you cannot enjoy it if you die. Therefore, in this study, it is assumed that the experience utility at the time of death is zero. At this time, assuming that the survival probability of the individual i is p_i, the expected utility Eu_i based on the experience utility for the individual i has the following simple form.

$$Eu_i = p_i u_i \tag{4}$$

According to Hammitt and Robinson (2011), the value of statistical life is defined as the marginal payment intention to raise the probability of survival. The limit payment intention amount MWTP_i against the rise in the probability of survival of the individual i is obtained from the expression (4) as follows.

$$\mathrm{MWTP}_i = \left.\frac{\mathrm{d}y_i}{\mathrm{d}p_i}\right|_{Eu_i=const.} = -\frac{\alpha+\gamma g(y_i)+x_i'\beta+\varepsilon_i}{p_i\cdot\gamma g'(y_i)} \tag{5}$$

As is apparent from the equation (5), MWTP_i is a random variable. Below, this expected value is defined as the value of statistical life VSL_i of individual i. That is,

$$\mathrm{VSL}_i = E(\mathrm{MWTP}_i) = \frac{\alpha+\gamma g(y_i)+x_i'\beta}{p_i\cdot\gamma g'(y_i)} \tag{6}$$

From equation (6), we see that the value of statistical life of individual i depends on income y_i of individual i, attribute x_i, survival probability p_i. Furthermore, if only an estimated value of each parameter can be obtained, the value of statistical life can be measured for all individual votes only by calculating equation (6), so if it is tabulated by attribute, statistical the value of life can be measured relatively easily.

4. Estimation of the VSL based on happiness survey

(1) Outline of happiness survey

Happiness survey is a survey aimed at clarifying determinants of subjective happiness degree, which questions include subjective degree of well-being, some attributes such as taste, habits, economic situation Questions concerning questions concerning the subjects are prepared. In recent years, international attention has also been paid to the indicators of happiness, and their findings are accumulating in each country. In recent years, some studies such as Layard et al. (2008) have been conducting research to estimate the relative risk aversion rate that expresses attitudes towards people's attitudes using this happiness survey. In light of the fact that if it is possible to obtain an estimate of the relative risk aversion degree in theory, it is considered that there is a possibility that economic evaluation of various mortality risks can be carried out, and in this study we conduct a happiness survey it was decided to.

The happiness survey of this study was conducted through a questionnaire survey company from March 8 to 10, 2016. Here, there are three types of Internet survey in quantitative analysis, open type, closed type, semi closed type, but this study was closed type. Since the examinees are general persons registered in the questionnaire survey company in advance, it was possible to grasp various personal attributes. The subjects of the survey were male and female residents living in Japan, and the age was 20 to 60 in consideration of the registration status of the monitor. Regarding the age and gender, based on the population (as announced on January 20, 2016) as of each month of the "population estimate" of the Statistics Bureau of the Ministry of Internal Affairs and Communications, the population estimate as of August 1, 2015.

Table 2: Assignment by gender and age in happiness survey

Sex	Age	Total population (Thousand people)	Composition ratio	Allocation (people)
Man	20-29	6,570	8.1%	285
	30-39	7,976	9.9%	346
	40-49	9,345	11.6%	405
	50-59	7,733	9.6%	335
	60-69	8,850	11.0%	384
Woman	20-29	6,222	7.7%	270
	30-39	7,749	9.6%	336
	40-49	9,174	11.4%	398
	50-59	7,770	9.6%	337
	60-69	9,338	11.6%	405
Total		80,727	100.0%	3,501

The allocation was carried out based on the fair value (Table 2). The number of collected samples was 3,501.

The questionnaire on the survey was "Questionnaire on yourself", prepared questions as shown in Table 3 and Table 4, and investigated. Question concerning the subjective degree of happiness, which is the central question in this survey, is question 12 (Figure 2). In addition, referring to the previous studies prepared questions on attributes that were statistically significant for happiness in these regression analyzes, and got responses.

Table 3: Question in happiness survey (Q1-Q25)

No.	Contents
Q1	Do you think "I want to live as simple as possible"?
Q2	Do you think "To save money is the purpose of life"?
Q3	Do you feel uneasy about health?
Q4	Are you conscious of the living standard of other people?
Q5	Do you enthusiastically believe religion?
Q6	If you compare it with 10,000 JPY after one month, how much should I get at the last minute in 13 months?
Q7	What if the amount you get in one month is 1 million JPY? How much does it take to get at the last minute in 13 months?
Q8	What if the amount you get in one month is 10 million JPY? How much does it take to get at the last minute in 13 months?
Q9	Compared with paying 1 million JPY in one month, how much should I pay the last minute in 13 months?
Q10	If you issue 1,000 JPY, subsidies of 99,000 JPY will come out from the government and a total of 100,000 JPY will be handed over to poor people you do not know. Do you give out this 1000 JPY?
Q11	If you issue 1,000 JPY, subsidies of 99,000 JPY will come out of the government and a total of 100,000 JPY will be handed over to the poor among your close relatives. Do you give out this 1000 JPY?
Q12	On the whole, how well do you feel as happy? Ten points for "very happy", 0 points for "very unhappy", how many points do you think you will have?
Q13	Please evaluate your behavior pattern with 10 points sympathizing completely with the idea of "Tiger Hole", 0 point sympathizing completely with the idea of "Kimiko" as 0 point.
Q14	Please answer your gender.
Q15	Are you married? Is your spouse still alive?
Q16	Which of the following is your full age (as of January 1, 2016)?
Q17	Please answer the school you graduated last. Those who are studying abroad please answer the school you are currently studying at.
Q18	Which of the following is your occupation?
Q19	Are you currently with your child?
Q20	Are you currently grandchildren?
Q21	How much was your tax included total income (including business income) including your own 2015 bonus?
Q22	How many people are currently in your household? Here, a household means a person who makes the same living. * Please answer with the number including yourself.
Q23	What was the purchase amount of durable consumer goods such as houses, cars, expensive electric products throughout your household in 2015?
Q24	How much is your household's total expenditure in 2015 on average on a monthly basis?
Q25	Are you currently looking for work? Please answer whether you currently have a job or not.

Table 4: Question in happiness survey(Q26-Q37)

No.	Contents
Q26	How is the total annual gross income tax included in 2015 for your entire household including the bonus? (If you are a student, please answer your parent's income.)
Q27	How do you anticipate the total annual gross income for the entire household of your house in 2016 compared to 2015? (If you are a student, please answer about your family home.)
Q28	How much is the current value of assets such as houses and land owned by the household of your house as a whole? (If you are a student, please answer about your real estate's housing / land property.)
Q29	How much is the balance of financial assets (deposits, savings, stocks, insurance, etc.) of the household of your house? (If you are a student, please answer the financial assets balance of your home.)
Q30	Ten points for "the richest" and 0 points for "the poorest", do you think how many points of your living standards will be?
Q31	With 10 points as "the richest", 0 points as "the poorest" as 0 points, and "medium standard of living" as 5 points, what do you think the standard of living in your family will be?
Q32	Please answer the prefecture name you live in when you are in junior high school.
Q33	Please answer the prefecture name and city / town / village you are currently residing in.
Q34	To what extent do you have a habit of smoking? Please choose one closest from the following.
Q35	Do you have anyone around you who can consult with you?
Q36	How many times have you experienced shocking events that will get hurt in your hearts over the past five years?
Q37	Which of the following is your preference (orientation) when choosing a residence?

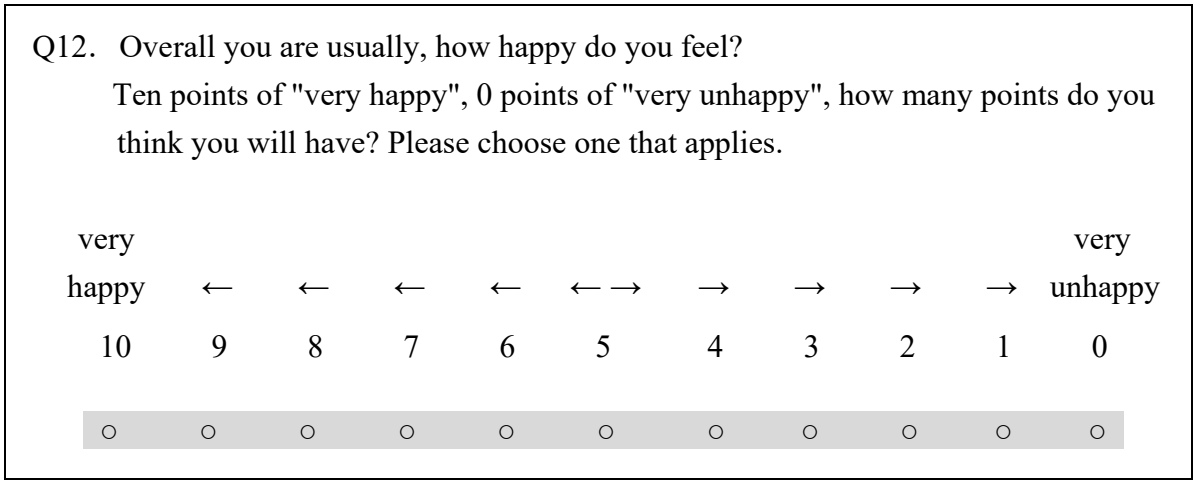

Figure 2: Question on Subjective Happiness (Question 12)

(2) Estimated parameters by applying ordered response model

The question on the subjective happiness level asked in this study is an 11 step category (option) variable as shown the Figure 2.That is, it can be regarded as a reaction variable taking an ordered discrete value (positive integer). Therefore, we decided to analyze using Ordered Response Model as analysis method. Furthermore, in order to make it possible to calculate VSL by attribute, based on existing studies such as Layard et al.(2008) and Tsutsui et al.(2009), the survey data conducted in this study is shown in Table 5. We classified and processed it as shown this table, decided to adopt these variables and try to analyze.

Table 5: Variables used for analysis

Variable		Property	Contents
Happiness on own		Order	Very happy= 0 ～Very unhappy= 10
Sex （Female）		Dummy	Male= 0, Female= 1
Spouse		Dummy	With= 1, Without= 0
Age	30s, 40s, 50s, 60s	Dummy	Applicable = 1, Not applicable = 0 ※all not applicable = 20s
Final Education	Elementary and junior high school, high school, vocational school, various schools, junior college, college (science), graduate school, other	Dummy	Applicable = 1, Not applicable = 0 ※all not applicable = college graduate (arts)
profession	Clerk and Sales, Managerial, Professional / Technical, Service, Worker, Agriculture and Fishery, Housewife / Househusband (Part-time), Housewife / Househusband (Unemployed), Student, Other	Dummy	Applicable = 1, Not applicable = 0 ※all not applicable = unemployed
Current residence	Each prefectures(except Tokyo)	Dummy	Applicable = 1, Not applicable = 0 ※all not applicable =Tokyo
Unemployed * Job Seeker		Dummy	Applicable = 1, Not applicable = 0
Simpleness		Dummy	Applicable = 1, Not applicable = 0
Propensity to save		Dummy	With = 1, Without = 0
Health insecurity		Dummy	With = 1, Without = 0
Awareness of the living standard of others		Dummy	With = 1, Without = 0
Religious belief		Dummy	With = 1, Without = 0
Altruism to acquaintance		Dummy	With = 1, Without = 0
Altruism to non-acquaintance		Dummy	With = 1, Without = 0
High risk tendency		Dummy	Applicable = 1, Not applicable = 0
Past living standard		Dummy	upper = 1, lower = 0
adviser		Dummy	With = 1, Without = 0
experience of mental injury		Dummy	With = 1, Without = 0
Residence oriented		Dummy	Convenience = 1, Suburban and rural = 0
Presence of children		Dummy	With = 1, Without = 0
Presence of grandchildren		Dummy	With = 1, Without = 0
smoking	nearly none, occasionally, about 10 peaces/ day, about 1 box / day, 2 boxes or more / day	Dummy	Applicable = 1, Not applicable = 0 ※all not applicable = none
$\ln\left(\frac{\text{HouseholdIncome(ten thousand JPY)}}{\sqrt{\text{number of householdmembers}}}\right)$		Consecution	ln （Equivalent income）

The procedure will be described below. Regression coefficients were estimated using an ordered logit model in a regression equation taking natural logarithm with respect to equivalent income. For the estimation of the parameters, the order regression (logit) function of IBM SPSS 23.0 was used. For parameter estimation using the evaluation model of this study, analysis was carried out by adopting all the attribute variables set in Table 5 for the initial estimation. This was taken as Model 1. However, since some of the attribute variables were values suggested as not significant in the statistical hypothesis test, except for the constant term (own happiness), all the attribute variables rejected the null hypothesis with a significance level of 10% Analysis was repeated with the sequential selection method (variable reduction method) until the region satisfied the region. This was taken as Model 2. As a result, the estimation results shown in Table 6 were obtained.

(3) Measurement of VSL by attribute

The VSL of each sample (individual) can be calculated by applying the parameter estimated by the evaluation model of this study to Equation (6). The average was measured as 36.44 million yen. Here, if the average value is calculated for each attribute, VSL for each attribute can be obtained. In this study, we tried to measure VSL considering age, family environment (household members, partner, children and grandchildren), and residential attributes.

Figures 3 to 8 show the results of VSL considering the ages, household members, with or without of the partner, with or without of the children, with or without of the grandchildren, and the place of residence, respectively. In each figure, VSL average value of all samples unconsidered as attribute is indicated by black broken lines. Below, the results are organized for each attribute.

In the case of considering of ages (Figure 3), the VSL in 20s is the lowest (comparison with attribute inconsideration: -20%), then rises with age until age 50s (comparison with attribute unconsideration: +18%), decreases in 60s. It turned into an inverted U shape type. Incidentally, over 40s were higher than VSL of attribute unconsideration.

In the case of considering of household members (Figure 4), the VSL in 1 person is the lowest (comparison with attribute unconsideration: -18%), whereas the VSL in 2 persons are the highest (comparison with attribute unconsideration + 14%) . In addition, the VSL of the 5 persons was slightly lower attribute unconsideration -9%, and there was no big difference in other person categolies.

In the case of considering with/without the partner (Figure 5), the VSL in with the partner was +15% of comparison with attribute unconsideration, whereas the VSL in without the partner was -26% of comparison with attribute unconsideration. Both had a difference from when attribute was not considered, and without partner had a big influence more than 10%.

Table 6: Estimated results of parameters

Variable		Modal 1 Factor	Modal 1 S.E.	Modal 2 Factor	Modal 2 S.E.
Happiness on own	0	-0.761 *	0.392	-0.750 **	0.325
	1	-0.071	0.380	-0.064	0.310
	2	0.792 **	0.373	0.791 ***	0.303
	3	1.664 ***	0.372	1.653 ***	0.301
	4	2.244 ***	0.373	2.228 ***	0.302
	5	3.547 ***	0.376	3.518 ***	0.306
	6	4.374 ***	0.378	4.338 ***	0.309
	7	5.642 ***	0.383	5.599 ***	0.314
	8	7.037 ***	0.390	6.988 ***	0.322
	9	8.409 ***	0.404	8.359 ***	0.339
Sex(Female)		0.572 ***	0.092	0.546 ***	0.076
Spouse		0.705 ***	0.103	0.682 ***	0.096
Age	30s	-0.057	0.127	-	-
	40s	-0.174	0.129	-	-
	50s	-0.063	0.137	-	-
	60s	0.314 **	0.148	0.399 ***	0.101
Final Education	E.S. & J.H.S.	0.016	0.278	-	-
	H.S.	0.024	0.094	-	-
	vocational/various	0.024	0.129	-	-
	junior college	-0.149	0.120	-0.196 *	0.105
	college(science)	0.114	0.114	-	-
	graduate school	0.328 *	0.179	0.305 *	0.166
	other	0.343	0.680	-	-
Profession	Desk job	0.109	0.148	-	-
	Clerk and Sales	0.020	0.206	-	-
	Managerial	-0.025	0.188	-	-
	Professional / Technical	0.088	0.164	-	-
	Service	-0.261	0.179	-0.305 **	0.137
	Field worker	-0.386 *	0.202	-0.451 ***	0.164
	Agriculture and Fishery	0.385	0.354	-	-
	Housewife (Part-time)	-0.092	0.178	-	-
	Housewife (Unemployed)	0.031	0.160	-	-
	Student	0.936 ***	0.265	0.907 ***	0.225
	Other	-0.151	0.189	-	-
Unemployed * Job Seeker		0.167	0.250	-	-
Simpleness		0.142 **	0.071	0.125 *	0.069
Propensity to save		-0.060	0.094	-	-
Health insecurity		-0.652 ***	0.072	-0.639 ***	0.071
Awareness of the living standard of others		-0.274 ***	0.078	-0.283 ***	0.076
Religious belief		0.616 ***	0.149	0.594 ***	0.146
Altruism to acquaintance		0.256 ***	0.085	0.248 ***	0.084
Altruism to non-acquaintance		0.347 ***	0.086	0.355 ***	0.085
High risk tendency		0.314 ***	0.081	0.301 ***	0.080
Past living standard		0.998 ***	0.075	1.012 ***	0.074
Adviser		0.715 ***	0.088	0.712 ***	0.087
Experience of mental injury		-0.328 ***	0.072	-0.340 ***	0.071
Presence of children		0.199 **	0.098	0.178 *	0.095
Presence of grandchildren		0.247 **	0.121	0.227 *	0.119
smoking	nearly none	-0.325	0.259	-	-
	occasionally	-0.180	0.226	-	-
	about 10 peaces/ day	-0.324 **	0.131	-0.300 **	0.129
	about 1 box/day	-0.387 ***	0.135	-0.389 ***	0.132
	2 boxes/day or more	-0.044	0.356	-	-

Variable		Modal 1 Factor	Modal 1 S.E.	Modal 2 Factor	Modal 2 S.E.
Current residence	Hokkaido	0.018	0.217	-	-
	Aomori	0.035	0.297	-	-
	Iwate	0.295	0.308	-	-
	Miyagi	-0.041	0.268	-	-
	Akita	-0.588 *	0.312	-0.597 **	0.279
	Yamagata	-0.825 ***	0.312	-0.817 ***	0.280
	Fukushima	-0.187	0.260	-	-
	Ibaraki	0.256	0.289	-	-
	Tochigi	-0.351	0.270	-	-
	Gunma	-0.348	0.268	-	-
	Saitama	0.061	0.222	-	-
	Chiba	-0.008	0.230	-	-
	Kanagawa	0.015	0.225	-	-
	Niigata	-0.015	0.266	-	-
	Toyama	-0.507 *	0.285	-0.488 *	0.249
	Ishikawa	-0.455	0.298	-0.445 *	0.265
	Fukui	0.757 **	0.343	0.769 **	0.313
	Yamanashi	-0.054	0.326	-	-
	Nagano	-0.089	0.254	-	-
	Gifu	-0.236	0.264	-	-
	Shizuoka	0.125	0.275	-	-
	Aichi	0.250	0.235	-	-
	Mie	-0.080	0.286	-	-
	Shiga	0.135	0.305	-	-
	Kyoto	-0.230	0.248	-	-
	Osaka	0.457 **	0.232	0.467 **	0.188
	Hyogo	-0.230	0.221	-	-
	Nara	0.035	0.268	-	-
	Wakayama	0.168	0.276	-	-
	Tottori	-0.196	0.385	-	-
	Shimane	-0.192	0.361	-	-
	Okayama	0.103	0.260	-	-
	Hiroshima	0.122	0.242	-	-
	Yamaguchi	0.036	0.271	-	-
	Tokushima	0.283	0.356	-	-
	Kagawa	-0.363	0.314	-	-
	Ehime	-0.126	0.259	-	-
	Kochi	-0.187	0.336	-	-
	Fukuoka	0.156	0.260	-	-
	Saga	-0.488	0.365	-	-
	Nagasaki	0.181	0.302	-	-
	Kumamoto	0.358	0.288	-	-
	Oita	-0.134	0.326	-	-
	Miyazaki	0.285	0.343	-	-
	Kagoshima	-0.069	0.329	-	-
	Okinawa	0.442	0.407	-	-
Residence oriented		0.040	0.077	-	-
$\ln\left(\frac{\text{Household income(ten thousand JPY)}}{\sqrt{\text{number of household members}}}\right)$		0.425 ***	0.057	0.423 ***	0.051
N(Sample size)		3,501		3,501	
N^* (Selection sample)		2,813		2,813	
Log likelihood		-5279.501		-5265.197	
Wald		1156.769		1119.174	
		(0.000)		(0.000)	

Note 1) ***, **, * indicate that they are significant at the 1%, 5% and 10% level, respectively.

Note 2) The value in parentheses of Wald statistic represents P-value.

In the case of considering with/without children (Figure 6), the VSL in with children was +11% of comparison with attribute unconsideration, whereas the VSL in without children was -16% of comparison with attribute unconsideration. Both had a difference from when attribute was not considered, and without children had a big influence more than 5%.

In the case of considering with/without grandchildren (Figure 7), the VSL in with grandchildren was +19% of comparison with attribute unconsideration, whereas the VSL in without grandchildren was -3% of comparison with attribute unconsideration. In this instance, there was a difference in the measured values only when there were grandchildren.

In the case of considering the place of residence (Figure 8), a difference of + 10% or more occurred in comparison with attribute unconsideration in the VSL of 8 prefectures. Among them, VSL in Fukui Prefecture had a specific difference of +50% as comparison with attribute unconsideration, 3 prefectures had +20% or more of comparison with attribute unconsideration (Nara prefecture +26%, Tokyo metropolitan prefecture +24%, Kanagawa prefecture +23%), and 4 prefectures had +10% or more of comparison with attribute unconsideration (Tottori prefecture +18%, Osaka prefecture +16%, Mie prefecture +15%, Hyogo prefecture +10%). Meanwhile, in the VSL of 16 prefectures, comparison with attribute unconsideration -10% or more differed. Among them, VSL in Akita Prefecture has a characteristically low difference of -37% as comparison with attribute unconsideration, 4 prefectures had -20% or more of comparison with attribute unconsideration (Shimane prefecture and Yamaguchi prefecture -29%, Okinawa prefecture -23%, Tochigi Prefecture -21%), and 11 prefectures had -10% or more of comparison with attribute unconsideration (Kyoto prefecture -16%, Fukushima prefecture and Iwate prefecture -14%, Toyama prefecture and Niigata prefecture -13%, Ehime prefecture -11%, Aomori prefecture, Nagano prefecture, Yamagata prefecture, Nagasaki prefecture and Kumamoto prefecture -10%).

The VSL estimated by the Cabinet Office is about 226.07 million yen. On the other hand, the results obtained by analyzing and estimating the data obtained from our own happiness degree survey in this study are one order of magnitude smaller than the above mentioned index. This is probably due to the assumption that the relative risk aversion degree is 1. Layard et al. (2008) is a research that estimates the relative risk aversion degree by using the data of the worldwide happiness degree survey, but the estimated value in that research is 1.260. Since VSL depends greatly on the relative risk aversion degree, it is considered that the VSL this time became a small value. It is considered that it is necessary to Box-Cox transformation of income to estimate the relative risk aversion degree, but I would like to make it a future work.

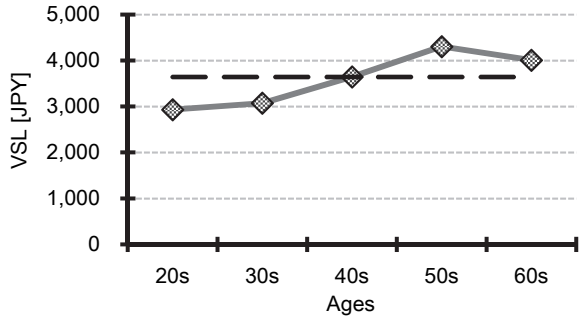

Figure 3: VSL by ages

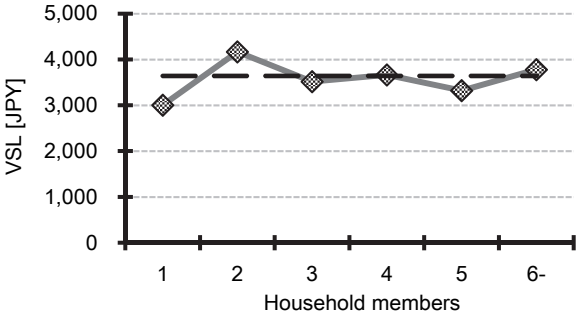

Figure 4: VSL by household members

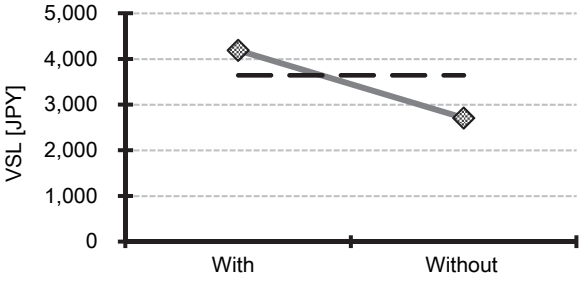

Figure 5: VSL by partner

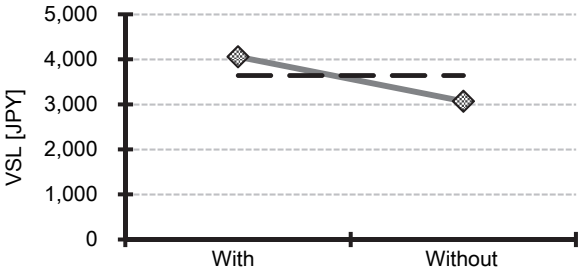

Figure 6: VSL by children

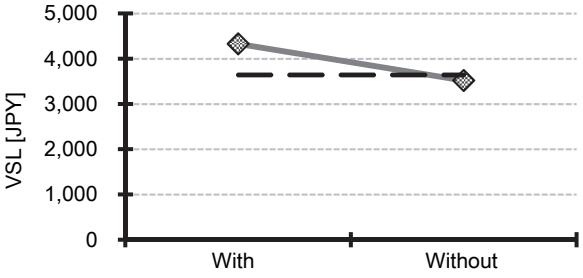

Figure 7: VSL by grandchildren

Note: Black dashed line is VSL of attribute unconsidered.

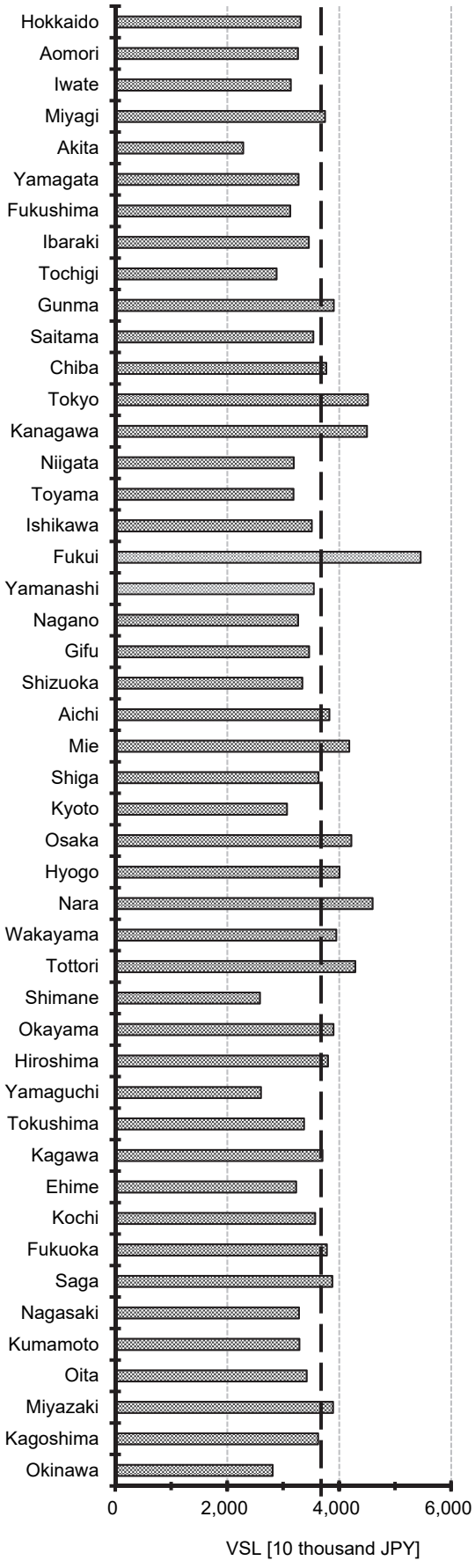

Figure 8: VSL by current residence

5. Concluding remarks

In this study, we focused on Senior discount of VSL abroad and attempted to measure VSL by attribute. Targeted general mortality risk, in order to measure theoretically consistent VSL, data was collected from the happiness survey and the happiness degree function was estimated using order response model. As a result, VSL showed inverted U-shaped shape in terms of ages as in existing studies. We tried using other attributes, it was suggested that not only age but family structure (children and grandchildren), household income, and current residence also affect VSL. The future work is that VSL depends greatly on the relative risk aversion degree, so it seems necessary to estimate it after box-cox transformation of income.

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