Aging, Economic Development, and Preference for Life-Saving Social Overhead Capital

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Mortality risk due to water pollution is one of serious problems especially for Asian developing countries. The timing to carry out a policy or project against such a problem is typical debate of Environmental Kuznets Curve hypothesis. With survey data sets in Laos and Vietnam to ask citizens' WTP for mortality risk reduction, we found relative robust relationships between their age or income and WTP. In a subsequent theoretical study, these relationships holds for both of Option Price Model and Optimal Expenditure Decision Model assumed that the one doesn't interest in the world after his death. So far as these empirical findings are consistent with theoretical suggestions, EKC hypothesis is supported well at least about transition of their preference for improved environment with economic development.

Key Words : *mortality risk, Environmental Kuznets Curve, option price, optimal expenditure*

1. Introduction

IPCC(2007) reports that Global Warming will cause severe decline of water quality in near future. An increase in average global precipitation does not necessarily relate to an increase in the amount of potable water available. The higher levels of nutrients were originally stored in the groundwater reserves, but the increase in precipitation will flush them out in the discharged water. When drought conditions persist and groundwater reserves are depleted, the residual water that remains is often of inferior quality. And the increase in water temperatures can lead to a bloom in microbial populations, which can have a negative impact on human health.

Generally speaking, implementation of sewage and water-supply system might be the most effective policy against such health problems related with water quality. In this thread, our precedent research Ohno et al. (2012) have conducted interview survey of Laos in 2011 and of Vietnam in 2010 to ask the willingness to pay (WTP) of residents to have a right to obtain improved water resources in their daily usages and avoid diarrheal or digestive mortality risk due to water pollution. These countries alongside the Great Mekong River have enjoyed rapid economic growth in these years, and would reach “adequate age” to implement these facilities (at least for urban zone) at an early date.

However, the time of “adequate age” remain ambiguous. The most proper explanations for the notion can be induced by “Environmental Kuznets Curve (EKC)” hypothesis. It suggests that there exists an empirical relation between per capita income and some measures of environmental quality. It has been observed that as income goes up there is increasing environmental degradation up to a point, after which environmental quality improves. The relation has an "inverted-U" shape.

As Grossman and Krueger (1993) suggested, the inverted U-shaped curve has been shown to apply to a selected set of pollutants only for poor sanitation, impure water supplies, suspended particulates, SOx, NOx, and CO. Moreover, only a limited water pollution matters seem to obey to the rule, and several recent empirical findings are mostly consistent with negative remarks about the law; see Arrow et.al. (1995), Stern (1998), and Dasgupta et al. (2002).

In contrast, earlier theoretical research in Lopez (1994) shows if preferences are non-homothetic, so that the proportion of household spending on different items changes as income rises, then the response of pollution to economic growth will depend on the degree of relative risk aversion and elasticity of substitution in production technology between pollution and conventional inputs. Some findings in our study will partially support his theorem in the aspect of individuals' preference. In our understanding, empirical critiques for EKC mentioned above may be due to the other reasons as institution, technology of supply side, or difficulties of measurement of pollution.

In the next chapter, we briefly introduce results of our precedent research. The most important index is participant's WTP (willingness to pay) for a right to get healthy water environment and reduce their mortality risk. The index can be also derived for each category of participant's generation, as 20's, 30's, 40's, 50's, and over 60. Then the depicted line charts show some characteristic and common configuration for these data sources. Furthermore, the same is found in another internet survey data that we have conducted in Japan with the object to evaluate mortality risk reduction policy about heat stroke (Ohno et al. 2010).

In chapter 3, to interpret the empirical findings theoretically, we construct two models, Option Price Model and Optimal Expenditure Decision Model, those are discriminated by typical ways of answering questions of the participants. And some propositions are derived.

In the last chapter, with the contents above, we make ourselves clear about the issues of EKC comprehensively and make concluding remarks.

2. Interview Survey in Laos and Vietnam

Table 2-1 shows some fundamental statistics of 6 countries those belong to Mekong River Basin, and of Japan. Also, Table 2-2 represents the so-called "Ruler of Risk" that is the number of people who has been died by each specific cause per every 100,000 population annually. The mortality risk indexes are taken in simple arithmetic mean of those 6 countries from WHO statistics (2004), and our subject problem of water pollution may influence the degree of diarrheal diseases directly and digestive diseases partially. The former one of Japan is much smaller, and the latter one is almost negligible. Such a difference between those countries must attribute to the difference of implementation of water supply and sewage systems.

Interview survey has been conducted around Vientiane City in Laos in 2011 and around Ho-Chi-Minh City and Mekong Delta in Vietnam in 2010. We have collected 2,825 samples in Laos and 1,000 samples in Vietnam, where 2,807 and 889 samples are valid respectively. Basic statistics of respondents are shown in Tables 2-3 and 2-4.

Table 2-1: Some fundamental statistics of 6 countries (2008)

Member state	Population (*/thousand)	Gross national income per capita (ppp $)	Access to improved drinking-water sources(%)	Access to improved sanitation(%)
Japan	127,293	34,115	100	100
China	1,345,751	5,962	89	55
Cambodia	14,805	2,066	61	29
Laos	6,320	2,204	57	53
Myanmar	50,020	1,159	71	81
Thailand	66,405	8,100	98	96
Vietnam	87,375	2,783	94	75

Source: WHO (2010)

Table 2-2: Mortality risk for each specific cause (* / 100,000)

Cause-specific mortality	Average of countries on Mekong River Basin	Japan
Cardiovascular diseases	330	12
Cancer	127	250
Digestive diseases	41	15
Diarrheal Diseases	36	0.51
HIV/AIDS	38	0.04
Road traffic accidents	21	9
Self-inflicted injuries	13	24
Violence and war	13	0.52

Source: WHO (2004) and Ohno et al (2010)

Table 2-3: Basic statistics of respondents in Laos

Sex	Proportion(%)
Male	60.0
Female	40.0
Total	100.0

Age	Proportion(%)
under 19	1.7
20 - 29	33.7
30 - 39	29.5
40 - 49	22.0
50 - 59	10.3
over 60	2.8
Total	100.0

Annual income	Proportion(%)
under 99 $	1.5
100-299 $	0.9
300 - 499 $	3.2
500 - 999 $	13.5
1,000 - 1,499 $	27.5
1,500 - 1,999 $	23.7
2,000 - 2,999 $	22.9
over 3,000 $	6.8
Total	100.0

Table 2-4: Basic statistics of respondents in Vietnam

Sex	Proportion(%)
Male	53.3
Female	46.7
Total	100.0

Age	Proportion(%)
under 19	0.3
20 – 29	15.2
30 – 39	28.5
40 - 49	30.8
50 - 59	19.4
over 60	5.8
Total	100.0

Annual income	Proportion(%)
under 99 $	1.5
100-299 $	0.9
300 - 499 $	3.2
500 - 999 $	13.5
1,000 - 1,499 $	27.5
1,500 - 1,999 $	23.7
2,000 - 2,999 $	22.9
over 3,000 $	6.8
Total	100.0

Questionnaire sheets consist of 5 parts as, recognition of general mortality risk, consciousness for water quality, 1st time and 2nd time to ask WTP to get a right having better water environmental therefore reduce their mortality risk, and personal information finally.

The hypothetical policy of double underlined part in Tables 2-5, we call it as the "option" hereafter. The participants are assumed to confront their mortality risk of 100/100,000 initially. Also, these questionnaire sheets are discriminated as Case1 to 8 (allocated equally) by the risk reduction level (*r*: 20, 40, 60, 80) as a result of the "option" adopted. Such a kind of asking question has been repeated twice for one participant, as 1st and 2nd questions of different set *r*.

On the subsequent questions, 10 patterns of annual "option" fee (*f*) are suggested as 1, 3, 5, 7, 10, 30, 50, 70, 100 and 300 US$. For each alternatives of "option" fee, the participant must make a choice between ‘yes’ or ‘no’. The data is judged to be available only if the participant replies ‘yes’ for cheaper "option" fee and once he has replied ‘no’ for one question then he should reply ‘no’ for all of subsequent questions.

Based on the random utility theory, participant’s choice behavior is expressed as the following usual logit model.

$$p_{yes} = \frac{\exp[w \cdot V_{yes}]}{\exp[w \cdot V_{yes}] + \exp[w \cdot V_{no}]} \qquad (2\text{-}1)$$

Table 2-5: Sample of questionnaire sheet

> From here, we ask hypothetical questions. Please answer the following questions by assuming, “If you can obtain such a service that supplies safer water and decreases death risk due to diarrhea and diseases of the various digestive organs”. For examples of such a service as, implementation of water supply and sewerage systems, or, distribution of drinking water in PET bottles. However, it is charged (not free). You have to pay a certain amount to get the service.
>
> In addition, please imagine,
>
> -Your death risk from diarrhea or diseases of the various digestive organs will be 100/100,000 a year without the service described above.
>
> -Your death risk from diarrhea or diseases of the various digestive organs will be 100-r/100,000 a year with the service described above.
>
> Next items (1)-(10) each has shown the annual fee level to be paid for receiving the service described above. In each condition, will you receive these services or not? Please choose the one that applies. Please sure that you have to own the following amount of money as an annual subscription to get the contract that you can get such a water service as much as you want. And, the amount of money that you paid for the service is subtracted from your annual free disposal income.
>
> (1) When the annual fee of the service is 1 dollar,
>
> 1. You will receive the services. 2. You will not receive the services.
>
> (2) When the annual fee of the service is 3 dollars,
>
> 1. You will receive the services. 2. You will not receive the services.
>
> :
>
> (10) When the annual fee of the service is 300 dollars,
>
> 1. You will receive the services. 2. You will not receive the services.

where, *Vyes*, *Vno*: utility levels when one answers ‘yes’ or ‘no’ for buying the water service,
Pyes, *Pno*: probability of one’s decision to answer ‘yes’ or ‘no’,
w: parameter of variance and generally set to be 1 for convenience

Utility difference between *Vyes* and *Vno* is assumed to depend on only the suggested "option" fee, and to be specified it as a log-linear function form, follows as;

$$V_{yes} - V_{no} = a + b \cdot \ln[f] \tag{2-2}$$

Then, Eq.(2-1) is rewritten simply as $1/[1+\exp(V_{no} - V_{yes})]$

With this equation, simultaneous probability density function is constructed, then parameters *a* and *b* are estimated by the maximum likelihood procedure, shown in below;

Table 2-6:Estimation results for each generation in Laos

Note: t-values are in brackets ( ).

20's

Case	α *constans	β *ln[suggested fee]	Likelihood ration	Hit ratio	Number of samples
C1-1st	2.697 (13.443)	-1.297 (-16.028)	0.402	0.810	990
C2-1st	2.511 (14.338)	-1.221 (-17.509)	0.378	0.806	1,190
C3-1st	3.891 (16.389)	-1.733 (-17.513)	0.524	0.860	1,200
C4-1st	3.245 (13.895)	-1.478 (-15.622)	0.458	0.841	920
C5-1st	3.223 (14.833)	-1.394 (-16.706)	0.439	0.811	1,000
C6-1st	3.115 (15.314)	-1.305 (-17.371)	0.414	0.818	1,060
C7-1st	3.231 (16.578)	-1.192 (-18.399)	0.382	0.804	1,150
C8-1st	2.949 (18.026)	-1.223 (-20.680)	0.388	0.806	1,510
C1-2nd	3.212 (15.143)	-1.279 (-17.001)	0.409	0.813	990
C2-2nd	3.038 (16.471)	-1.152 (-18.526)	0.367	0.803	1,190
C3-2nd	4.238 (18.037)	-1.504 (-19.382)	0.485	0.857	1,200
C4-2nd	3.482 (15.139)	-1.285 (-16.654)	0.414	0.827	920
C5-2nd	2.382 (11.809)	-1.382 (-15.003)	0.411	0.826	1,000
C6-2nd	2.461 (12.234)	-1.429 (-15.351)	0.423	0.831	1,060
C7-2nd	2.482 (13.897)	-1.236 (-17.083)	0.381	0.803	1,150
C8-2nd	2.553 (15.726)	-1.327 (-19.236)	0.405	0.822	1,510

30's

Case	α *constans	β *ln[suggested fee]	Likelihood ration	Hit ratio	Number of samples
C1-1st	3.246 (14.164)	-1.366 (-15.917)	0.433	0.812	890
C2-1st	2.503 (12.865)	-1.323 (-15.874)	0.403	0.821	1,040
C3-1st	3.071 (14.716)	-1.468 (-16.830)	0.451	0.843	1,110
C4-1st	2.638 (12.768)	-1.143 (-15.120)	0.358	0.788	840
C5-1st	2.762 (13.556)	-1.069 (-15.532)	0.335	0.791	870
C6-1st	3.583 (15.021)	-1.355 (-16.494)	0.436	0.831	900
C7-1st	3.313 (14.148)	-1.321 (-15.792)	0.422	0.825	850
C8-1st	3.235 (18.491)	-1.155 (-20.379)	0.369	0.800	1,420
C1-2nd	3.732 (15.162)	-1.356 (-16.519)	0.438	0.827	890
C2-2nd	3.035 (15.183)	-1.233 (-17.270)	0.392	0.812	1,040
C3-2nd	3.650 (16.790)	-1.362 (-18.375)	0.439	0.840	1,110
C4-2nd	2.905 (13.659)	-1.079 (-15.374)	0.339	0.795	840
C5-2nd	2.040 (11.044)	-1.045 (-14.547)	0.316	0.787	870
C6-2nd	2.531 (11.900)	-1.359 (-14.648)	0.411	0.836	900
C7-2nd	2.733 (11.169)	-1.575 (-13.469)	0.457	0.848	850
C8-2nd	2.557 (16.270)	-1.140 (-19.510)	0.356	0.796	1,420

40's

Case	α *constans	β *ln[suggested fee]	Likelihood ration	Hit ratio	Number of samples
C1-1st	3.207 (12.491)	-1.385 (-14.087)	0.436	0.824	710
C2-1st	2.439 (10.265)	-1.226 (-12.706)	0.377	0.811	640
C3-1st	3.880 (13.014)	-1.620 (-14.014)	0.505	0.839	700
C4-1st	3.434 (14.261)	-1.401 (-15.814)	0.446	0.828	860
C5-1st	2.346 (10.823)	-1.028 (-13.202)	0.315	0.779	670
C6-1st	4.269 (13.564)	-1.653 (-14.457)	0.522	0.859	700
C7-1st	4.233 (13.575)	-1.388 (-14.499)	0.448	0.832	680
C8-1st	3.431 (15.306)	-1.218 (-16.762)	0.391	0.812	940
C1-2nd	3.870 (13.607)	-1.433 (-14.771)	0.462	0.845	710
C2-2nd	2.821 (11.716)	-1.096 (-13.393)	0.345	0.797	640
C3-2nd	4.652 (13.917)	-1.626 (-14.847)	0.520	0.864	700
C4-2nd	4.058 (15.181)	-1.326 (-16.219)	0.428	0.835	860
C5-2nd	1.718 (8.233)	-1.090 (-12.127)	0.321	0.793	670
C6-2nd	3.371 (11.521)	-1.668 (-12.797)	0.494	0.849	700
C7-2nd	3.156 (12.022)	-1.404 (-13.623)	0.439	0.829	680
C8-2nd	3.099 (13.859)	-1.425 (-15.795)	0.443	0.827	940

50's

Case	α *constans	β *ln[suggested fee]	Likelihood ration	Hit ratio	Number of samples
C1-1st	3.103 (8.345)	-1.498 (-9.514)	0.455	0.819	360
C2-1st	3.670 (7.658)	-1.934 (-8.328)	0.533	0.877	350
C3-1st	4.896 (8.103)	-2.039 (-8.258)	0.595	0.870	270
C4-1st	3.094 (8.930)	-1.485 (-10.191)	0.453	0.834	410
C5-1st	2.994 (6.894)	-1.255 (-7.891)	0.394	0.791	220
C6-1st	3.746 (8.409)	-1.498 (-9.672)	0.453	0.829	380
C7-1st	3.714 (8.678)	-1.197 (-9.253)	0.38	0.821	290
C8-1st	3.995 (12.083)	-1.444 (-13.063)	0.465	0.849	550
C1-2nd	3.471 (9.180)	-1.446 (-10.154)	0.456	0.831	360
C2-2nd	3.534 (9.325)	-1.345 (-10.265)	0.431	0.814	350
C3-2nd	4.196 (8.549)	-1.388 (-9.145)	0.445	0.83	270
C4-2nd	3.867 (10.252)	-1.492 (-11.122)	0.476	0.839	410
C5-2nd	2.156 (4.936)	-1.450 (-6.674)	0.413	0.832	220
C6-2nd	2.470 (6.613)	-1.657 (-8.485)	0.459	0.847	380
C7-2nd	2.559 (7.185)	-1.219 (-8.699)	0.375	0.821	290
C8-2nd	3.105 (10.729)	-1.394 (-12.216)	0.435	0.835	550

Over 60

Case	α *constans	β *ln[suggested fee]	Likelihood ration	Hit ratio	Number of samples
C1-1st	2.054 (3.186)	-1.198 (-4.293)	0.344	0.788	80
C2-1st	8.589 (2.771)	-4.317 (-2.744)	0.722	0.9	70
C3-1st	4.153 (4.619)	-2.079 (-4.840)	0.559	0.850	120
C4-1st	3.695 (4.236)	-1.361 (-4.625)	0.424	0.829	70
C5-1st	4.666 (5.161)	-1.959 (-5.309)	0.574	0.864	110
C6-1st	3.434 (4.712)	-1.279 (-5.198)	0.4	0.833	90
C7-1st	6.965 (5.056)	-2.307 (-5.355)	0.669	0.9	100
C8-1st	2.765 (4.879)	-9.575×10-1 (-5.388)	0.281	0.745	110
C1-2nd	2.285 (3.564)	-1.130 (-4.496)	0.332	0.788	80
C2-2nd	6.239 (4.223)	-2.406 (-4.210)	0.669	0.9	70
C3-2nd	4.560 (5.751)	-1.607 (-6.142)	0.508	0.858	120
C4-2nd	5.435 (4.297)	-1.635 (-4.537)	0.5	0.843	70
C5-2nd	3.190 (4.282)	-1.707 (-4.861)	0.484	0.845	110
C6-2nd	3.167 (3.825)	-1.721 (-4.359)	0.483	0.867	90
C7-2nd	5.062 (4.621)	-2.236 (-4.623)	0.61	0.88	100
C8-2nd	2.564 (4.543)	-1.134 (-5.437)	0.343	0.764	110

Table 2-7:Estimation results for each generation in Vietnam

Note: t-values are in brackets ( ).

20's

Case	α *constans	β *ln[suggested fee]	Likelihood ration	Hit ratio	Number of samples
C1-1st	2.810 (3.917)	-9.729×10-1 (-4.321)	0.28	0.771	70
C2-1st	2.218 (5.320)	-6.676×10-1 (-5.461)	0.164	0.719	160
C3-1st	5.244 (4.655)	-1.642 (-4.941)	0.509	0.850	80
C4-1st	3.884 (5.603)	-1.176 (-5.857)	0.363	0.817	120
C5-1st	4.461 (5.704)	-1.397 (-6.039)	0.441	0.817	120
C6-1st	7.269 (4.995)	-2.168 (-5.325)	0.623	0.891	110
C7-1st	8.951 (5.292)	-2.462 (-5.560)	0.637	0.894	160
C8-1st	3.552 (5.290)	-1.119 (-5.600)	0.343	0.791	110
C1-2nd	4.711 (4.336)	-1.418 (-4.553)	0.437	0.843	70
C2-2nd	3.724 (6.306)	-9.585×10-1 (-6.083)	0.274	0.800	160
C3-2nd	3.781 (4.577)	-1.243 (-4.903)	0.385	0.825	80
C4-2nd	7.627 (4.956)	-2.115 (-5.201)	0.588	0.900	120
C5-2nd	3.287 (5.409)	-9.898×10-1 (-5.613)	0.293	0.750	120
C6-2nd	4.275 (5.458)	-1.374 (-5.809)	0.434	0.818	110
C7-2nd	4.386 (6.491)	-1.252 (-6.674)	0.387	0.825	160
C8-2nd	3.816 (5.335)	-1.121 (-5.510)	0.34	0.800	110

30's

Case	α *constans	β *ln[suggested fee]	Likelihood ration	Hit ratio	Number of samples
C1-1st	4.483 (8.045)	-1.218 (-8.116)	0.373	0.804	250
C2-1st	1.542 (5.378)	-4.434×10-1 (-5.276)	0.081	0.658	260
C3-1st	3.951 (8.431)	-1.044 (-8.299)	0.311	0.789	280
C4-1st	5.150 (7.307)	-1.266 (-7.108)	0.372	0.836	220
C5-1st	7.812 (6.874)	-1.967 (-6.951)	0.530	0.864	250
C6-1st	5.457 (6.866)	-1.316 (-6.648)	0.381	0.805	200
C7-1st	6.877 (5.823)	-1.767 (-5.909)	0.500	0.844	160
C8-1st	5.299 (7.454)	-1.449 (-7.634)	0.443	0.827	220
C1-2nd	5.301 (7.833)	-1.364 (-7.814)	0.409	0.832	250
C2-2nd	2.152 (6.646)	-5.688×10-1 (-6.200)	0.127	0.712	260
C3-2nd	4.774 (8.412)	-1.236 (-8.342)	0.373	0.829	280
C4-2nd	5.584 (7.193)	-1.369 (-7.040)	0.399	0.841	220
C5-2nd	3.878 (7.930)	-1.006 (-7.716)	0.295	0.768	250
C6-2nd	2.619 (6.390)	-6.703×10-1 (-5.921)	0.164	0.71	200
C7-2nd	5.044 (6.256)	-1.245 (-6.087)	0.364	0.788	160
C8-2nd	5.336 (7.366)	-1.395 (-7.405)	0.419	0.818	220

40's

Case	α *constans	β *ln[suggested fee]	Likelihood ration	Hit ratio	Number of samples
C1-1st	4.052 (9.399)	-1.141 (-9.582)	0.352	0.806	340
C2-1st	3.148 (7.051)	-9.092×10-1 (-7.156)	0.264	0.757	210
C3-1st	5.713 (9.008)	-1.479 (-9.065)	0.442	0.832	340
C4-1st	7.210 (7.585)	-1.875 (-7.754)	0.527	0.861	280
C5-1st	5.440 (8.288)	-1.322 (-8.055)	0.386	0.843	290
C6-1st	1.110×10 (6.042)	-2.840 (-6.190)	0.639	0.869	260
C7-1st	1.116×10 (6.548)	-2.703 (-6.555)	0.600	0.894	310
C8-1st	9.209 (6.968)	-2.233 (-6.960)	0.553	0.873	300
C1-2nd	4.857 (9.310)	-1.294 (-9.369)	0.396	0.818	340
C2-2nd	3.437 (7.149)	-9.068×10-1 (-6.942)	0.259	0.757	210
C3-2nd	7.184 (8.357)	-1.858 (-8.521)	0.523	0.871	340
C4-2nd	8.678 (6.996)	-2.264 (-7.206)	0.588	0.886	280
C5-2nd	3.757 (8.460)	-9.389×10-1 (-8.027)	0.268	0.786	290
C6-2nd	4.436 (8.227)	-1.223 (-8.348)	0.377	0.819	260
C7-2nd	5.627 (8.530)	-1.385 (-8.368)	0.406	0.832	310
C8-2nd	7.454 (7.646)	-1.826 (-7.619)	0.498	0.85	300

50's

Case	α *constans	β *ln[suggested fee]	Likelihood ration	Hit ratio	Number of samples
C1-1st	4.297 (7.012)	-1.169 (-7.054)	0.355	0.795	190
C2-1st	6.725 (6.075)	-1.754 (-6.196)	0.502	0.835	170
C3-1st	6.403 (6.288)	-1.595 (-6.265)	0.456	0.833	180
C4-1st	4.927 (7.544)	-1.366 (-7.728)	0.421	0.818	220
C5-1st	3.394 (7.650)	-9.250×10-1 (-7.559)	0.268	0.767	240
C6-1st	3.746 (8.134)	-1.047 (-8.203)	0.316	0.800	260
C7-1st	6.220 (6.989)	-1.522 (-6.891)	0.437	0.836	220
C8-1st	7.283 (5.706)	-1.889 (-5.830)	0.526	0.863	160
C1-2nd	4.917 (6.832)	-1.207 (-6.612)	0.456	0.831	190
C2-2nd	6.532 (6.1229)	-1.688 (-6.211)	0.486	0.829	170
C3-2nd	6.929 (6.054)	-1.621 (-5.881)	0.445	0.822	180
C4-2nd	5.470 (7.430)	-1.507 (-7.649)	0.46	0.841	220
C5-2nd	2.923 (7.317)	-7.771×10-1 (-7.034)	0.209	0.746	240
C6-2nd	2.440 (7.113)	-7.166×10-1 (-7.209)	0.188	0.715	260
C7-2nd	3.843 (7.483)	-1.045 (-7.460)	0.313	0.805	220
C8-2nd	6.747 (5.983)	-1.851 (-6.225)	0.538	0.863	160

Over 60

Case	α *constans	β *ln[suggested fee]	Likelihood ration	Hit ratio	Number of samples
C1-1st	9.912 (2.838)	-2.153 (-2.704)	0.496	0.880	50
C2-1st	4.648 (4.475)	-1.165 (-4.354)	0.334	0.800	80
C3-1st	− (−)	− (−)	−	−	−
C4-1st	9.936 (3.075)	-2.731 (-3.231)	0.661	0.917	70
C5-1st	1.762×10 (2.140)	-4.705 (-2.200)	0.767	0.925	40
C6-1st	2.142×10 (2.518)	-5.031 (-2.509)	0.704	0.917	60
C7-1st	9.898 (3.021)	-2.393 (-3.017)	0.558	0.917	60
C8-1st	1.682×10 (3.406)	-4.184 (-3.451)	0.702	0.930	100
C1-2nd	7.604 (3.055)	-1.569 (-2.812)	0.385	0.880	50
C2-2nd	6.670 (4.060)	-1.490 (-3.843)	0.397	0.838	80
C3-2nd	− (−)	− (−)	−	−	−
C4-2nd	7.998 (3.372)	-2.110 (-3.482)	0.560	0.883	60
C5-2nd	1.435×10 (2.037)	-4.133 (-2.137)	0.789	0.925	40
C6-2nd	1.720×10 (2.597)	-4.098 (-2.594)	0.670	0.900	60
C7-2nd	5.894 (3.774)	-1.556 (-3.838)	0.450	0.850	60
C8-2nd	8.281 (4.241)	-2.096 (-4.308)	0.546	0.900	100

WTP (willingness to pay for each the "option") is evaluated by the median value defined as the fee level where 50% of people will agree to pay for the assumed water service supplies.

$$WTP_{median} = \exp\left[-\frac{a}{b}\right] \qquad (2\text{-}3)$$

This measurement can be derived for each situation of Cases, of 1st and 2nd questions, of generation, and of countries.

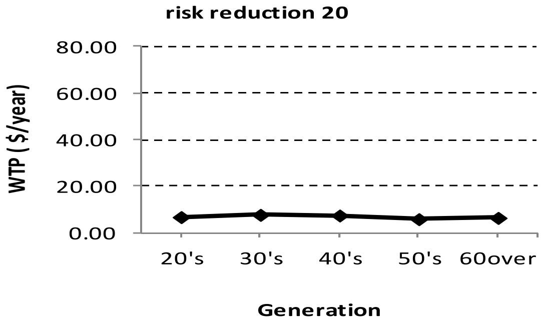
Furthermore, VSL (value of statistical life) can be introduced with WTP divided by the risk reduction (r). The "option" suggested here actually means the scale or technology level of implementing facilities such as water supply and sewage system. It follows that the coverage area and persons of the facilities are limited generally. Let denote the number of persons who receive benefit from the "option" as N, then VSL index can be rewritten as;

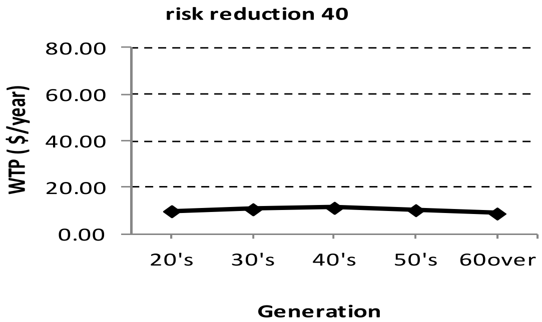
$$VSL \equiv \frac{WTP \cdot N}{r \cdot N} \qquad (2\text{-}4)$$

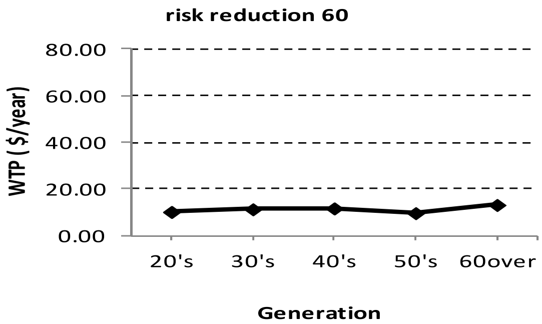
therefore, VSL means just average benefit of the "option" per persons who will be saved one's life. It is noteworthy that to interpret VSL as economic value of one’s whole life may cause serious misleading, as well known example of Broome’s paradox in Feldman and Serrano (2006). The degree of VSL is easily influenced by the participant's several circumstances, as income, age, sex, family, society, one's initial total mortality risk, and the effectiveness of the subject policy or project. And from definition of Eq. (2-4), it is true for WTP too.

Details of estimates are left to Ohno et al.(2012) and omitted here.

Now, we shows the results of WTP estimated but these are compiled for each level of risk reduction and the participant's generation.







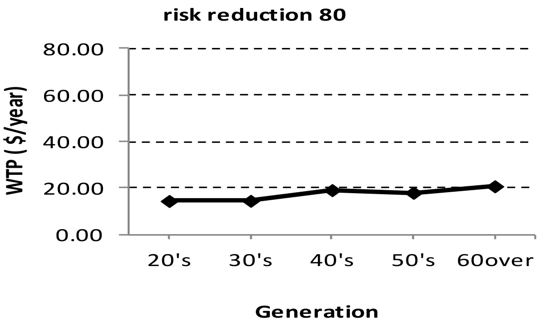


Figure 2-1: Average WTP of each generation for each risk reduction in Laos

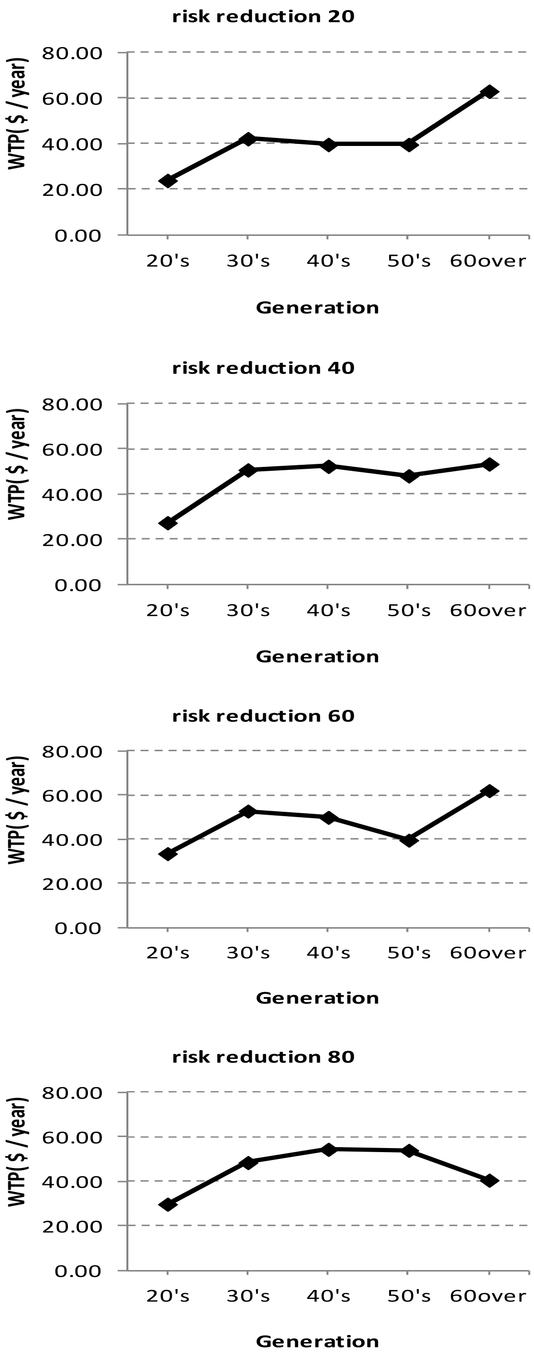


Figure 2-2: Average WTP of each generation for each risk reduction in Vietnam

These line graphs have rather common characteristics. Firstly, WTP of 20's is the lowest among the generations. Up to 30's or 40's, the one become higher than the previous generation. It seems to make a valley for 50's compared with bilateral generations. And surprisingly, WTP of 60's is not low, more likely, most of the cases show the highest values.

We will look back to this empirical finding in chapter 4.

Lastly, we examined configuration of the estimated WTP function with respect to risk reduction. For each plotted of WTP in Figure 2-3 and 2-4 are corresponding to Case 1 to 8 and 1st and 2nd questions (the same ones were also depicted in Ohno (2012)). Though the approximate curve with a log-linear shape is also attached, however, it doesn't match up to the plots so and the curve is hardly conceived as a concave function.

What does it suggest? We will seek these causes and meanings with the theoretical models explicated in the next chapter.

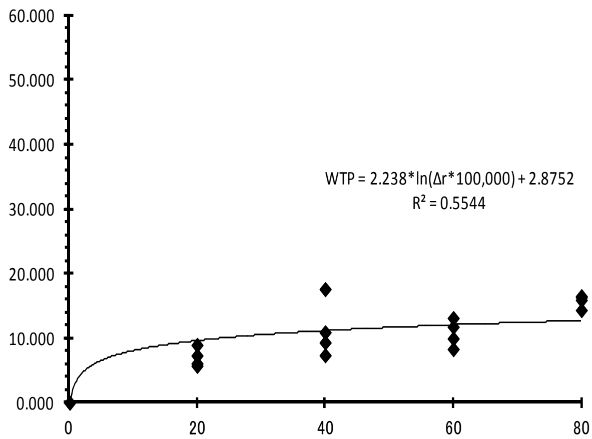


Figure 2-3: Estimated WTP-function in Laos

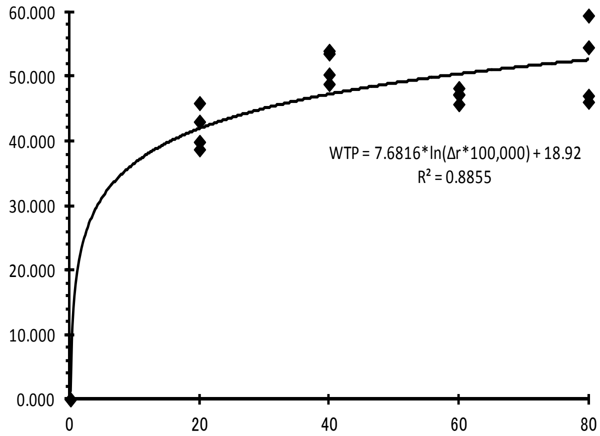


Figure 2-4: Estimated WTP-function in Vietnam

3. Interpretation in Theoretical Approach

In this chapter, we develop two simple theoretical models with an assumption that the participants have narcissistic personality and preference identically, and that they are not interested in the situation after he would die. The final objective is to confirm theoretical significance of the empirical findings shown in previous chapter and to make an order of them normatively. It has been done in the next Chapter.

The first model suggested here is Option Price Model and the second one is Optimal Expenditure Decision Model. The difference between them depends on ways of thinking when participants come up against the questionnaire sheet in Table2-5 and determine their WTP for the "option".

We consider two possible states for participant's figure in near future during one year, death or alive. But, they don't care about income level of their family, relatives, and friends after he would die.

Let denote, U: ordinary utility function and to be explained by only their income for each state. U function is assumed to hold the general characteristics of revealed preference and risk aversion, namely $U'>0$ and $U''\leqq 0$.

Also, y: the participant's initial income level, p: the participant's initial total mortality rate (it involves also the subject morality risk comes from water pollution, heat stroke, or so on), r: reduction of mortality rate due to the effect of applying the "option", x: the participant's decision level for applying the "option", namely WTP. These variables are non-negative rigidly, and $0 < p < 1$, $0 < r < 1$, $r \leqq p$, and $x \leqq y$.

We represent their welfare as usual expected utility form of von Neumann and Morgenstern.

[Option Price Model]

In this model the participant is assumed to decide the level of x or WTP to get the "option" while they set their ex-ante expected utility level equals to their ex-post one, as;

$$(1-p)U(y) = (1-p+r)U\left(y-x^*\right) \quad (3\text{-}1)$$

The x^* is just as option price, though he doesn't care about his expenditure for the "option" after his death.

From now on, we try to conduct comparative analysis of the relationships between some variables. Total differentiation of Eq.(3-1) and set the other variables than p and x^* are fixed derives,

$$-U(y)dp = -U\left(y-x^*\right)dp - (1-p+r)U'\left(y-x^*\right)dx^*$$

$$\Leftrightarrow \frac{dx^*}{dp} = \frac{\left(U(y) - U\left(y-x^*\right)\right)}{(1-p+r)U'\left(y-x^*\right)} > 0 \quad (3\text{-}2)$$

***Proposition 1*:**

Option price x^* increases with the total mortality rate.//

Total differentiation of Eq.(3-1) and set the other variables than y and x^* are fixed derives,

$$\left\{(1-p+r)U'\left(y-x^*\right) - (1-p)U'(y)\right\}dy = (1-p+r)U'\left(y-x^*\right)dx^*$$

$$\Leftrightarrow \frac{dx^*}{dy} = \frac{\left\{(1-p+r)U'\left(y-x^*\right) - (1-p)U'(y)\right\}}{(1-p+r)U'\left(y-x^*\right)} > 0 \quad (3\text{-}3)$$

***Proposition 2*:**

Option price x^* increases with the income level.//

Another interesting point is concavity of WTP function with respect to risk reduction. To assure of that, total differentiation of Eq.(3-1) and set the other variables than r and x are fixed derives,

$$U\left(y-x^*\right)dr - (1-p+r)U'\left(y-x^*\right)dx^* = 0 \quad (3\text{-}4)$$

and additional partial differentiation of Eq.(3-4) with respect to r derives,

$$\frac{d^2x^*}{dr^2} = \frac{-U'\left(y-x^*\right)}{(1-p+r)^2\,U'\left(y-x^*\right)} < 0 \quad (3\text{-}5)$$

***Proposition 3*:**

When one regards WTP is option price x^* in this model, WTP curve holds concavity with respect to risk reduction r. //

[Optimal Expenditure Decision Model]

In this another model, the participant is assumed to decide the optimal level of x or WTP to get the "option". Fundamentally, when the participant confronts the questionnaire sheet in Table 2-5 and thinks of pricing for the mortality risk reduction level, can he evaluate the "option" without imaging any example in his dairy life? Probably cannot. Speaking as our survey, he must imagine actual fares of water supply and sewage public services, or something medical and medicinal expenditure to compare with the "option". Then, his reply x shows just the effective cost of some alternatives in his dairy goods and services to obtain such a mortality risk reduction r. Therefore, our estimated WTP curve has not revealed his preference to the "option" any more. In fact, medical expenditure may suggest increasing returns to scale with respect to mortality risk reduction, represented as convexity in opposition to the result of Option Price Model. Furthermore, such phenomena of "out of order" have been detected frequently in our precedent researches.

However, whereas the participant's reply is formed as a manner of mentioned above, the data is available still because it shows their Optimal Expenditure

Decision for the "option" only if the mortality risk reduction *r* is actual effect of the "option" supplied. Therefore, the participant's behavior is maximizing his ex-post expected utility concerning with actual cost of the mortality risk reduction *r(x)*, as;

$$\max_{x} E(x)=\{1-p+r\}U(y-x) \qquad (3\text{-}6)$$

and first order condition is derived here.

$$r'(x^{\#})U(y-x^{\#})-\{1-p+r(x^{\#})\}U'(y-x^{\#})=0 \qquad (3\text{-}7)$$

Second order condition is also satisfied when first differentiation of *E(x)* with respect to *x* is positive for slightly smaller than *x** and second differentiation of left hand side of Eq. (3-7) is negative, follows as;

$$\begin{aligned} & r''(x^{\#})U(y-x^{\#})-2r'(x^{\#})U'(y-x^{*}) \\ & +\{1-p+r(x^{\#})\}U''(y-x^{\#})<0 \end{aligned} \qquad (3\text{-}8)$$

so that, $r''(x\#) \leqq 0$ is sufficient condition. Therefore, it is quite natural to assume that *r(x)* function is decreasing returns to scale, or another to say, inverse function of *r(x)*: $x^{-1}(r)$ shows increasing returns to scale and convexity.

***Proposition 4*:**

When one regards WTP is optimal expenditure *x#* in this model, the revealed WTP curve is just effective cost function for the participants to obtain the risk reduction in general methods, so that it possibly shows convexity with respect to risk reduction *r*. //

As the same manner with the Option Price Model, Total differentiation of Eq.(3-7) and set the other variables than *p* and *x#* are fixed derives,

$$\begin{aligned} & U\,r''dx^{\#}-r'U'dx^{\#} \\ & =-U'dp+r'U'dx^{\#}-(1-p+r)U''dx^{\#} \end{aligned} \qquad (3\text{-}9)$$

where, all of *U*, *U'*, *U"* functions are explained by *y-x#* and all of *r, r'*, *r"* functions are explained by *x#*.

***Proposition 5*:**

Optimal expenditure *x#* increases with the total mortality rate.//

Total differentiation of Eq.(3-7) and set the other variables than y and x# are fixed derives,

$$\begin{aligned} & Ur''dx^{\#}-r'U'dx^{\#}+r'U'dy \\ & =r'U'dx^{\#}-(1-p+r)U''dx^{\#}+(1-p+r)U''dy \\ & \Leftrightarrow \frac{dx^{\#}}{dy}=\frac{[r'U'-(1-p+r)U'']}{2r'U'-Ur''-(1-p+r)U''}>0 \end{aligned} \qquad (3\text{-}10)$$

***Proposition 6*:**

Optimal expenditure *x#* increases with the income level.//

4.Comprehensive Analysis and Remarks

Propositions 1, 2, 5 and 6 in chapter 3 are core issue of this paper. The revealed WTP for the "option" increases with the total mortality rate and income level regardless of the participant's attitude to answer our questionnaire. These theoretical properties are almost consistent with the empirical results in chapter 2 as explained below. Firstly, here shows total mortality rate of each generation in Laos, Vietnam, and Japan induced from WHO (2010).

The depicted shapes of total mortality rate with respect to ages are homothetic for these countries, but the ones of Vietnam and Laos are considerably located left and upward. As reported in WHO (2004) or some international articles, in developing countries 180 million people die of diarrhea and about 90% of which is caused by contaminated water. In Southeast Asia, the death due to diarrheal disease occupied 8.5% of all causes of one's death, that 90% of the death due to diarrheal disease is taking place to infants and children under 5 years old. One out of 8 children loses his life before he become 5 years old in Laos and Cambodia, and that 65-70 newborn babies die every day in Vietnam.

Also, about the ages over 20, the total mortality rate increases consistently corresponding to their lifetime, although it is almost negligible until their age reached around 50's. Over 60's, the gradient turns to be steeper like as some exponential function.

On the other hand, as shown in Figure 4-2 (data source is the same as Table 2-3 and 2-4 for Laos and Vietnam, and the one induced by the statistics of Ministry of Internal Affairs and Communications for Japan), the average of their income also increases consistently with their ages, but up to 50's around. Japan's seniority wage system is well known and general compulsory retirement age is 60, nevertheless the actual time be lower than that. Therefore, the average income of 60's is lower than the one of 50's, and the cases of Laos and Vietnam also seems to be in line with the rule.

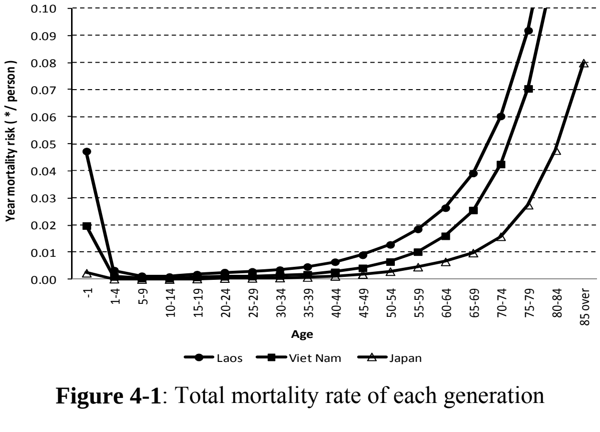


Figure 4-1: Total mortality rate of each generation

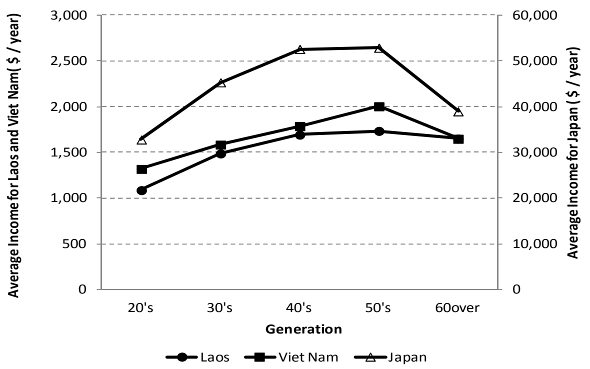


Figure 4-2: Average annual income of each generation

Then it goes to explain well most part of the estimated WTP shape with respect to generation in Figure 2-1, 2-2. Especially, those empirical suggestions and proposition 2, 6 are consistent with the point of view in traditional Environmental Kuznets Curve. In addition to that, focusing on the fact that almost of WTP of 60's is larger than 50's, one can guess that the aging effect dominates the income effect at the generation. Subsequently, we suggest that the turning point of EKC does not rely on the income level but also aging degree of the society. Aging is ongoing rapidly in nowadays of Japan, but the results indicate that it may not be so miserable rather a chance to create more environmental friendly society.

However, the suggested theoretical conjecture conflicts with one point of the estimated WTP, about 50's. From 40's to 50's, the average income is increasing slightly and the total mortality risk does so, but the estimated WTP goes down between these generations for most cases of the "option". This is event without law of these propositions mentioned above. What the matter is it? One possible answer to this question is existence of altruistic preference of the participant for families, relatives, or friends. In fact, our questionnaire sheet is not designed rigorously to exclude his altruistic preference. Although the details are omitted here, but one can construct such an ex-post expected utility function like as;

$$(1 - p + r)U(y - x) + (p - r)V(z - x) \quad (4\text{-}1)$$

where, V is his utility by someone his intimates getting the annual income level of z after his death. Then, one calculates as the same manner in chapter 3, and will find that all of propositions 1, 2, 3, 5, 6 are violated in this case. For 50's, the time to retire comes near sufficiently, therefore, they may place more importance on saving than to expenditure to save temporal his life, partly because of one's sake but also of the others' reserve.

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