Decision Making under Ecological Regime Shift: An Experimental Economic Approach

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Abstract : Environmental economics postulates the assumption of *homo economicus* and presumes that externality occurs as a result of the rational economic activities of economic agents. This paper examines this assumption using an experimental economic approach in the context of regime shift, which has been receiving increasing attention. We observe that when externality does not exist, economic agents (subjects of experimemt) act economically rationally, but when externality exists, economic agents avoid the risk of a regime shift that would have negative consequences for others. Our results suggest that environmental economics may have to reconsider the assumption of *homo economicus*.

Key Words : *homo economicus*, unboundedly rational economic agents, regime shift, experimental economics

JEL : C90, D63, D64, Q57

1. INTRODUCTION

Mainstream economics asserts that economic agents are selfish and that households and firms maximize their utilities and profits, respectively. As is well known, the assumption of *homo economicus* is underlying behind such explanations, where unboundedly rational economic agents are supposed. It is general knowledge that social welfare will be maximized as a result of selfish economic activities by unboundedly rational economic agents.

In some situations, however, market failures will occur under the abovementioned situations; an example would be externalities in the form of environmental issues. Mainstream economics has treated externalities as exceptional cases whereas environmental economics has regarded externalities as frequent events and has built the subject to treat issues attributed to externalities.

Until now, environmental economics has expressed disagreement with the fact that mainstream economics treats externalities as exceptions, but has connived at the assumption of *homo economicus*. Further, it examines solutions for externalities using tax, permit and other environmental policies. However, recently, doubts have been raised whether sustainable development can be achieved under the assumption of *homo economicus* (Becker 2006). In addition, many have argued that in the context of environmental economics, *homo economicus* and related agencies be replaced with other agencies such as *homo biologicus*, *homo corporativus*, *homo ecologicus*, *homo politicus*, and *homo sustinens* (Becker 2006, Bastien and Cardoso 2007). Kahneman (2003) suggests that economic agents are boundedly rational and a series of results of ultimatum games seems to support his suggestion.

It is possible to explore a new image of an economic agent based on real human behaviour using experimental economic approaches. In doing so, the following should be noted. First, how different is a real human from *homo economicus*? Second, is it possible to suppose that the new image of the economic agent will be desirable under certain criteria? Even if we extract the new image of the economic agent which is remarkably similar to a real human, this new image may not necessarily be appropriate as the new model of a human in economics. In this paper, we apply experimental economic methods to empirically examine the difference between a real human and *homo economicus*.

Experimental economic methods were introduced relatively early in the field of environmental valuation. As Horowitz (2006) states that '[e]xperimental economics and environmental valuation have grown up together', environmental valuation is one of the leading fields in experimental economics. However, in the other fields of environmental economics, application of experimental economic methods and behavioural economic studies has been lagging. Venkatachalam (2008) states that, in the real economic activities, experimental and behavioural economic studies have revealed that rational behaviours are not necessarily observed. However, he also states that these studies are not common in environmental economics.

In this paper, we study regime shift, which has recently been receiving increasing attention and examine the behaviours of economic agents in the context of environmental issues using experimental economic approaches. Regime shift is a phenomenon where the environment changes catastrophically. The catastrophe theory was advocated by the French mathematician René F. Thom in the 1960s and covered in Thom (1975). Recently, many related studies—Scheffer et al. (2001) and Scheffer and Carpenter (2003)—have been done in the context of ecology or environmental management. To the best of the author's knowledge, there is no existing research which treats regime shift in environmental issues as a topic of experimental economics.

In short, this paper has originality in the following points. First, it examines how different is *homo economicus* from a real human in the context of environmental economics with particular focus on externality. Second, it applies the experimental economic approach when examining the first point. Third, it treats regime shift when applying the experimental economic approach.

2. MATERIALS AND METHODS

The subjects were the attendants of the *Agriculture and Economics* class, which is one of the author's relay-type lectures at his university. In fiscal 2009, there are

201 freshmen in the university. The number of students who take this class is 163 (92% of the attendants are freshmen), of which 148 students attended the author's lecture. The lecture and the experiment were performed on 3rd June 2009, when the freshmen were almost 2 months old. Almost all of the attendants will select an area of specialization other than economics in the future and we can regard that most of the students do not have any special knowledge of economics or any considerable concern related to economics. The 3rd June class lasted 90 minutes: an 80-minute lecture followed by a 10-minute questionnaire.

It is pointed out that those who have studied economics tend to be selfish (Marwell and Ames 1981, Frank, Gilovich and Regan 1993, 1996). In the class, the author briefly explained that mainstream economics supposes selfish and unboundedly rational economic agents using simple examples. Before starting the experiment, the author clearly stated that subjects (students) can select whether or not they suppose selfish economic agents when they answer the questions. By doing so, it could be expected that some subjects reply based on rational economic decision making and others reply based on some other decision-making process. Because of the students' status (less economic knowledge) and the brief explanation, it is expected that the subjects are not heavily biased toward 'selfish'.

The questionnaire used in the experiment is presented in Table 1 (one of four types of questionnaire). As is stated there, in the experiment, the following situation was described. There is a small beautiful lake where water fowl and fish abound. Subjects were supposed to be farmers who used 10 tons of lake water per year and in the process, earned ten million yen (or nearly a hundred thousand dollars). If subjects increase the amount of water intake, their annual revenues will increase. However, as the amount of water intake increases, the possibility of the occurrence of a regime shift will also increase.

Once regime shift occurs, annual revenues will decrease to n% of the current annual revenues without regime shift, where n is alternatively set to 10, 20, 30 or 40. The author randomly distributed these 4 types of questionnaires among the subjects. In what follows, n% questionnaires and their respondents will be referred to as the n% group.

In the above, farmers (subjects themselves), fishermen and tourists were supposed as economic agents, where it was implicitly supposed that there is only one farmer who uses lake water and decides the amount of water intake. Unless subjects maintain the current water intake (10 tons), regime shift will not occur, but once they increase the water intake, there is a possibility that regime shift will occur. A regime shift only has a negative impact on the subjects; this impact is regarded as an interior cost. The impacts on fishermen and tourists may or may not be negative; if the impact is negative, it is regarded as an external cost for the subject.

There are 4 questions in the questionnaire. Q1 asked the amount of water intake when only the subject will suffer from a negative impact if a regime shift occurs (there is no externality). Q2 asked the amount of water intake when both the subject and tourists will suffer from a negative impact if a regime shift occurs (there is an externality in consumption). Q3 asked the amount of water intake when both the subject and fishermen will suffer from a negative impact if a regime shift occurs (there is an externality in production). Q4 asked the subjects the reasons for their answers to Q1–Q3.

There are two cases where the answers are the same for Q1–Q3: some respondents reply economically rationally, resulting in the same answers for Q1–Q3, while other respondents gave the same answers based on other reasons. Under the assumption of homo economicus, because negative impacts for tourists and fishermen are external costs for the subject, the decision making of the subject has not been influenced by the existence of these negative impacts and, as a result, answers to Q1–Q3 coincide.

As mentioned above, 10 minutes were provided for answering the questionnaire, which is relatively short given the contents of the questionnaire. It is expected that if more answering time is provided, some subjects will calculate the optimum amount of water intake and answer accordingly (in fact, a few students did correctly arrived at the optimum solutions.) However, it is expected that many students do not know how to calculate the optimum solutions and those who do, might make calculation mistakes. A rather unfortunate occurrence would have been that the subjects’ attention would be on calculation and they would answer without distinguishing among questions Q1, Q2 and Q3. To prevent these mistakes and/or undesirable concentration, the answering time was limited.

Further, it was clearly stated that accurate answers were not required and subjects could answer based on their intuition. Under the above setting, it is expected that the average amount of water intake can be different for both the three questions and the four groups.

To ensure that subjects are familiar with the situation presented in the experiment, the author provided an explanation of regime shift and introduced Aral Sea as a real example in the lecture. The shrinking of the Aral Sea is caused by intensive irrigation for agriculture in the watershed countries. The example of the Aral Sea is larger in scale than our experiment, but the situation is somewhat similar. The author presented pictures, maps and statistical data related to the shrinking of the Aral Sea. It may seem that further explanation may be required in the questionnaire (Table 1); this, however, was not provided because it was included in the lecture.

3. ANALYSIS AND RESULTS

Current annual water intake is set at 10 tons; the maximum intake is 30 tons per year. The probabilities of the occurrence of a regime shift and the revenues are provided for every 2-ton increment from 12–30 tons. The subjects will select one among the 11 choices for Q1–Q3. Once the level of annual water intake is increased, expected annual revenue increases, reaches a maximum and then starts to decrease. Optimum solution refers to the average level of annual water intake (average intake level) wherein the expected revenue reaches a maximum. Critical solution refers to the highest possible average intake level wherein the annual revenue is higher than when the annual intake is 10 tons. The optimum solutions and critical solutions are 16 tons (10%), 18 tons (20%), 20 tons (30%) and 22 tons (40%) and 22 tons (10%), 24 tons (20%), 28 tons (30%) and 32 tons (40%), respectively (see Fig. 1). In our setting, because the upper limit of water intake is set at 30 tons, the critical solution for the 40% group (32 tons) will not attained. In what follows, we will use 'risk averse' to refer to subjects whose solutions are less than the optimum solution and 'risk loving' to refer to those whose solutions more than the optimum solution.

3.1 Differences in the responses among groups

Fig. 1 depicts the average intake level of the subjects, optimum solutions and critical solutions for the 4 groups. First, let us compare the optimum solutions and average intake level of subjects. Average intake levels for Q1 are 18.26 tons (10%), 18.81 tons (20%), 19.67 tons (30%) and 23.89 tons (40%). The differences between the optimum solutions and average intake levels are –2.26 tons (10%), –0.81 ton (20%), 0.33 ton (30%) and –1.89 tons (40%), which are quite small. We applied the two independent samples t-test for the difference between the optimum solutions and average intake levels[1)][1]. For all groups, the null hypothesis that *there are no differences between the two samples* was not rejected at 10% (two-tail test). Therefore, the differences between the optimum solutions and average intake levels are not statistically significant for all groups.

The values of the optimum solutions increase as the reduction rate of the annual revenue decreases (that is, as n increases from 10–40). Average intake levels for Q1 also seem to exhibit this trend. We confirm this finding statistically. First, we used the Bartlett test to test the homogeneity of variance. The null hypothesis is that *the variances in the water intake values of every group are the same*. The test statistic was 18.29 and the null hypothesis was rejected at 1%. Therefore we used the Kruskal-Wallis test, which is a non-parametric test, and test the null hypothesis that *there are no differences in the average water intake values of the 4 groups*. The test statistic was 15.52 and the null hypothesis was rejected at 1%. Therefore, it is statistically shown that at least the average value of one group is different from those of the others. In our case, as is easily seen from the values (and Fig. 1), average intake levels increase with n.

Next, we proceed to Q2 (Fig. 2). The average intake levels for Q2 are 13.32 tons (10%), 12.11 tons (20%), 12.72 tons (30%) and 14.27 tons (40%). The differences between the optimum solutions and average intake levels are 2.68 tons (10%), 5.89 tons (20%), 7.28 tons (30%) and 7.73 tons (40%). Finally, we proceed to Q3. The average intake levels for Q3 are 13.26 tons (10%), 12.22 tons (20%), 13.67 tons (30%) and 13.78 tons (40%). The differences between the optimum solutions and average intake levels are 2.74 tons (10%), 5.78 tons

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[1] We used SPSS 17.0 for the following tests: two independent samples t-test, Kruskal-Wallis test, Friedman test, and Kolmogorov-Smirnov test. In all other instances, we calculated manually.

(20%), 6.33 tons (30%) and 8.22 tons (40%).

The values of optimum solutions increase as n increases. However, average intake levels for Q2 and Q3 seem not to exhibit this trend. We confirm this statistically as in the case of Q1. The test statistics of the Bartlett test were 46.13 and 9.92 for Q2 and Q3, respectively; the null hypotheses were rejected at 1% and 5% for Q2 and Q3, respectively. Therefore, we used the Kruskal-Wallis test. The test statistics were 2.64 and 2.55 for Q2 and Q3, respectively; the null hypotheses were not rejected at 10%. Therefore, the differences among the average values of the 4 groups are not statistically significant.

Because the average intake levels for all groups for Q2 and Q3 are similar (as is suggested above), we use the Friedman test, which is a non-parametric test, and test the null hypothesis that *there are no differences among the 8 average water intake values*. The test statistics was 5.4 and the null hypothesis was not rejected at 10%. This result implies that (1) the subjects do not distinguish between the externalities in production and consumption and that (2) when externality occurs, the differences among the 4 groups do not influence the average intake levels.

3.2 Differences in the standard variations of the responses among the groups

Standard variations are 7.37 (10%), 6.39 (20%), 7.24 (30%) and 5.44 (40%) for Q1; 5.01 (10%), 4.03 (20%), 3.58 (30%) and 5.85 (40%) for Q2; and 5.19 (10%), 4.49 (20%), 4.79 (30%) and 5.67 (40%) for Q3. This suggests that the standard variations for Q1 are substantially larger than those for Q2 and Q3 for all groups except for the 40% group.

The Kolmogorov-Smirnov test was applied to these 12 cases to test the null hypothesis that the *variable follows a normal distribution*. The null hypothesis was rejected at 5% for all cases. Therefore, we cannot apply normal distribution using the average values and the standard variations of each case to calculate the percentage of subjects whose water intake is within a certain level. However, because the average intake levels for Q1 are close to the optimum values and standard variations are generally larger, there is a high possibility that many subjects select water intake levels which are higher than the critical solutions. On the other hand, because average intake levels for Q2 and Q3 are fairly less than the optimum values and standard variations are generally smaller, there is a low possibility of the above occurring.

3.3 Response patterns for Q1–Q3 and the answers to Q4

In the questionnaire, the subjects were asked to provide the reasons for their answers. The responses are classified and summarized in Table 3.

Q1 = Q2 = Q3 type: such responses account for 20.3% of the responses. From Q4, we get that only 6% (30% of this type) of respondents responded based on economically rational decision making. The rest 14% (70% of this type) responded due to different reasons. One of the reasons is that the subjects wanted to avoid the risk of a regime shift. Table 4 shows the number of respondents who selected 10 tons for Q1–Q3. In the 10%–30% groups, almost half of the respondents selected 10 tons. From the responses to Q4, we get that the reason for selecting 10 tons is to avoid the risk of a regime shift. On the other hand, in the 40% group, no respondent selected 10 tons.

Table 4 shows the average intake levels for those whose three responses were equal (Q1 = Q2 = Q3). Average intake levels are 12.5–13.78 tons in 10%–30% groups; the corresponding figure for the 40% group is 18.8 tons. Thus, at least for such respondents, there is a tendency to lower the average intake level when the impact of a regime shift on them is high (10%–30% groups) and to increase the average intake level when the impact of a regime shift on them is less (40% group). Because our sample size is small, we applied the Kruskal-Wallis test to test the null hypothesis that *there are no differences among the 4 average intake levels*. The test statistic was 5.9 and the null hypothesis was not rejected at 10%. We do not have a statistically significant result but once enough data is accumulated, the result may change.

Q1 > Q2 = Q3 type: such responses account for 59.5% of the responses. From Q4, we get that most of the respondents state that they increase their level of water intake even if the risk of a regime shift rises as long as there is no externality, but avoid increasing their level of water intake if externalities exist. As a result, average intake level in Q1 is 22.2 tons, which is close to the average optimum value of 19.0 tons, the average of the optimum solutions for the 4 groups. However, the average level of water intake in Q2 and Q3 is 11.6 tons, which is substantially lower than the average optimum value.

Q1 > Q2 > Q3 and Q1 > Q3 > Q2 type: such responses account for 8.1% (5.4% + 2.7%) of the responses. While the responses of the Q1 > Q2 = Q3 type do not distinguish between the externalities in production and in consumption, such responses do. Respondents whose responses were of the Q1 > Q2 > Q3 type find the influence of the externality in production to be stronger than that of the externality in consumption; for the respondents whose responses were of the Q1 > Q3 > Q2 type, the inverse holds true.

Others: such responses account for 12.2% of the responses. Most of the respondents provide inconsequential explanation, (not) focusing on specific impact(s) (e.g., ignoring the impact on fishery) or creating specific situations (e.g., making new assumptions for the relationship between fish, water fowls and water quality and accordingly answering). Because such responses vary considerably and are essentially non-consequential, we omit the details for such responses.

4. DISCUSSION

Based on traditional mainstream economics and environmental economics, subjects will select an economically rational level of water intake under the assumption of *homo economicus* without taking account of external benefits or external costs. However, the results of the experiments suggest that if there is a possibility that subjects' actions will cause substantial environmental problems in the form of a regime shift and result in serious damage to other economic agents in the form of externalities, the subjects will not behave economically rational and will not ignore external costs.

If subjects behave economically rationally, the average intake level for Q1–Q3 will coincide. Only 6% of our responses that had the same water intake level for the three questions were based on economically rational decision making while 14% of our responses that had the same water intake level for the three questions were based on different reasons. Based on these results, we can say that when subjects have little knowledge of economics, most will select the level of water intake using a decision-making process other than that of economic, even if an explanation is provided for the assumption of *homo economicus*.

In what follows, we will examine the results in greater detail. First, let us consider the average values of the responses. If only the subjects will be negatively impacted, they may exhibit risk loving behaviour but if other economic agents will also be negatively impacted, the subjects are averse to risk. When there is no externality, the selection of the level of water intake is consistent with the economically rational optimum solutions predicted by traditional theory. Further, subjects seem to reply correctly based on their intuition because here the answering time was limited to 10 minutes.

When externalities exist, subjects take external costs into account and lower the level of water intake. There are at least two reasons as to why we obtained such results. First, it might be because, in our experiences, there is no real money transfer and the subjects therefore behave nicely.

Second, there may be an incentive which is similar to the warm glow effect. This incentive resulted in subjects exhibiting risk avoidance behaviour when externalities exist. The warm glow effect implies that the subjects feel good that their behaviour will have positive consequences for others. In our case, subjects seek to reduce their guilt because their behaviour will have negative consequences for others. This can be referred to as the *guilt-alleviation effect*. In our experience, because only one subject will have a substantial negative effect on the environment, the guilt-alleviation effect is stronger than in the case where there are at least two subjects who have a negative effect on the environment.

The most common response was Q1 > Q2 = Q3. Q2 is the case where externality in consumption occurs and Q3 is the case where externality in production occurs. Because externalities in consumption and production affect the utility function of the households and the production function of the producers, respectively, it is expected that the latter externality is easier to recognize for the subjects as a monetarily negative impact. However, the difference between the average intake levels for Q2 and Q3 is not statistically significant. This implies that subjects exhibited similar risk avoidance behaviour regardless of the type of externality. One of the reasons may be that the situation in this experiment is considerably simple and the total biomass of water fowls and fishes has not been described in detail. Further, a detailed description of a regime shift was not provided. Nevertheless, there are no statistically significant differences among the 8 average water intake levels (for 10–40% groups for Q2 and Q3). However, it can be inferred that the same risk avoidance behaviour was exhibited for the different types of influences.

Next, let us consider the variance of the responses. If there is no externality (Q1), it is easier for the subjects to express their primary preference for risk. Subjects need not consider externalities; they exhibit risk-loving behaviour, and as such, standard variance takes larger values. In fact, the standard variance for Q1 is larger than those for Q2 and Q3. This fact supports that in Q1, the subjects both risk avoidance and risk-loving behaviour, and that in Q2 and Q3, the subjects tend to avoid risk and reduce water intake.

Finally, let us consider the cases where the average values for Q1–Q3 are the same. As illustrated in Table 4, if the damages are expected to be large (10%–30%), subjects tend to exhibit altruistic behaviour whereas if the damage is less serious (40%) subjects tend to exhibit selfish or economically rational behaviour. Further, the lack of significance may be due to the small group sizes and the small sample size. Statistically significant results may be obtained from larger samples and larger sample sizes. In this paper, because we used university freshmen as subjects, the results may change if we apply the same experiment to different groups. Further, because the subjects are not faced with real money transfer and they also have little experience of real farm management, their answers for Q2 and Q3 might be too low.

5. CONCLUSIONS

Thus far, environmental issues have been treated as externalities in mainstream and environmental economics, and *homo economicus* has been assumed. This paper examined whether externality occurs because of the subjects' economically rational behaviour using experimental economic approach in the framework of regime shift.

Our results suggest that when there is no externality, subjects act economically rationally but when there is an externality, subjects exhibit risk avoidance behaviour. We proposed that *guilt-alleviation effect* will exist and subjects will exhibit risk avoidance behaviour when externalities can happen. We also obtained the results that risk avoidance behaviour is independent of the impact of the externality. These results have serious implications for current economics that considers environmental issues to be externalities right from the start. As such, it may be conducive to reconsider a new image of an economic agent.

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Table 1 Questionnaire (for the 10% group)

Suppose that there is a small scenic lake. In this small lake, water fowls and fish abound. Suppose that you are a farmer and use lake water for agriculture. There are fishermen who fish in the lake for a living. Moreover, tens of thousands of tourists visit this lake to watch water fowls and the beautiful scenery. You have managed your agricultural drainage properly and the drainage has no impact on the water fowls, fish and the beautiful scenery of the lake.

Suppose that you are now thinking of increasing the level of water intake. **Suppose that you are now taking 10 tons of lake water annually and earn ten million yen from agriculture annually**. If a regime shift does not happen, your revenue will increase. However, once a regime shift happens, water quality decreases and your revenue will be **10%** of your current revenue. The details are tabulated as follows.

(Unit: million yen)

Water intake	10t	12t	14t	16t	18t	20t	22t	24t	26t	28t	30t
Without regime shift	10	12	14	16	18	20	22	24	26	28	30
With regime shift	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3
Probability of regime shift	0%	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %	90 %	100 %

For example, suppose that you select 12 tons. Your annual revenue will be 12 million yen if a regime shift does not occur but it will be 1.2 million yen if a regime shift occurs. The possibility of the latter (1.2 million) is 10% whereas that of the former (12 million) is 100 – 10% = 90%.

Q1 Scientists predict that the **beautiful scenery of the lake and the number of water fowls and fishes will be maintained** if a regime shift happens. Then, what is your choice for the level of water intake. Select one option from the above table.

________ tons

Q2 Scientists predict that the **beautiful scenery of the lake will be degraded and the number of water fowls will decrease but the number of fish will be maintained** if a regime shift happens. Then, what is your choice for the level of water intake. Select one option from the above table.

________ tons

Q3 Scientists predict that the **beautiful scenery of the lake and the number of water fowls will be maintained but the number of fish will be decreased by half** if a regime shift happens. Then, what is your choice for the level of water intake. Select one option from the above table.

________ tons

Q4 Provide a brief explanation for your answers to the above three questions. The contents of the lecture need not be taken into account here.

Table 2 Differences in standard variations of the responses among groups

	10%	20%	30%	40%
Q1	7.37	6.39	7.24	5.44
Q2	5.01	4.03	3.58	5.85
Q3	5.19	4.49	4.79	5.67

Table 3 Response rates for the different response types

	10%	20%	30%	40%	Total
	38	37	36	37	148
Q1 = Q2 = Q3					
Economic	3 (7.9%)	1 (2.7%)	2 (5.6%)	3 (8.1%)	9 (6.1%)
Non-economic	6 (15.8%)	7 (18.9%)	6 (16.7%)	2 (5.4%)	21 (14.2%)
Q1 > Q2 = Q3	21 (55.3%)	24 (64.9%)	20 (55.6%)	23 (62.2%)	88 (59.5%)
Q1 > Q2 > Q3	2 (5.3%)	1 (2.7%)	2 (5.6%)	3 (8.1%)	8 (5.4%)
Q1 = Q2 > Q3	1 (2.6%)	2 (5.4%)	0 (0.0%)	2 (5.4%)	5 (3.4%)
Q1 > Q3 > Q2	0 (0.0%)	1 (2.7%)	2 (5.6%)	1 (2.7%)	4 (2.7%)
Q1 = Q3 > Q2	1 (2.6%)	0 (0.0%)	0 (0.0%)	2 (5.4%)	3 (2.0%)
Q1 < Q2 = Q3	2 (5.3%)	0 (0.0%)	0 (0.0%)	1 (2.7%)	3 (2.0%)
Q1 < Q3 < Q2	1 (2.6%)	0 (0.0%)	1 (2.8%)	0 (0.0%)	2 (1.4%)
Q2 < Q1 < Q3	0 (0.0%)	1 (2.7%)	1 (2.8%)	0 (0.0%)	2 (1.4%)
Q1 = Q3 < Q2	1 (2.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.7%)
Q1 < Q2 < Q3	0 (0.0%)	0 (0.0%)	1 (2.8%)	0 (0.0%)	1 (0.7%)
Q1 = Q2 < Q3	0 (0.0%)	0 (0.0%)	1 (2.8%)	0 (0.0%)	1 (0.7%)

Table 4 Response rates for Q1 = Q2 = Q3

	10%	20%	30%	40%
Q1 = Q2 = Q3	9	8	8	5
10 tons throughout	4	5	4	0
	(44.4%)	(62.5%)	(50.0%)	(0%)
Average intake	13.78	13.25	12.50	18.80
Optimum solution	16	18	20	22

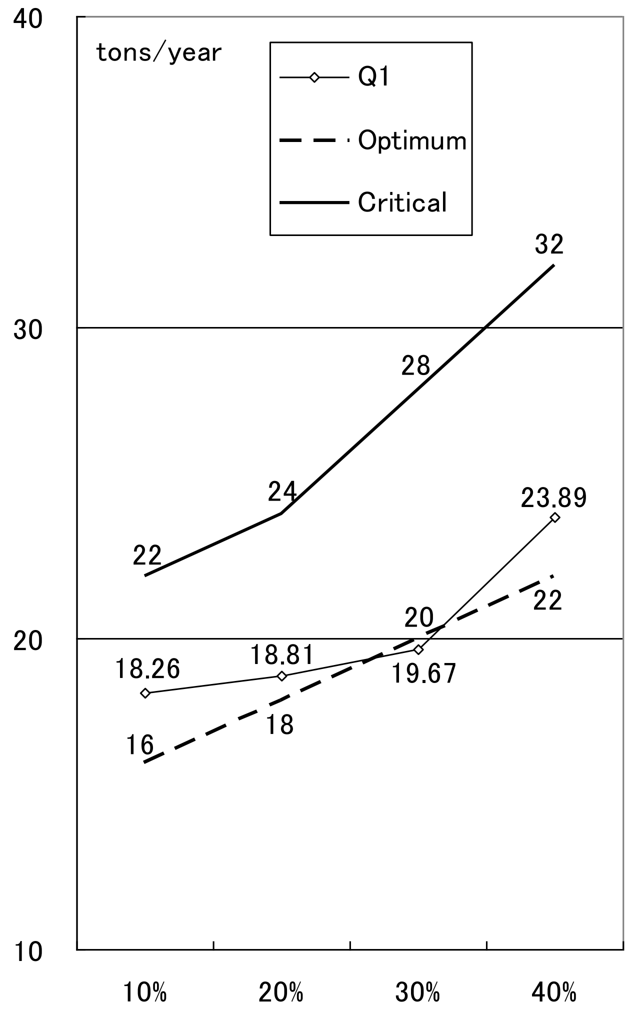

Fig. 1 Average water intake levels with and without externalities (Q1)

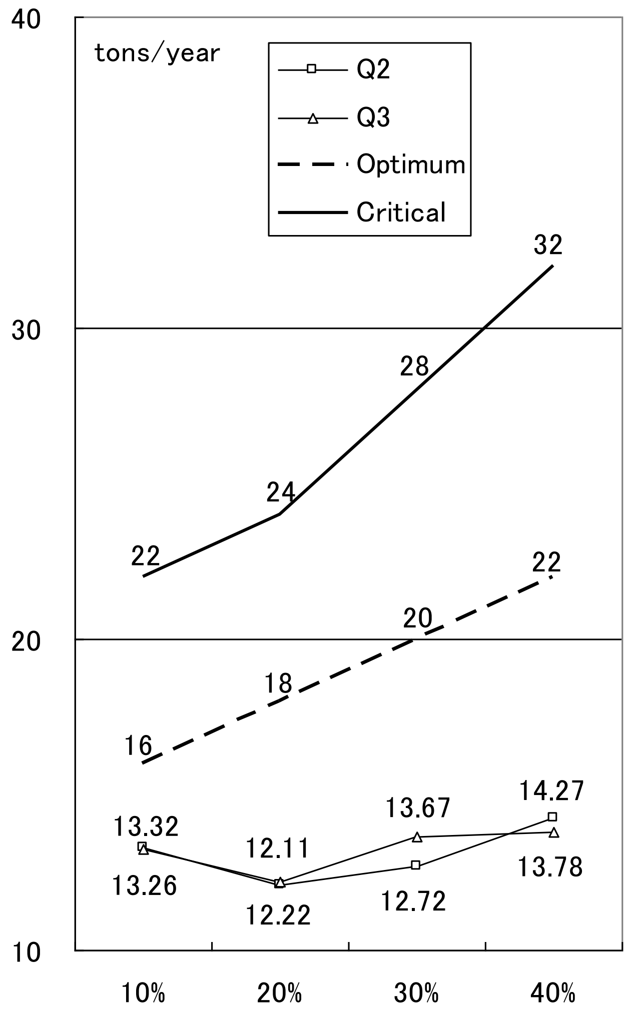

Fig. 2 Average water intake levels with and without externalities (Q2, Q3)