Changing Risk Attitude Between Two Prospects (($*Y*, *p*) and ($*X*, 1)) in Gain and Loss Domains with Small *p*-Values and *Y* >>*X*

Reflection Effects and Conditions for Reversal of Choice

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***Abstract*-This study investigated the irrationality in decision-making on risk attitude. More specifically, the readiness of reflection in decision-making was investigated and compared between two conditions (the reflection from the risk-seeking choice to the risk-aversion choice and that from the risk-aversion choice to the risk-seeking choice). Second, the condition (*p*-value (probability of gain or loss)) for the reversal of choice (change of risk attitude) was identified and compared to gain and loss domains. In such a way, the irrationality in decision-making on risk attitude was introduced. On the basis of such an approach, it was discussed how choosing one of the two prospects A ($*Y*, *p*) or B ($*X*, 1) should be systematically treated in order to generalize the change of risk attitude under the condition of a smaller value of *p* and *Y* >> *X* (*Y* is much larger than *X*). While the reflection effect from the risk-seeking choice to the risk-aversion choice readily occurred when the occurrence probability *p* of the larger gain was low, the reflection effect from the risk-aversion choice to the risk-seeking choice did not readily occur. The amount of change (increment or decrement) of *p*-value necessary for changing the risk attitude (from risk-aversion to risk-seeking, and vice versa) was identified for both the gain and loss domains. A simple demonstrative decision-making paradigm is insufficient for the generalization of characteristics of the weighting function $\pi(p)>p$.**

Keywords- Behavioral Economics; Prospect Theory; Reflection Effect; Reversal of Choice; Irrationality; Change of Risk Attitude

I. INTRODUCTION

Kahneman and Tversky [1] used the following questionnaire on risk attitude to verify that the value of probability weighting function ($\pi(p)$) becomes larger than the actual probability *p*.

Problem 1

Which would you choose?

(A) Get $5,000 with the probability of 0.001 ((A)=($5,000, 0.001)).

(B) Get $5 for sure ((B)=($5, 1)).

Problem 2

Which would you choose?

(A) Lose $5,000 with the probability of 0.001 ((A)=(-$5000, 0.001)).

(B) Lose $5 for sure ((B)=(-$5, 1)).

The alternatives (A) and (B) corresponded to risk-seeking and risk-aversion risk attitude, respectively. The risk attitude was variable according to the probability of higher gain or loss in Problem 1 and Problem 2. The risk attitude represented the results of decision-making. Although Wakkaer [2], Bosch-Dom'enech [3], and Kuhberger [4] discussed the reflection effect, the reversal of risk attitude, and the framing effect, these studies did not explore how the risk attitude changed as a function of a smaller value of *p* under smaller *p*-values and *Y*>>*X*. How one chooses from two prospects ($Y, *p*) or ($*X*, 1) in both gain and loss domains under smaller *p*-values and *Y*>>*X* should be more systematically explored in order to gain insight into decision-making under such conditions.

First, the two decision-making situations above are insufficient for the generalization of characteristics of the weighting function $\pi(p)>p$ for smaller *p* values because the inequality was derived on the basis of the experimental results on the only basis of Problems 1 and 2 above. The reflection effect shows the following phenomena: (i) Certainty effect is dominant in gain domain ((B) is preferred to (A) in Problem 1), but is reduced in loss domain ((A) is preferred to (B) in Problem 2). (ii) Risk seeking is dominant in the gain domain ((A) is preferred to (B) in Problem 1), but is reduced in the loss domain ((B) is

preferred to (A) in Problem 2). It has been shown that the reflection effects of (i) or (ii), that is, the reversal of risk attitude between gain and loss domains, is observable [5, 6]. However, it has not been definitely stated whether the readiness of the occurrence of the reflection effect in decision-making is different between the change of risk attitude from the risk-seeking choice to the risk-aversion choice (ii) and vice versa (i).

Second, the change of *p*-value necessary for changing the risk attitude (from risk aversion to risk seeking, and vice versa) has also not been explored in either loss or gain domains. In other words, the conditions under which the risk attitude changes from risk aversion to risk seeking and vice versa have not been systematically identified. It is expected that the value of *p* necessary for changing the risk attitude in both gain and loss domains are different between the change from risk aversion to risk seeking and that from risk seeking to risk aversion.

Third, the following discussion was conducted on the generalization of the characteristics of weighting function $\pi(p)>p$. Risk attitude changes in decision-making between two prospects ($Y, *p*) and ($X, 1) under a smaller *p*-value and $Y>>X$ must be examined systematically in order to get insight into irrational properties (for example, one does not make decisions rationally on the basis of a mathematical expected value) on the change of risk attitude from risk aversion to risk seeking and vice versa. Moreover, what is lacking in the generalization of the characteristics of the weighting function $\pi(p)>p$ must be made clear to enhance the applicability of prospect theory [7-10] to a variety of decision-making situations because the inequality was derived on the basis of experimental results on only the basis of Problems 1 and 2 mentioned previously, and it is not certain whether the characteristics of weighting function $\pi(p)>p$ holds constantly (universally) under a small *p*-value.

The aim of this study was to investigate the irrationality in decision-making on risk attitude, i.e. irrational behaviour that does not obey rational calculation on the basis of a mathematical expected value. More specifically, the readiness of reflection effect in decision-making was investigated. First, the difference of readiness of reflection effect between two conditions (the reflection effect from the risk-seeking choice to the risk-aversion choice and vice versa) was clarified from the viewpoint of irrational risk-aversion property in decision-making. Second, the *p*-value (probability of gain or loss) necessary for the reversal of choice (change of risk attitude) was compared between the shift from the risk-seeking choice (A) to the risk-aversion choice (B) and the shift from the risk-aversion choice (B) to the risk-seeking choice (A). It must be noted that the probability weighting function $\pi(p)$ for the *p*-value obtained in such a way is enough to change the risk attitude. To be precise, it was clarified if the change of *p*-value from the initial value (0.1%) in this study was different between the shift from (A) to (B) and the shift from (B) to (A), and this phenomena was discussed from the viewpoint of irrational decision-making property, that is, risk-aversion property. Third, on the basis of such an approach, it was also discussed how choosing one of the two prospects (A) ($Y, *p*) or (B) ($X, 1) should be systematically treated in order to generalize the change of risk attitude under the condition of a smaller value of *p* and $Y>>X$ (*Y* is much larger than *X*). In other words, an attempt was made to point out that the derivation of the property of probability weighting function $\pi(p)>p$ under a smaller value of *p* and $Y>>X$ in prospect theory cannot be generalized by a simple demonstrative decision-making paradigm using only Problems 1 and 2. In this study, it was shown that the relationship between the gain or loss $Y for the risk-seeking choice, the corresponding *p*-value (the probability of gain or loss $Y), and the gain or loss $X for the sure thing must be further investigated in order to generalize the property $\pi(p)>p$ under a smaller value of *p* and $Y>>X$.

This study conducted investigations on the following three issues:

(1) It was investigated whether the readiness of occurrence of reflection effect differed between the change from the risk-seeking choice to the risk-aversion choice and vice versa. Due to the irrational risk-aversion property, it was hypothesized that the reflection effect more readily occurs in the change from the risk-seeking choice in the gain domain to the risk-aversion choice in the loss domain than for the change from the risk-aversion choice in the gain domain to the risk-seeking choice in the loss domain.

(2) It was investigated how the *p*-value necessary for changing the risk attitude differed between the shift from the risk-seeking choice to the risk-aversion choice and that from the risk-aversion choice to the risk-seeking choice. Due to the irrational risk-aversion property, it was hypothesized that the amount of change of the *p*-value necessary for changing the risk attitude from risk-aversion to risk-seeking was larger than that for changing the risk attitude from risk-seeking to risk-aversion.

(3) It was demonstrated that the above two decision-making situations (Problem 1 and Problem 2) were insufficient for the generalization of characteristics of the weighting function $\pi(p)>p$ for smaller *p* values.

II. METHODS

A. Participants

Twenty-one undergraduate and graduate students between 20 and 26 years old took part in the experiment. All had no knowledge or skill in psychology or behavioural economics. All agreed to participate in the experiment after receiving a brief explanation.

B. Experimental Task and Procedure

First, the participant was required to answer Problem 1 below.

Problem 1

Which would you choose?

(A) Get $5,000 with the probability of 0.001.

(B) Get $5 for sure.

The participants who chose (A) were required to answer Problem 2a, which is presented below. The participant was required to enter the probability *p* at which he or she changed their decision from (A) to (B). The following values of *p* were presented to the participant in descending order: 0.09%, 0.08%, 0.07%, 0.06%, 0.05%, 0.04%, 0.03%, 0.02%, 0.01%, 0.005%, 0.002%, 0.001%, 0.0005%, 0.0002%, 0.0001%, 0.00005%, 0.00002%, and 0.00001%. The choices were presented in descending order because of the possibility that multiple reversals of choice from (A) to (B) would occur if the *p*-values above were presented at random.

Problem 2a

You chose option (A) in Problem 1. At which probability of getting $50,000 would you change your decision to (B)?

The participants who chose (B) in Problem 1 were required to answer Problem 2b, which is presented below. The participant was required to enter the probability p at which he or she changed their decision from (B) to (A). The following discrete *p* values were presented to the participant in ascending order in order to avoid multiple reversals of choice from (B) to (A): 0.5%, 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 15%, and 20%.

In this experiment, the order of judgment for values of *p* was not randomized, because it was possible that multiple reversals of choice from (B) to (A) would occur if a random presentation of *p* was adopted. Firstly, the minimum and the maximum values of *p* were determined, and the value of *p* was determined empirically by a preliminary experiment so that the participant did not become frustrated with too many alternative values of *p*.

Problem 2b

Assuming that you chose alternative (B) in Problem 1, at which probability of getting $5,000 would you change your decision to (A)?

These problems (Problem 2a and Problem 2b) corresponded to the problem related to the gain situation (see Fig. 1).

Next, the participant was required to answer Problem 3.

Problem 3

Which would you choose?

(A) Lose $5,000 with the probability of 0.001.

(B) Lose $5 for sure.

The participants who chose (A) in Problem 3 were required to answer Problem 4a, which is presented below. The participant was required to answer the probability *p* at which he or she changed their decision from (A) to (B). The following values of *p* were presented to the participant in ascending order in order to avoid multiple reversals of choice: 0.5%, 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 9%, 10%, 15%, and 20%.

Problem 4a

Assuming that you selected option (A) in Problem 3, at which probability of losing $5,000 would you change your decision to (B)?

The participants who chose (B) in Problem 3 were required to answer Problem 4b. The following discrete *p* values were presented to the participant in descending order: 0.09%, 0.08%, 0.07%, 0.06%, 0.05%, 0.04%, 0.03%, 0.02%, 0.01%, 0.005%, 0.002%, 0.001%, 0.0005%, 0.0002%, 0.0001%, 0.00005%, 0.00002%, and 0.00001%.

Problem 4b

Assuming that you chose option (B) in Problem 3, at which probability of losing $5,000 would you change your decision to (A)?

These problems (Problem 4a) and Problem 4b) corresponded to the problem related to the loss situation (see Fig. 2).

In this study, it was explored how the reversal of preference occurred with the change of *p*. In other words, by identifying the value of *p* at which the preference (choice) was reversed, the conditions were examined under which the reflection effect was observed.

The contents of the experiment were explained to the participants, all of whom were required to answer Problem 1, Problem 2a or 2b, Problem 3, and Problem 4a or 4b, in this order. The meanings of value function and *p*-value in prospect theory were not explained to the participants.

The absolute value of value function is larger in the loss domain (Fig. 2) than in the gain domain (Fig. 1), which means that the loss (for example, *v*(-5000)) is felt more seriously than a gain of the same amount (*v*(5000)). Therefore, one tends to lean toward risk-aversion when one is in the loss domain.

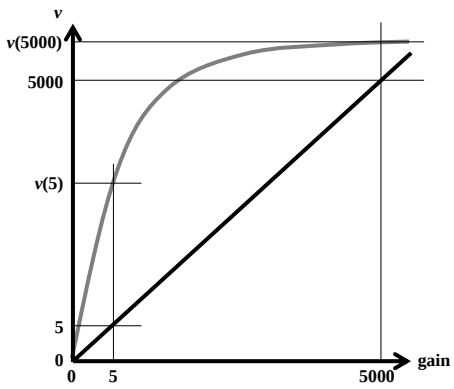

Fig. 1 Relationship between gain and value function *v* in Problem 1. A concave function *v* is assumed in the gain domain

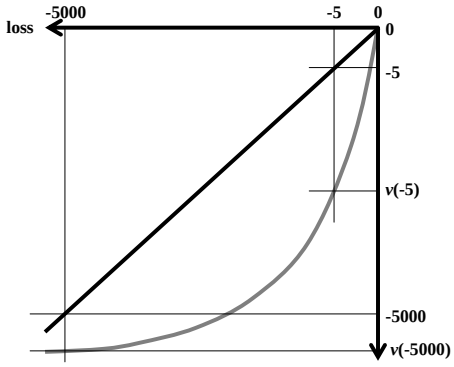

Fig. 2 Relationship between loss and value function *v* in Problem 3. A convex function *v* is assumed in the loss domain

III. RESULTS

A. Percentage of Choices for Each Alternatives and Reversal of Choice

In the gain domain, about 66.7% of the participants (14 out of 21) chose the risk-seeking alternative (A) (Get $5,000 with the probability of 0.001(0.1%)). About 33.3% of the participants chose (B) (Get $5 for sure).

In the loss domain, about 14.3% of the participants (3 out of 21) chose (A) (Lose $5,000 with the probability of 0.001). About 85.7% of the participants chose the risk-aversion alternative (B) (Lose $5 for sure).

The percentages of the reversal of choices between Problem 1 and Problem 3 were as follow. About 85.7% (12 out of 14) of the participants who chose (A) in Problem 1 (risk-seeking) chose (B) in Problem 3 (risk-aversion). The reversal of choice (reflection effect) occurred in about 85.7% of the participants. For the participants who chose the risk-aversion alternative (B) in Problem 1, the reversal of choice occurred for only one participant (14.3%). In other words, six out of seven participants who chose the risk-aversion alternative (B) in Problem 1 chose the risk-aversion alternative (B) in Problem 3 (the reversal of choice did not occur). In such a way, the reversal of choice (reflection effect) was more frequently observed in the participants who chose the risk-seeking alternative (A) in Problem 1 than for the participants who chose the risk-aversion alternative (B) in Problem 1.

A ratio test was conducted to reveal the statistical difference of the percentage reflection effect between the group of participants who chose risk-seeking alternative (A) in the gain domain (Group I) and the group of participants who chose the risk-aversion alternative (B) in the gain domains (Group II). As a result, the percentage of reflection effect for Group I was significantly higher than that for Group II (z=3.20, p<0.01).

B. p-value When the Shift from (A) to (B) or from (B) to (A) Occurs in Gain Domain (Problem 1)

For the participants who chose (A), the mean value of probability *p* at which the decision changed from (A) to (B) (Get \$5 for sure) was found to be 0.00014 (0.014%) (Range: from 0.00001% to 0.09%).

For the participants who chose (B), the mean value of probability *p* at which the decision changed from (B) to (A) (Get \$5,000 with the probability of *p*) was found to be 0.091(9.1%) (Range: from 0.5% to 20%).

C. p-value When the Shift from (A) to (B) or from (B) to (A) Occurs in Loss Domain (Problem 3)

For the participants who chose (A), the mean value of probability *p* at which the decision changed from (A) to (B) (Lose \$5 for sure) was found to be 0.0279 (2.79%) (Range: from 0.5% to 20%).

For the participants who chose (B), the mean value of probability *p* at which the decision changed from (B) to (A) (Lose \$5,000 with the probability of *p*) was found to be 0.00008 (0.008%) (Range: from 0.00001% to 0.09%).

The results of *p*-value when the shift from (B) to (A) or from (A) to (B) occurred in both the gain and loss domains are summarized in Fig. 4. The following *t*-tests were conducted: (1) p=0.014% (shift from (A) to (B) in the gain domain) vs. p=0.008% (shift from (B) to (A) in the loss domain), and (2) p=2.79% (shift from (A) to (B) in the loss domain vs. p=9.1% (shift from (B) to (A) in the gain domain). It must be noted that the *p*-values in (1) were converted by dividing 0.1% by each *p*-value (for example, 0.1%/0.014% (=7.14)). Significant differences were detected for both (1) (t =4.02, p<0.05) and (2) (t=6.31, p<0.01).

IV. DISCUSSION

A. Reflection Effect

The reversal of choice (reflection effect) was clearly observed in about 85.7% of the participants who chose (A) in Problem 1 (risk-seeking). They chose (B) in Problem 3 (risk-aversion), and the attitude toward the risk was different between the gain and the loss domain. For the seven participants who chose the risk-aversion alternative (B) in Problem 1, the reflection effect was observed for only one participant (14.3%). Six out of seven participants chose the risk-aversion alternative (B), even in Problem 3.

In such a way, the reversal of choice (reflection effect) was more frequently observed in the participants who chose the risk-seeking alternative (A) in Problem 1 than for the participants who chose the risk-aversion alternative (B) in Problem 1. This meant that the reflection effect from the risk-seeking choice ((A) in Problem 1) to the risk-aversion choice ((B) in Problem 3) readily occurred when the occurrence probability of the larger gain was low. On the other hand, as for the participants who chose the risk-aversion alternative (B) in Problem 1, a reflective effect was observed for only one participant, which meant that the reflective effect from the risk-aversion choice to the risk-seeking choice was unlikely and didn't readily occur.

As hypothesized, the reflection effect more readily occurred for the change from the risk-seeking choice to the risk-aversion choice than for the change from the risk-aversion choice to the risk-seeking choice. (The difference was statistically significant, as mentioned in the Results section). This result can be explained by risk-aversion property in the loss domain. As mentioned previously, the loss is felt more seriously than the gain of the same amount. Therefore, the participants tended to portray more risk-aversion behaviours in the loss domain. They evidently preferred the sure loss of a small amount of money (like an insurance premium) to the gamble of losing a large amount of money with a smaller probability. Therefore, the participant who chose prospect B (\$5, 100%) in the gain domain also tended to choose prospect B (-\$5, 100%), which meant that the reflection effect from the risk-aversion choice to the risk-seeking choice did not readily occur.

B. p-value When the Shift from (A) to (B) or from (B) to (A) Occurs in Both Gain and Loss Domains

Kahneman and Tversky [1], assuming a concave function in the gain domain, showed that the following relationships hold on the basis of the questionnaire using Problem 1 (see Fig. 1). Here, $v(x)$ and $\pi(x)$ represent the value function and the probability weighting function, respectively.

$$\pi(0.001)v(5000) > v(5) \tag{1}$$

$$\pi(0.001) > \frac{v(5)}{v(5000)} > 0.001 \tag{2}$$

The inequality above doesn't mean that the relationship (1) or (2) universally holds. According to Kahneman and Tversky [1], about 72 % of participants choose (A) in Problem 1. For about 28% of the participants, Eq. (1) or (2) does not hold.

Similarly, the following relationships hold by assuming a convex function in the loss domain on the basis of the questionnaire survey in Problem 3 (see Fig. 2).

$$\pi(0.001)v(-5000) < v(-5) \tag{3}$$

$$\pi(0.001) > \frac{v(-5)}{v(-5000)} > 0.001 \tag{4}$$

Although Kahneman and Tversky [1] believed that the following relationship was satisfied on the basis of the relationship above, it cannot be assured that the relationship generally holds on the basis of the derivation above.

$$\pi(p) > p \tag{5}$$

This shows that the occurrence of an event with such a small value of p is overestimated when p is small.

Problem 1 and Problem 3 are expressed more generally as follows. (It should be noted that p^* is a small value.)

Problem 1*

Which do you choose?

(A) Get \$$Y$ with the probability of p^*.

(B) Get \$$X$ for sure.

Problem 3*

Which do you choose?

(A) Lose \$$Y$ with the probability of p^*.

(B) Lose \$$X$ for sure.

When (A) is preferred to (B) in Problem 1*, the following inequality holds if x is larger than y (see Fig. 3).

$$\pi(p^*) > \frac{v(X)}{v(Y)} > \frac{X}{Y} \tag{6}$$

When (B) is preferred to (A) in Problem 3*, the following inequality is satisfied if x is larger than y.

$$\pi(p^*) > \frac{v(-X)}{v(-Y)} > \frac{X}{Y} \tag{7}$$

It is reasonable to assume $x>y$ for a concave value function, as shown in Fig. 3. The value function $v(x)$ is generally assumed to be concave. Therefore, $v(x)$ is larger than X, and $v(y)$ is larger than Y. If $v(x)$ is set to xX, and $v(y)$ to yY, x and y get larger than 1. The relationships in (6) and (7) prove that Eq. (5) does not necessarily hold. It is, generally, impossible to determine whether X/Y is larger than p^*. As X was equal to p^*Y in Problem 1 and Problem 2, it happens that Eq. (5) holds. However, only such cases (Eqs. (2) and (4)) were not enough to demonstrate that Eq. (5) generally holds. Therefore, it was necessary to explore the relationship between p and X/Y in more detail in order to investigate the characteristics of probability weighting function $\pi(p)$ and the attitude change toward risk under the condition of smaller values of p and $Y>>X$ (>> represents that Y is much larger than X).

The empirical and more indirect verification of Eq. (5) by the identification of the relationship between the number of deaths and the predicted number of deaths for a variety of diseases and accidents [11, 12] would be more generalized to verify Eq. (5) empirically.

On the basis of the results of this study, the change of risk attitude is mentioned. First, the p-value when the choice shifts from (A) to (B) and from (B) to (A) in the gain domain was discussed. On average, the shift of choice from (A) to (B) occurred when p-value decreased from 0.1% to 0.014%. The p-value of 0.014% may be expressed as a value that makes the participant abandon the risk-seeking alternative and display risk-aversion. The expected value of the risk-seeking alternative corresponded to about \$0.7 (=\$5000X 0.00014), and was by far smaller than the \$5-for-sure gain. If one judged rationally, one would shift from (A) to (B) at the moment (p=0.09%) the expected value of (A) became smaller than that of (B) (=\$5). This means that the participants did not necessarily judge rationally on the basis of the mathematical expected value and made decisions using the calculated expected value. This situation can be expressed as follows.

$$\pi(0.00014)v(5000) < v(5) \tag{8}$$

The p-value (0.014%) was about 1/7.14 of the initial p-value of 0.1%. Although it was impossible to identify the exact shape of the probability weighting function for smaller values of p in the range of this experiment, the following discussion was possible. When the values of p were larger than 0.014%, it could be said that the probability weighting function was more than 0.001 (0.1%). When the values of p were equal to or less than 0.014%, it was expected that the probability weighting function became smaller than 0.1% on the basis of Eq. (8). This must be one cause of the reversal of choice from (A) to (B).

Although the change of p from 0.0002 (this value did not yet induce the reversal of choice from (A) to (B)) to 0.00014 was very slight, it must be noted that such a slight decrease induced the change of risk attitude. It must be also noted that most people are not accustomed to dealing with small probabilities, and do not make rational decisions with small probabilities, as shown in Lichtenstein, et al. [11] and Murata [12].

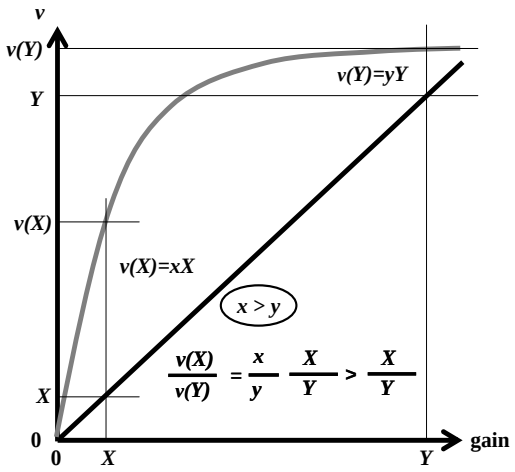

Fig. 3 Relationship between gain and value function v in more generalized Problem 1* in the gain domain. Here, $Y>>X$ (Y is much larger than X), and $x>y$. A concave function v is assumed in the gain domain

On average, the shift from (B) to (A) occurred when the p-value increased from 0.1% to 9.1%. The expected value of the risk-seeking alternative corresponded to about \$455 (\$5,000 × 0.091), and is by far larger than the \$5-for-sure gain. If one judges rationally, one should shift from (B) to (A) at the moment (p=0.5%) the expected value of (A) gets larger than that of (B) (=\$5). This also means that the participants do not necessarily judge rationally on the basis of the mathematical expected value and make decision using the calculated expected value. The irrational change of risk attitude lies in this result. This situation can be expressed in the following:

$$\pi(0.091)v(5000) > v(5) \tag{9}$$

The p-value (9.1%) was about 91 times the initial p-value of 0.1%. Even in this case, it was difficult to identify the exact shape of the probability weighting function. When the values of p were smaller than 9.1%, it could be said that the probability weighting function was smaller than 0.1%. When the value of p was equal to 9.1%, the probability weighting function got larger than 0.1% (0.001) on the basis of Eq. (9). Due to this, the reversal of choice from (B) to (A) must occur. Although the change of p from 8% to 9.1% was slight, such a slight increase induced the change of risk attitude.

Next, the p-value when the choice shifted from (A) to (B) and from (B) to (A) in the loss domain was investigated. On average, the shift from choice (A) to choice (B) occurred when the p-value increased from 0.1% to 2.79%. The expected value of the risk-seeking alternative corresponded to about -\$139.5 (-\$5000 × 0.0279 = -\$139.5), and was by far smaller than the \$5-for-sure loss. If one judges rationally, one should shift from (A) to (B) at the moment (p=0.05%) the absolute value of expected value of (A) gets larger than that of (B) (=\$5). The participants did not necessarily judge rationally on the basis of the mathematical expected value and made decisions using the calculated expected value. If the participants made rational decisions, they would have changed their attitude to the risk-aversion one for a smaller p-value than this. The irrational change of risk attitude was observed in this result. This situation can be expressed as follows.

$$\pi(0.0279)v(-5000) < v(-5) \tag{10}$$

The p-value (2.79%) was about 27.9 times the initial p-value of 0.1%. When the values of p were smaller than 2.79%, the probability weighting function was larger than 0.001 (0.1%). When the value of p was equal to 2.79%, the probability weighting function got smaller than 0.001 on the basis of Eq. (10). Due to this, the reversal of choice from (A) to (B) occurred. Although the change of p from 2% to 2.79% was very slight, such a slight increase induced the change of risk attitude. Ninety-one times the initial p (=0.001) was necessary to change the decision from (A) to (B) in the gain domain, while 27.9 times the initial p was necessary in the loss domain. This difference was indicative of the loss aversive property in the loss domain. Due to the loss aversive property, the change of the decision from (A) to (B) occurred for the smaller change from the initial value of 0.001 (0.1%).

On average, the shift from choice (B) to choice (A) occurred when the p-value decreased from 0.1% to 0.008%. The expected value of the risk-seeking alternative corresponded to about -\$0.4 (-\$5000 × 0.00008 = -\$0.4), and was by far larger than the \$5-for-sure loss. If the participants tended to make decisions rationally on the basis of the calculated expected value, they would have changed their attitude to the risk-seeking one for a larger value of p than this. Simply put, if one judges

rationally, one should shift from (B) to (A) at the moment (p=0.09%) the expected value of (A) gets smaller than that of (B) (=$5). This situation can be expressed as follows.

$$\pi(0.00008)v(-5000) > v(-5) \tag{11}$$

The p-value (0.008%) was about 1/12.5 of the initial p-value of 0.1%. When the value of p is larger than 0.008%, it can be judged that the probability weighting function is smaller than 0.001 (0.1%) on the basis of Eq. (11), and the sure loss of $5 should be chosen. When the value of p is equal to 0.008%, it is expected that the probability weighting function gets larger than 0.001 (0.1%) on the basis of Eq. (11). This must be one cause of the reversal of choice from (B) (sure loss) to (A). A slight decrease of p from 0.0001 to 0.00008 induced the change of risk attitude.

As a whole, the results showed that the change of risk attitude from risk-aversion to risk-seeking or from risk-seeking to risk-aversion was carried out on the basis of the irrational decision.

When p must be decreased from the initial value (p=0.1%) to change a risk attitude from (A) to (B) in the gain domain, or from (B) to (A) in the loss domain, a larger amount of change of p is necessary in the loss domain. When p must be increased from the initial value (p=0.1%) to change a risk attitude from (B) to (A) in the gain domain, or from (A) to (B) in the loss domain, a larger amount of change of p is necessary in the gain domain. In such a way, the amount of change (increment or decrement) of p-value necessary to change the risk attitude (from risk aversion to risk seeking and vice versa) characteristically differed between the gain and the loss domains.

Comparing the shifts from (B) to (A) and from (A) to (B) in Fig. 4, it is clear that smaller changes of p-value from the initial value (=0.1%) induced the shift from (A) to (B) in both the gain and loss domains, and larger changes of p-value were necessary to change the choice from (B) to (A) in both the gain and loss domains. As hypothesized, the amount of change of p-value necessary for changing the risk attitude from risk-aversion to risk-seeking was larger than that for changing the risk attitude from risk-seeking to risk-aversion. When the shift from (A) to (B) in both gain and loss domains occurred, the participants displayed risk-aversion behaviour, and consequently, the smaller change of p-value from the initial value was enough to induce the shift from (A) to (B). The shift from (A) to (B) corresponded to the following cases: in the gain domain, one changed one's attitude from a lottery buyer to a sure winner of a smaller amount sooner due to risk-aversion property; in the loss domain, one changed one's attitude from risk-seeking gambling behaviour to an acceptance of sure loss like an insurance premium sooner. On the other hand, in order to change one's attitude from (B) (sure gain or loss) to (A) (lottery buyer in the gain domain or risk-seeking gambling in the loss domain), larger changes of p-value from the initial value are necessary. In other words, larger changes of p were necessary for inducing risk-seeking decisions in both the gain and loss domains. The shift from (B) to (A) included the following cases: in the gain domain, one did not change one's attitude from a sure winner of a small amount to a lottery buyer if the value of p did not change to a larger amount; in the loss domain, one did not change one's attitude from an acceptance of sure loss like an insurance premium to risk-seeking gambling behaviour if the value of p did not change to a larger amount.

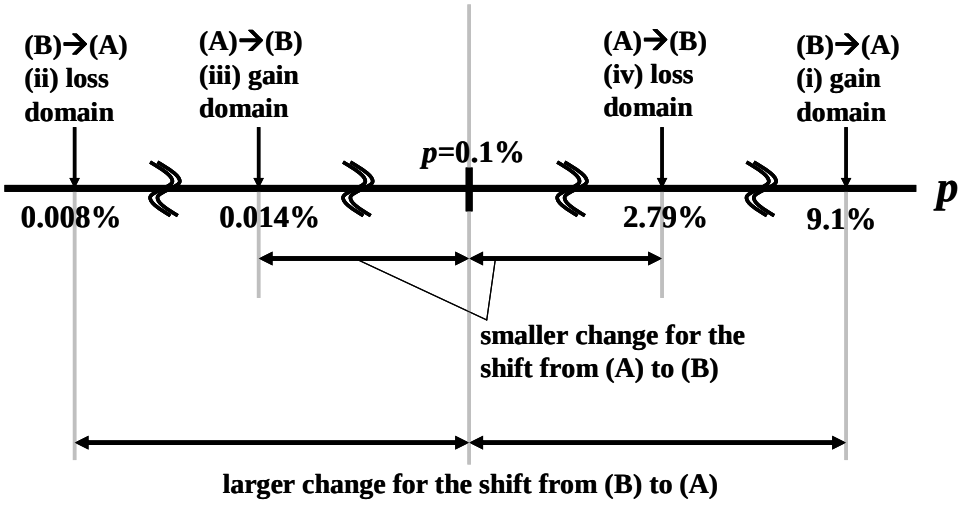

Fig. 4 Comparison of the values of p between the shift from (A) to (B) and the shift from (B) to (A)

V. CONCLUSIONS

This study investigated the irrationality in decision-making on risk attitude. The readiness of reflection effect in such decision-making was compared between two conditions (the change from risk-seeking choice to risk-aversion choice and vice versa). Second, the p-value (probability of gain or loss) that led to the reversal of choice (change of risk attitude) was identified and compared between the gain and loss domains.

On the basis of the experimental results, it was discussed how decision-making on choosing one of the two prospects (A) ($Y, p) or (B) ($X, 1) should be systematically treated in order to generalize the irrational change of risk attitude under the condition of a smaller p and $Y>>X$. Moreover, it was also showed that the derivation of the property of probability weighting function $\pi(p)>p$ in prospect theory using a simple demonstrative decision-making paradigm outlined in Kahneman and Tversky [4] cannot be generalized and is not appropriate for verifying and deriving this property.

In such a way, the irrational property of the participants in decision-making on risk attitude was examined. The results can be summarized as follow.

(1) Due to the risk-aversion property, the reflection effect from the risk-seeking choice to the risk-aversion choice readily occurred when the occurrence probability of the larger gain was low. In the gain domain under smaller p with the same expected value, some were risk-seeking (lottery buyers), and others were risk-aversion (persons who chose a sure thing).

(2) Due to the risk-aversion property, the reflection effect from the risk-aversion choice to the risk-seeking choice was unlikely and didn't readily occur. In the loss domain under smaller p with the same expected value, the majority tended to show risk-aversion behaviour (insurance subscribers).

(3) As a result of identifying the condition of p under which the reversal of choice occurred for both gain and loss domains, the value of p differed between the gain and the loss domains, and between the increment and the decrement of p. More specifically, characters of 21 participants were revealed; decisions changed from (A) to (B) at 0.014% and from (B) to (A) at 9.1% in Problem 2; from (A) to (B) at 2.79% and from (B) to (A) at 0.008% in Problem 4.

(4) Due to the risk-aversion property, the amount of change of p-value necessary for changing the risk attitude from risk-aversion to risk-seeking was larger than that for changing the risk attitude from risk-seeking to risk-aversion.

(5) It was shown that the relationship between the gain or loss $Y for the risk-seeking choice, the corresponding p-value (the probability of gain or loss $Y), and the gain or loss $X for the sure thing must be further investigated to generalize the property $\pi(p)>p$ under a smaller value of p and $Y>>X$. Only Eqs. (2) and (4) above were insufficient for the generalization of characteristics of the weighting function $\delta(p)>p$. It is generally known that inequality $\delta(p) < p$ holds in a wide range of p, especially for larger values of p. Because decisions are occasionally irrational, decision weight (probability weighting function) $\delta(p)$ is applicable for the interpretation of some extremities, such as common ratio effect and common consequence effect. Belief, experience, preference, and so on are simply considered to be more dominant in such an extremity under $p<0.001$ and $Y>>X$ with the same expected value.

For the systematic generalization of the change of risk attitude, the detailed exploration of the characteristics of the following more general prospects must be conducted in future work:

Prospect (A) ($Y, p)

Prospect (B) ($X, 1)

where p is a smaller probability, and $Y>>X$. The results of this study were limited to the population of young adults. Future research should explore whether the results differ among different age groups other than young male adults.

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