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Disposition Effect and Loss Aversion: An Analysis Based on a Simulated Experimental Stock Market

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Disposition Effect and Loss Aversion: An Analysis Based on a Simulated Experimental Stock Market*

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Abstract

We experimentally investigate the existence of and possible origin of the disposition effect. Our approach has three distinct characteristics: Firstly, we created an experimental environment that closely mimics a real stock market and were thus able to obtain and analyze trading behavior data that accurately depicts actual individual investor trading behavior. Secondly, based on a questionnaire survey we conducted during the experiment, we were able to pinpoint each individual participant's reference point. This, in effect, allowed us to verify an independent hypothesis of the existence of the disposition effect – such an approach differs from the extant literature, where only a joint hypothesis has been examined so far. Thirdly, we measured individual loss aversion coefficients and directly tested whether loss aversion is a cause of the disposition effect. Our results indicate both the existence of the disposition effect as well as prospect theory's loss aversion being one of its sources.

JEL classification codes: G02
Keywords: disposition effect, loss aversion, investor behavior, experimental economics

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1. Introduction

The purpose of this paper is to examine the existence and causes of the disposition effect. Empirical evidence points to the fact that individual investors exhibit a tendency to hold on to losing stocks for too long, thereby incurring excessive negative returns. While numerous informal "advice on investing" books have been written on how to avoid the trap of being unable to cut one's losses early, careful scientific studies are called for since casual observations often suffer from representative biases. We attempt in this paper a careful examination of the disposition effect aiming to shed some light on whether it really is difficult to sell stocks trading on a loss and if so, what are the underlying processes behind it.

There are two basic strands of extant research on this topic. The first one entails empirical investigations of real world financial transaction data, while the second consists of laboratory experiments. Papers in the first strand analyze data from various security markets around the world. Some representative empirical work, all of which confirms the existence of the disposition effect, includes: Odean (1998) – USA stock market; Grinblatt and Keloharju (2001) – Finnish stock market; Coval and Shumway (2005) – The Chicago Board of Trade; Shumway and Wu (2006) – Shanghai stock market; Fogel and Berry (2006) – 176 members of the American Association of Individual Investors; Misumi at al. (2007) – Tokyo Stock Exchange; Choe and Eom (2009) – South Korean futures index market.[1] As far as the second type of literature is concerned, the disposition effect has also been obtained in laboratory experiments conducted on a range of subjects in diverse locations, including: Weber and Camerer (1998) – university students in Germany; Chui (2001) – university students in Macau; Kirchler et al.

[1] Choe and Eom (2009) find in addition that individual investors are much more susceptible to the disposition effect than institutional and foreign investors.

(2005) – university students in Vienna; Rubaltelli et al. (2005) – university students in Italy; Vlcek and Wang (2007) – university students in Switzerland; Shiroshita (2009) – university students in Japan.

Empirical data analyses of the disposition effect are valuable in that they directly test for its existence in real world financial markets. Experimental research on the other hand, while it cannot discard the possibility that a "disposition effect" discovered in the laboratory is in fact distinct from its real world counterpart, has the undisputed merit of allowing for a strict control over and accurate design of the environment stocks are traded in. On top of that, individual investor information that is vitally important yet difficult or impossible to obtain in empirical studies can be acquired relatively easy in experimental settings. In our case, this type of information takes the form of individual-specific reference points, degree of loss aversion, and personal and demographic attributes of our experiment subjects. As such, economic experiments, besides offering another avenue to test for its existence, permit also the opportunity to seek for potential causes of the disposition effect.

There exists a multitude of candidate explanations for the apparent prevalence of the disposition effect. Below we enumerate and briefly describe the most salient of those.

(1) The shape of the value function from Kahneman and Tversky's (1979) prospect theory, which implies risk aversion in the domain of gains and risk seeking in the domain of losses. In this paper, we refer to this phenomenon simply as "loss aversion".[2]

(2) Belief in reversion to the mean: If investors believe that stocks trading at a loss will rebound in the future with high probability, holding on to such stocks might be optimal.

[2] While it is common in the literature to refer to "loss aversion" as the disproportionately amplified effect losses, as opposed to gains, have on utility levels, in this paper we use the term "loss aversion" to represent a general tendency to avoid the realization of losses.

(3) Portfolio rebalancing: Investors might wish to maintain a constant proportion of certain stocks in terms of cash value in their portfolios. This would lead them to rationally hold on to or even buy more of the losing stocks.

(4) Transaction costs: All other things equal, selling out losing stocks entails higher per-unit transaction costs. This, in turn, implies that holding on to them is the smart thing to do.

(5) Psychologically-motivated reasons, such as mental accounting, regret aversion, and self-control (Shefrin and Statman (1985)).

(6) Taxation system: Although early research on the disposition effect (Shefrin and Statman (1985), Lakonishok and Smidt (1986), Odean (1998)), following Constantinides' (1984) exposition of a rational loss realization model, pointed to tax-related issues as one of its possible causes, tax exemption rules associated with capital losses imply behavior that would result in an alleviation of any disposition effect-type of behavior.

Odean (1998) conjectured that loss aversion might bring about the disposition effect and, proving its existence in a large data sample at the same time eliminated other factors as its possible sources. In particular, Odean's (1998) results do not support the trading costs hypothesis, which is shown to be inconsistent with the disposition effect: investors in his sample sell winners more frequently than they sell losers regardless of transaction costs. Also, by eliminating from his analyses trades that may be motivated by a desire to rebalance, he effectively controlled for portfolio rebalancing. Odean (1998), while initially reluctant to reject belief in mean reversion as a potential cause of the disposition effect refers later on to his complementary analysis based on the same data sample (Odean (1999)). Therein he finds those same investors tend to buy stocks that have outperformed the market in the past, whereas a belief in mean reversion implies precisely the opposite.

Weber and Camerer (1998) use an experimental setup and find their participants to be significantly more inclined to buy stocks trading at a loss as opposed to those trading at a gain. They attribute these findings to reversion to the mean, or, more generally, to misperception of stochastic processes.

It has been widely believed that concavity of prospect theory's value function in the domain of losses accounts for the disposition effect. This belief, however, has in turn come to be questioned recently. Kaustia (2010) parameterizes cumulative prospect theory's S-shaped value function (Tversky and Kahneman (1992)) to show that propensity to sell is highest at reference point (buying price) and declines when either gain or loss becomes larger. Strangely enough the model predicts that holding any stocks is more beneficial than selling in most of the cases. On the other hand, he finds empirically using Finnish transaction data that the propensity to sell a stock does not decline as gains or losses increase but rather it is increasing or constant in the domain of gains and insensitive to returns in the domain of losses. In other words, there is a discontinuity (a "jump") in the investors' attitudes towards selling exactly at the point where capital gains are zero. Given these evidences, he concludes that the S-shaped value function cannot predict the pattern of realized returns found in the data and hence that the disposition effect is unlikely to be driven by preferences dictated by prospect theory.

Barberis and Xiong (2009) study theoretically the trading behavior of an investor with prospect theory preferences and conclude that for a significant range of parameter values, the prospect theory predicts that investors will be more inclined to sell stocks with prior *annual* losses than stocks with prior *annual* gains – exactly the opposite to what the disposition effect leads to.[3] However, when prospect theory is defined over *realized* gains and losses then the theory indeed does predict a disposition effect, although not for all values of the parameters; for some values, the opposite prediction still materializes.

In view of these recent results, the question of what type or shape of the value function (if any, indeed) is consistent with the disposition effect remains an open one, at least for now. In fact, a more general and more important question of whether prospect theory preferences may lead to the disposition effect is left unresolved, as well. This paper is an attempt at a resolution of these questions.

Our approach employs the following three distinct characteristics. Firstly, we use data generated through an experiment designed to mimic as closely as possible a real world security market – our data is thus very similar to real stock market data. Specifically, the simulated market in our experiment lasts four weeks and is open four and a half hours each trading day – exactly like the Tokyo Stock Exchange. However, our market is open in the evening hours to facilitate frequent trading. We use real world past price data for 10 stocks from the TSE edited from tick data so that the prices are updated every two minutes.[4] Participants in our experimental market can trade at any time the market remains open. Remuneration from participation in the experiment is proportional to the earnings (or losses) they acquire through trading. Thus we may assert that any results obtained through the experiment mimic closely those of a real world stock market.

The second characteristic lies in the directness of our method to test the hypothesis of whether loss aversion leads to the disposition effect. We assess whether the degree to which

[3] Hens and Vlcek (2011) derive an analogical result.
[4] This method guarantees that subjects of the experiment will be able to trade at the price they desire to.

subjects are prone to exhibit loss aversion predicts the strength of the disposition effect. To this end, we perform supplemental experiments measuring our subjects' degrees of risk aversion in both domains of gain and losses. This method allows a more general inquiry into the potential causality relation between loss aversion and the disposition effect and thus an improvement over previous studies by Kaustia (2010) or Barberis and Xiong (2009) who resort to rather strict assumptions based on a particular form of the value function.

The third characteristic is linked to Odean's (1998) observation that testing for the disposition effect is equivalent to testing the joint hypothesis for the disposition effect and for the reference point. Assuming a particular value for the reference price – e.g. first purchase price, last purchase price, weighted average purchase price, etc. – has been the standard practice used in empirical research on the disposition effect. This practice does constitute a type of robustness check of the results obtained, but it ignores the possibility of heterogeneity in reference points across investors. To address this problem, using a questionnaire survey we solicit individual participants' reference points and use obtained values when calculating gains and losses. In effect, our method constitutes an independent test for the disposition effect, not merely a test for the joint hypothesis.

Our analyses, employing the characteristics spelled out above, clearly confirm existence of the disposition effect and point to loss aversion as being one of its causes.

The rest of this paper is arranged as follows. In the next section we describe the experimental design and methods. In Section 3, we explain techniques used to analyze the data. In Section 4 we report main results and robustness checks involving subjects' personal attributes as well as verify that our results remain unaffected when alternative values are substituted for individual reference points. We wrap up with conclusions in Section 5.

2. Experimental Design and Procedures

Our design contains the main "Stock Trading" experiment, where participants buy and sell shares in a simulated security market, and the supplemental "Insurance Buying" and "Lottery Selling", where we measure participants' risk aversion in the respective domains of losses and gains.

2.1. Stock Trading Experiment

2.1.1. Outline of the Experiment

The "Stock Trading" experiment requires its participants, each afforded with an initial endowment of shares and virtual cash, to buy and sell shares of 10 companies in a simulated stock market accessed through the internet. The market lasts for four weeks and is open for four hours and thirty minutes every day from 18:00 through 22:36 (with a six minutes break from 20:00 to 20:06).[5]

The stock price data we use is authentic middle price tick data from the past edited so that it is updated every two minutes.[6] In this way, we avoid any possible negative auto-correlation issues resulting from the bid-ask spread we might have otherwise encountered if we had used

[5] The six minutes break replicates lunchtime break from 11:00 through 12:30 instituted in the Tokyo Stock Exchange.

[6] Specifically, we randomly selected ten high-liquidity stocks traded on the Tokyo Stock Exchange and for each extracted 33 days worth of tick data from "Nikkei Tick Data". We subsequently created for each of the ten stocks a vector of mid-quotes corresponding to those observed at the mid-quotes of 2-minute intervals in the original data file and used morning period mid-quote data for the 18:00 through 20:00 experiment trading period, and afternoon mid-quote data for the 20:06 through 22:36 trading period. On top of that we performed a simple linear transformation on the data to preclude any possibility of identification of actual stocks by the participants.

actual execution prices. Subjects in our experiment are guaranteed that their trades are going to be carried out exactly at prices shown on their monitors and that those prices are not in any way affected by their own nor by other subjects' quantities demanded and quantities supplied.[7] Short-selling and negative cash positions are not allowed.

The initial endowment of each participant consists of 10 shares of each of the ten stocks and a cash allotment of 10,000,000p ("points"). Participants have access to a transaction panel (Figure 1) through which they get information on the present composition of their portfolios, stock prices and cash holdings. The panel also allows them to order buy and sell trades, which are immediately executed: for instance, by changing the number of shares in the "After Transaction" column and clicking on "Execute Trade", a corresponding order is completed. Traders in our experiment also have access to graphs representing both the paths of past prices (closing quotes) until the present day and that day's price paths, starting from the opening bell until the present time.[8] There are no dividends or transaction costs, nor are there any taxes. This differs from real world markets but confers the merit of excluding from analysis the above-mentioned factors as possible explanations for the disposition effect.

2.1.2. Compensation Structure

Participants receive three types of compensation. The first type depends on the number of days they logged on to the experiment homepage throughout its duration. In addition to ¥30 for each day one logged on, subjects are entitled to receive a bonus payment of a few thousand yen if

[7] Consequently, experiment participants emulate small individual investors facing a highly liquid market.
[8] On the first day of the experiment, data from preceding five trading days is made available.

they accessed the system on at least 18 days.[9] The second type of compensation is commensurate with the final portfolio return – for each 1% of the return rate, ¥180 are awarded. In case of negative returns, resulting losses are subtracted from bonus payment awarded for regular logging on to the experiment homepage described above.[10] The third payment type is a ¥30,000 "winner prize" awarded to the participant whose final holdings after the experiment has ended were the highest.

2.1.3. Basic Experiment Data

Participants were recruited (with the assistance of an internet research company) from among individual investors with previous stock trading experience, defined as having recent history of trading at least once per month on the stock market. The average age was 41.94 years (SD=10.74; For males 41.03, SD＝10.98, for females 44.38, SD=10.06). Attributes of the experiment participants are summarized in Table 1. The most numerous age groups were people in their 30s, followed by 40s, with fewer representatives of 60s and 70s. Employment income earners comprised about half of the pool of subjects. Four of the male participants were business owners. Household income ranged from 3 million yen to 15 million yen levels. Finally, subjects reported real-world markets trading frequency was most commonly "roughly once a week" or "almost daily", either type of responses accounting for over 30% of total.

On January 24th 2010, subjects were gathered together at a computer laboratory on Osaka University campus and explained thoroughly the experiment. On the same day, the supplemental

[9] These bonus payments are: ¥1,800 for logging on between 18 and 22 days, ¥2,600 for logging on between 23 and 27 days, and ¥3,600 for logging on 28 days (every day of the experiment).

[10] Should the resulting yen amount be negative, a concerned subject was to receive ¥0. However, there were no relevant cases.

risk aversion estimation experiments elaborated on below and questionnaire survey designed to elicit reference points were conducted. From Monday January 25th 2010 through Sunday February 21st 2010, every evening between the hours 18:00 and 22:36 the simulated stock market was open for trading.

2.2. Loss Aversion Measurement Experiment

The measurements of individual loss aversion levels were carried out by means of two simple experiments. The “Insurance Buying Experiment” was implemented to estimate individual risk aversion levels in the loss domain. The “Lottery Selling Experiment” was implemented to estimate risk aversion levels in the gain domain. Both were conducted on Sunday January 24th 2010 – on the same day participants were gathered and explained experiment procedures.

2.2.1. Insurance Buying Experiment

In this experiment, a subject is asked whether they are willing to purchase insurance at various prices displayed on the monitor. Given an initial endowment of assets, the insurance – if purchased – guarantees a payment equivalent to the value of assets in case these are lost or damaged. This design in effect allows the experimenters to estimate the degree of participants’ loss aversion.

The details of the experiment are as follows. A subject is first presented with an initial endowment of ¥2,000. Then, an amount of potential damage and the probability its occurrence are displayed along with a proposed insurance premium. The subject chooses whether to purchase the insurance or to decline it. There are four categories of potential damage (¥100,

¥400, ¥1200, ¥2000) with the probability of their occurrence set constant at 50%. The insurance premiums (along with corresponding premium rates, equal to the premium sum divided by the damage total) are displayed in random order. An example screenshot is illustrated in Figure 2. This procedure is repeated 30 times in a row for each category applicable to the four potential damage totals, starting from the lowest ¥100.

Thus, each subject goes through 120 yes-or-no queries. After that, the computer randomly chooses one of the 120 queries, which is then used to determine payments for this experiment.[11]

2.2.2. Lottery Selling Experiment

Individual levels of risk aversion were estimated via the "Lottery Selling Experiment". In it, the subjects are asked whether they are willing to sell at a proposed price a lottery ticket, which has a 50% chance of winning a prize. The prize falls into one of four categories: ¥100, ¥400, ¥1200, ¥2000. A participant's task is to answer "yes" or "no" to 30 choice problems for each of the four categories. The procedures as well as settlement of payments are analogous to those employed in the "Insurance Buying Experiment".[12]

2.3. Questionnaire Survey

The survey was conducted mainly to find out reference prices, but we also included in the

[11] If a subject had in fact purchased insurance for the randomly chosen query, they were given the option to avert any potential damage by actually paying the premium. In the reverse case when they had not purchased the insurance, the subject had to pay the amount of damage (in case it occurred), which was subtracted from their initial endowment. The endowment was left intact whenever no damage actually occurred. Whether the damage in fact occurred or not was selected randomly by the computer with independent probability of 50%.

[12] Out of 120 choice sub-tasks, one was selected randomly by the computer. Had the subject chosen to sell the lottery ticket in that sub-task, they received an amount of money specified therein. In the opposite case – when the subject had chosen to not sell – the computer drew the lottery and payments were decided depending upon whether a winning ticket or a losing ticket was drawn. In the former case the subject was paid the prize, whilst in the latter they received nothing.

questionnaire items regarding subjects' preferences and demographic attributes. Here, we constrain ourselves to the description of our main purpose – identification of individual reference points.

In the questionnaire, hypothetical stock prices paths for two cases – a rising price path and a declining one – spanning 6 discrete periods are presented. For each respective point in time, hypothetical buy and sell transactions along with resulting positions in the stock in question are shown. Furthermore, a 7th period price is shown along with 8 different ways to calculate paper gains and paper losses for the relevant stock. Subjects are then requested to choose a method of calculation closest to their own.[13] The available choices for a reference point are: (1) the first purchase price; (2) FIFO: first-in, first-out; (3) the last purchase price; (4) LIFO: last-in, first-out; (5) the highest purchase price; (6) the lowest purchase price; (7) weighted average purchase price; (8) weighted average purchase price minus average profit/loss for the portion of shares sold in the interim time.

3. Analysis Method

3.1. Estimating the Degree of Risk Aversion

We restrict our explanation here to the case of Insurance Buying Experiment, wherein we used computational methods exactly analogical to those used in the Lottery Buying Experiment.

First we compute for all experiment participants their individual insurance values. When specific insurance policies are ordered starting from the cheapest one going in value up to the most expensive one, we would expect to observe any given subject to first choose "buy" for a

[13] There is also an additional item corresponding to a "none of the above" option, where a subject is asked to describe in detail their method of calculation.

few times, at some point switch to "sell", then continue to choose "sell" for the remaining cases. We define the "individual insurance value" as the midpoint between the two values between which said switch occurs. It is however conceivable, and indeed turns out to be the case that, some subjects choose to switch multiple times. In these cases, we estimate a LOGIT regression model for the 30 proposed insurance prices where we assign a "1" to each "buy" decision and a "0" to each "do not buy" decision. The individual insurance value is then defined as the one corresponding to 0.5 in the regression.

Absolute risk aversion (ARA) coefficient for the *i*th subject is defined and calculated according to the following formula due to Cramer et al. (2002).

$$ARA_i = \frac{az - p_i}{\frac{1}{2} \times (az^2 - 2ap_i z + p_i^2)} \tag{1}$$

Here, a is the probability of winning equal to 0.5, z is the damage amount, and p_i is the "individual insurance value". As there are four different z values, we take an arithmetic average of those to get the final ARA coefficient values.[14]

3.2. The Estimation Model

Estimation of the disposition effect and its potential relationship with loss aversion is performed with a LOGIT analysis. The dependent variable $SELL_{i,j,t}$ is defined as follows. For each subject i we first look for all instances (measured in two-minute units) any trades were recorded. The subscript t then corresponds to a location of a trade when trades are ordered starting from the first one recorded on. $SELL_{i,j,t}$ is set to 1 whenever a subject i sells a stock j at a time t and to 0 otherwise. The independent variable $LOSS_{i,j,t}$ is set to 1 whenever a stock j in a subject i's

[14] Four subjects in total appeared to either answer Yes/No randomly or reverse the "Yes's" with the "No's". We exclude their data from the regressions.

portfolio is trading at a loss at a time *t*, and to 0 otherwise. The regression model is thus

Model 1 : $$SELL_{i,j,t} = \alpha + \beta_1 \cdot LOSS_{i,j,t} + \varepsilon_{i,j,t}, \quad (2)$$

where α and β_1 are the regression coefficients and $\varepsilon_{i,j,t}$ is the error term. β_1 will be negative if the disposition effect obtains, that is, if the tendency to sell is stronger in the domain of gains than it is in the domain of losses.

Next, we test for loss aversion as a possible cause of the disposition effect. It is plausible that as the degree of loss aversion increases, disposition effect becomes stronger. The absolute value of coefficient β_1 from equation (2) in this case increases with the degree of loss aversion *LA*. The regression model in this case is thus

Model 2 : $$SELL_{i,j,t} = \alpha + (\beta_{11} + \beta_{12} \cdot LA_i) \cdot LOSS_{i,j,t} + \varepsilon_{i,j,t}$$

$$= \alpha + \beta_{11} \cdot LOSS_{i,j,t} + \beta_{12} \cdot LA_i \cdot LOSS_{i,j,t} + \varepsilon_{i,j,t}. \quad (3)$$

We expect β_{12} to be negative if indeed loss aversion is a cause of the disposition effect. We use here two variables to represent loss aversion. The first one *LA*1 is the degree of risk tolerance (the negative of risk aversion) in the domain of losses, which corresponds to a measure of convexity of the value function. The second one *LA*2 is the risk tolerance degree in the domain of losses relative to its counterpart in the domain of gains, defined as risk aversion coefficient in the domain of gains minus risk aversion coefficient in the domain of losses. This second relative measure of loss aversion might be a more appropriate one given that the disposition effect itself is in its nature a relative measure of the extent to which winners are more likely to be sold than losers.

4. Results

4.1. Reference Points

We use each experiment participant's individual reference point estimated from the questionnaire survey data outlined above. Table 2 summarizes our findings on the reference points: calculated reference points for the domain of gains are in rows, while those for the domain of losses in columns. For instance, the "1" in the left-uppermost cell of the table indicates that one person chose the first purchase price for both the gain and the loss domains. Thus we find most of subjects choosing a weighted average of the purchase prices for their reference points, many of them profits for the portion of shares sold in the interim. We note that most of respondents selected the same reference points for both the loss and the gain domains.

4.2. Results of the Stock Trading Experiment

Throughout 28 days of the experiment and across 49 participants we recorded a total of 3527 sell transactions and 4005 buy transactions – about 153 trades per subject, roughly 5.5 trades per subject per day. Out of the 10 stocks trades, the most frequently bought and sold one was traded 1639 times, the least popular one 430 times, whilst the corresponding figures for remaining eights stocks were between 527 and 839. We observe thus an overall abundance of trading activity, with one stock out-topping all the others in popularity. Out of all sell orders, 1620 (45.9%) were profitable while 1357 (38.5%) were accompanied by losses. The remaining 550 (15.6%) trades were zero-profit transactions. For the case of buy orders, 622 (15.58%) additional purchases were recorded in the gain domain, 1108 (27.7%) additional purchases in the loss domain, while 2275 (56.8%) additional purchases were recorded on zero-profit accounts.

Final asset value scores, when compared with the initial benchmark of 10,000,000 points, averaged an approximate 70,000 point loss (SD=34,000), with the highest scoring subject winning a profit of some 80,000 points and the biggest loser incurring some 88,000 points in losses.

4.3. Results of the Loss Aversion Measurement Experiment

The average absolute risk aversion coefficient across all subjects was –0.0014 in the Lottery Selling Experiment, –0.0031 in the Insurance Buying Experiment. The apparent risk loving attitudes in the domain of gains is perhaps a byproduct of the relatively small stakes used in the simple lottery tasks we employed to estimate loss aversion attitudes.

When we subtract the risk tolerance coefficient measured in the Lottery Selling Experiment from the one measured in the Insurance Buying Experiment, we obtain 0.00168, which is significant at a 5% level. We conclude therefore that our subjects exhibit more risk-seeking behavior in the domain of losses as opposed to the domain of gains.

4.4. Incidence of the Disposition Effect – LOGIT Regressions

The summary of LOGIT analysis using individual-specific reference points determined through a questionnaire survey is presented in Table 3. The first panel reports pooled results for all ten stocks. The "Model 1" section reports estimation results for formula (1). The coefficient for the loser-stocks variable $LOSS$ is significantly negative at 1% revealing a tendency to avoid the realization of losses. The "Model 2 (1)" section adds the $LA1 \cdot LOSS$ as an explanatory variable to the regression. Again, the $LOSS$ coefficient is negative at a 1% significance level. Together with "Model 1", this implies reluctance on the part of subjects to get rid of losing stocks and thereby the existence of disposition effect. Furthermore, the coefficient for the $LA1 \cdot LOSS$ variable is also significantly negative at a 1% level. Also for the alternative measure of loss aversion used in "Model 2 (2)", the coefficient of interest is negative and statistically significant at a 1% level. These results support the hypothesis that loss aversion is a cause of the disposition effect: The higher the degree of loss aversion, the more reluctant investors are to sell losing stocks.

With the exception of stock #8, we obtain analogical statistically significant results for the *LOSS* coefficients when we perform the regressions for individual stocks (not reported here). As for its interaction term with the loss aversion variable *LA1*, the coefficients are negative except for stock #8 and significantly negative except for stocks #8, #1 and #5. When *LA2* is substituted for the loss aversion variable, the interaction term coefficients are negative except for stock #9 and significantly negative except for stocks #3 and #9. Hence we conclude that for most of the cases our results are consistent with the disposition effect hypothesis and that loss aversion is one of its sources. In other words, these outcomes are not driven by any one of the stocks in subjects' portfolios but are a prevalent tendency evident throughout the entire stock spectrum.

4.5. Participants' Demographic and Personal Attributes

In this section we check whether results reported in the previous section are replicated when we take into account experiment participants' individual demographic and personal traits. The particular attributes we include in our analyses are gender, age, household income, and stock trading experience.

Table 4 summarizes the results. In a nutshell: (1) The disposition effect obtains even when individual attributes are accounted for; (2) The cross-term coefficients for the losing stocks term *LOSS* and both loss aversion terms *LA1* and *LA2* are negative and statistically significant. Clearly, higher loss aversion produces a more pronounced disposition effect.

A look at the control variables tells us that women are less prone to selling. Also, propensity to sell grows stronger with both age and income, albeit in a diminishing manner. Finally, those with more real-world trading experience tend to sell stocks more frequently.

4.6. Alternative Reference Points

In the analyses reported thus far we used individual-specific reference points elicited from the experiment participants through a carefully tailored questionnaire survey. It is prudent therefore to verify whether obtained results are not changed when other, arbitrarily chosen reference prices are employed. For completeness, we performed this verification exercise for all subjects for each of the eight reference points specified above in Section 2.3, for both "Model 1" and "Model 2". The findings do not differ much from the main results reported above. In Table 5 we show the estimation results for two out of eight reference prices – average purchase price WAPP1 and first-bought first-sold FIFO. These findings corroborate previous empirical studies that report robustness of the disposition effect with respect to a variety of assumptions on reference points.

5. Conclusions

The economic experiment reported in this paper adds to a substantial body of work on the existence of disposition effect and potential causes thereof. While numerous experimental works do exist on the topic, the distinguishing feature of our approach is the close similarity of our experimental environment with real-world stock markets. For a span of 28 days, participants of our simulated stock market bought and sold shares in 10 stocks whose prices were taken from actual past market data. Participants' remuneration was commensurate with profits and losses incurred from buying and selling stocks. On top of that, a winner's prize was awarded to the most successful trader. As a result, we acquired ample trading data with a total of 7532 transactions. With all the advantages stemming from similarities of our simulated market with real-world stock exchanges, the fact that it is not one adds to its merits as it allows the experimenters to control for a range of conditions. For instance, absence of taxation and transaction costs eliminates the need to consider their effects. [15]

The largest merit of our experiment lies in the fact that we were able to extract two types of information from the participants. First, we pinpointed each participant's individual reference point using a questionnaire survey we conducted before the experiment. This information is impossible to get in empirical studies and to the best of our knowledge, no previous experimental studies attempted it, either. Accordingly, we succeeded in testing for an independent hypothesis for the existence of disposition effect, and not merely for a joint hypothesis of the disposition effect and a reference point.

Second, we measured participants' risk aversion attitudes in both domains of gains and losses in two supplementary experiments – the "Lottery Selling Experiment" and the "Insurance Buying Experiment" – and used thus obtained results to examine the influence of loss aversion

[15] However, we can eliminate neither portfolio rebalancing nor regression to the mean arguments as potential causes of the disposition effect as we were unable to control for them.

on the disposition effect. Loss aversion is a cause of the disposition effect if the latter becomes stronger whenever either (i) behavior in the domain of losses becomes more risk-seeking, or (ii) behavior in the domain of losses compared to behavior in the domain of gains becomes more risk-seeking.

Our approach has an additional merit over previous studies of being a *direct* examination of loss aversion as a potential cause of the disposition effect. Odean (1998) deduces that loss aversion brings about the disposition effect in an *indirect* manner – he shows by elimination that alternative explanations do not account for the disposition effect.

We demonstrate directly with LOGIT regression analyses that the disposition effect exists and that loss aversion is one of its causes. This result remains valid even when we change the personal reference points to any potential reference point including a weighted average of purchase prices and FIFO.

In a recent study relevant to the present research, Kaustia (2010) reports simulation results that point to a lack of relationship between loss aversion and the disposition effect. His method assumes a particular for of the value function proposed by Tversky and Kahnaman (1992) as well as normally distributed returns in both domains of gains and losses. One might rightly question then whether it is possible to reconcile our results showing that loss aversion is a cause of the disposition effect with Kaustia's (2010) findings. We conjecture though that the two seemingly contradictory findings are not necessarily inconsistent, that being not for reasons related to differences in measurement targets (Kaustia's Finland vs. Japan in our case) or method of investigation (Kaustia's simulation vs. our experiment). Kaustia's stylized analysis relies heavily on three devices: (1) Assuming a particular (albeit typical) form of the value function; (2) Ignoring the probability weighting function; (3) Assuming a specific rate of return distribution for the entire range of gains and losses combined. Contrastingly, we consider a more general issue of whether the degree of loss aversion impacts the disposition effect without resorting to prospect theory-related peculiarities. For an instance, with regard to (1), a rudimentary check for the effects of increased convexity/concavity of the value function is called for. Also, concerning (3), it would be instructive to consider a possibility that an investor trapped in the domain of losses might limit her beliefs about the distribution of future returns to losses.

Another related study by Barberis and Xiong (2009), which also assumes a parameterized Tversky and Kahneman's (1992) value function, reports that resulting behavior should be opposite to predictions of the disposition effect. Barberis and Xiong's (2009) method involves solving a theoretical model and a numerical calibration. Interestingly though, the authors confirm their results become consistent with the disposition effect once value function is redefined over *realized* gains and losses, and not *paper* gains and losses. Since we only consider realized gains and losses in our paper, Barberis and Xiong's (2009) findings are a statement to the consistency of our results with the prospect theory preferences.

These studies point toward a pressing need for further research on the specifications of prospect theory's value function that are consistent with the disposition effect. Our results clearly support value functions based on loss aversion.

References

Barberis, N., and W. Xiong (2009), “What Drives the Disposition Effect? An Analysis of a Long-Standing Preference-Based Explanation,” *Journal of Finance,* 64, pp. 751–784.

Choe, H., and Y. Eom (2009), “The Disposition Effect and Investment Performance in the Futures Market,” *Journal of Futures Markets*, 29, pp. 496-522.

Chui, P. M. W. (2001), “An Experimental Study of the Disposition Effect: Evidence from Macau,” *Journal of Psychology and Financial Markets*, 2, pp. 215–221.

Constantinides, George M., 1984. "Optimal stock trading with personal taxes: Implications for prices and the abnormal January returns," *Journal of Financial Economics*, 13(1), pages 65-89.

Coval, J. D., and T. Shumway (2005), “Do Behavioral Biases Affect Prices?” *Journal of Finance*, 60, pp. 1-34.

Cramer, J.S. Hatog, J. Jonker, N. & Van Praag, C.M. (2002) “Low risk aversion encourages the choice for entrepreneurship: an empirical test of a truism,” *Journal of Economic Behavior & Organization*, 48, 29-36

Fogel S., and T. Berry (2006), “The Disposition Effect and Individual Investor Decisions: The Roles of Regret and Counterfactual Alternatives”, *Journal of Behavioral Finance*, 7(2), 107–116.

Grinblatt, M., and M. Keloharju (2001), “What Makes Investors Trade?” *Journal of Finance*, 56, pp. 589–616.

Hens, T., and M. Vlcek (2011), “Does Prospect Theory Explain the Disposition Effect" *Journal of Behavioral Finance*, 12(3), 141–157.

Kahneman, D., and A. Tversky (1979), “Prospect Theory: An Analysis of Decision under Risk” *Econometrica*, 47, pp. 263–291.

Kaustia, M. (2010), “Prospect Theory and the Disposition Effect,” *Journal of Financial and Quantitative Analysis*, 45, pp. 791-812.

Kirchler, E., B. Maciejovsky, and M. Weber (2005), “Framing Effects, Selective Information, and Market Behavior: An Experimental Analysis,” *Journal of Behavioral Finance*, 6 (2), 90–100.

Lakonishok, J., and S. Smidt (1986), “Volume for Winners and Losers: Taxation and Other Motives for Stock Trading,” *Journal of Finance*, 41, pp. 951–974.

Misumi, T., T. Shumway, and H. Takahashi (2007) “On the Behavior of Investors from a

Behavioral Finance Viewpoint: Evidence from the Trades of Japanese Individual Investors“, mimeo.

Odean, T. (1998), “Are Investors Reluctant to Realize Their Losses?” *Journal of Finance,* 53, pp. 1775–1798.

Odean, T. (1999), “Do Investors Trade Too Much?” *American Economic Review*, 89(5), pp. 1279-1298.

Rubaltelli, E, S. Rubichi, L. Savadori, M. Tedeschi, and Riccardo Ferretti (2005), “Numerical Information Format and Investment Decisions: Implications for the Disposition Effect and the Status Quo Bias,” *The Journal of Behavioral Finance*, 6 (1), 19–26.

Shefrin, H., and M. Statman (1985), “The Disposition to Sell Winners Too Early and Ride Losers Too Long: Theory and Evidence”, *Journal of Finance*, 40, pp. 777–790.

Shiroshita, K., (2009) “Kishitsu-Koka (Disposition Effect),” in Shiroshita, K., and H. Moriyasu eds., *Nihon Kabushiki Shijō no Tōshi Kōdō Bunseki (Analysis of Investment Behavior in Japanese Stock Market)* Chpt. 7, pp. 139-159, Chuokeizai-Sha, (in Japanese).

Shumway, T. and G. Wu (2006) “Does Disposition Drive Momentum?” mimeo.

Tversky, A., and D. Kahneman (1992) “Advances in Prospect Theory: Cumulative Representation of Uncertainty.” *Journal of Risk and Uncertainty*, 5, 297–323.

Vlcek, M., and M. Wang (2007), “The Disposition Effect in the Lab”, Working Paper, University of Zurich.

Weber, M., and C.F. Camerer (1998), “The Disposition Effect in Securities Trading: An Experimental Analysis”, *Journal of Economic Behavior and Organization*, 33, pp. 167–184.

Table 1: Summary of experiment participants' attributes data.

Participants were recruited (with the assistance of an internet research company) from among individual investors with previous stock trading experience, defined as having recent history of trading on the stock market at least once per month.

	Male		Female		Total	
	n	%	n	%	n	%
age_group						
20-29	3	8.60%	1	7.70%	4	8.30%
30-39	16	45.70%	4	30.80%	20	41.70%
40-49	9	25.70%	5	38.50%	14	29.20%
50-59	5	14.30%	1	7.70%	6	12.50%
60-69	0	0.00%	2	15.40%	2	4.20%
70-	2	5.70%	0	0.00%	2	4.20%
Total	35	100.00%	13	100.00%	48	100.00%
JOB						
civil servant	1	2.90%	0	0.00%	1	2.10%
business executive	2	5.70%	1	7.70%	3	6.30%
administrative staff	1	2.90%	0	0.00%	1	2.10%
office staff	2	5.70%	3	23.10%	5	10.40%
technical staff	10	28.60%	0	0.00%	10	20.80%
sales/customer service	4	11.40%	2	15.40%	6	12.50%
other salaried worker	2	5.70%	0	0.00%	2	4.20%
teacher	1	2.90%	0	0.00%	1	2.10%
medical expert	1	2.90%	0	0.00%	1	2.10%
self-employed	4	11.40%	0	0.00%	4	8.30%
other part-time	2	5.70%	0	0.00%	2	4.20%
homemaker	1	2.90%	4	30.80%	5	10.40%
working homemaker	0	0.00%	2	15.40%	2	4.20%
unemployed	1	2.90%	1	7.70%	2	4.20%
other	3	8.60%	0	0.00%	3	6.30%
Total	35	100.00%	13	100.00%	48	100.00%
INCOME_GROUP (unit: 10,000yen)						
<100	1	2.90%	0	0.00%	1	2.10%
100-200	0	0.00%	1	7.70%	1	2.10%
200-300	1	2.90%	0	0.00%	1	2.10%
300-400	3	8.60%	2	15.40%	5	10.40%
400-500	5	14.30%	1	7.70%	6	12.50%
500-600	5	14.30%	3	23.10%	8	16.70%
600-700	5	14.30%	0	0.00%	5	10.40%
700-800	2	5.70%	2	15.40%	4	8.30%
800-900	6	17.10%	0	0.00%	6	12.50%
900-1000	4	11.40%	1	7.70%	5	10.40%
1000-1500	1	2.90%	0	0.00%	1	2.10%
1500-	1	2.90%	3	23.10%	4	8.30%
unknown	1	2.90%	0	0.00%	1	2.10%
Total	35	100.00%	13	100.00%	48	100.00%
FREQ_TRADE (about once in ~)						
a month	9	25.70%	0	0.00%	9	18.80%
half a month	2	5.70%	6	46.20%	8	16.70%
a week	11	31.40%	5	38.50%	16	33.30%
daily	13	37.10%	2	15.40%	15	31.30%
Total	35	100.00%	13	100.00%	48	100.00%

Table 2: Questionnaire Survey of Reference Points – Summary of Results.

This table summarizes the results of a questionnaire survey conducted to elicit individual reference points. It reports the number of subjects corresponding to each combination of reference points. Each row represents a reference point for the domain of gains and each column represents a corresponding reference point for the domain of losses. The labels for each reference point are as follows. FIRST: first purchase price; FIFO: first-in first-out; LAST: last purchase price; LIFO: last-in first-out; HIGH: highest purchase price; LOW: lowest purchase price; WA1: weighted average purchase price; WA2: weighted average purchase price minus average profit/loss for the portion of shares sold in the interim time NULL: no response.

		LOSS									
		FIRST	FIFO	LAST	LIFO	LOW	WA1	WA2	OTHER	NULL	TOTAL
GAIN	FIRST	1									1
	FIFO		2						1		3
	LAST		2	1							3
	LOW					1					1
	WA1			1	1		15	1		1	19
	WA2							21			21
	OTHER						1				1
	TOTAL	1	4	2	1	1	16	22	1	1	49

Table 3: Summary of LOGIT Regressions Using Individual-Specific Reference Points

This table shows regression results for two models – "Model 1" and "Model 2". Data for this analysis consists of trade records for all the stocks in subjects' portfolios. The dependent variable *SELL* takes the value of 1 whenever a sell transaction occurs, and 0 otherwise. The variable *LOSS* is set equal to 1 whenever a stock is trading at a loss and 0 otherwise. Whether the stock in question is actually trading at a loss is determined via a subject-specific reference point elicited through a questionnaire survey. Whenever such determination was not possible, corresponding data was excluded from analysis. Loss aversion coefficients *LA1* and *LA2* used for Model 2 (1) and Model 2 (2) are defined as *LA1 = (–1) * (Degree of Risk Aversion in the Insurance Buying Experiment)* and *LA2 = (–1) * (Degree of Risk Aversion in the Insurance Buying Experiment) – (–1) * (Degree of Risk Aversion in the Lottery Selling Experiment)*, respectively. *** indicates coefficients which are significant at the 1% significance level.

	Model 1			Model 2					
				(1)			(2)		
	coef.	z		coef.	z		coef.	z	
LOSS	-0.75	-19.64	***	-0.53	-10.39	***	-0.55	-13.10	***
LA1・LOSS				-58.27	-6.23	***			
LA2・LOSS							-46.19	-9.13	***
Constant	-1.15	-46.07	***	-1.15	-46.07	***	-1.15	-46.07	***
Pseudo R^2	0.02			0.02			0.03		
Number of Observations	19451			19451			19451		

Marginal Effects									
LOSS	-0.11	-19.91	***	-0.11	-19.60	***	-0.11	-19.53	***
LA1				-3.61	-6.23	***			
LA2							-2.85	-9.11	***

Table 4: Summary of LOGIT Regressions Including Individual Attributes

This table reports results of regressions for "Model 1" and "Model 2" with experiment subjects' personal attributes added as independent variables. The dependent variable *SELL* takes the value of 1 whenever a sell transaction occurs, and 0 otherwise. The variable *LOSS* is set equal to 1 whenever a stock is trading at a loss and 0 otherwise. Whether the stock in question is actually trading at a loss is determined via a subject-specific reference point elicited through a questionnaire survey. Whenever such determination was not possible, corresponding data was excluded from analysis. *FEMALE* is a dummy variable equal to 1 for females and 0 for males, *AGE* is the age variable and *INCOME* is the income variable. *FREQ_TRADE_dummy* is the dummy variable with values assigned according to subjects' real-world market trading experience. Loss aversion coefficients *LA1* and *LA2* used for Model 2 (1) and Model 2 (2) are defined as *LA1 = (–1) * (Degree of Risk Aversion in the Insurance Buying Experiment)* and *LA2 = (–1) * (Degree of Risk Aversion in the Insurance Buying Experiment) – (–1) * (Degree of Risk Aversion in the Lottery Selling Experiment)*, respectively. **, *** indicate coefficients which are significant at the 5% and 1% significance level, respectively.

	Model 1			Model 2					
				(1)			(2)		
	coef.	z		coef.	z		coef.	z	
LOSS	-0.719	-18.30	***	-0.608	-11.28	***	-0.604	-13.68	***
LA1·LOSS				-31.804	-2.95	***			
LA2·LOSS							-29.091	-5.36	***
FEMALE	-0.726	-13.64	***	-0.660	-11.44	***	-0.672	-12.55	***
AGE(x0.01)	5.164	3.66	***	4.459	3.12	***	0.045	3.21	***
AGE^2(x0.0001)	-6.851	-4.81	***	-6.155	-4.27	***	-5.975	-4.21	***
INCOME(x0.01)	-0.127	-10.77	***	-0.124	-10.46	***	-0.115	-9.66	***
INCOME^2(x0.0001)	0.001	11.10	***	0.001	10.84	***	0.001	10.14	***
FREQ_TRADE_dummy	(against "once/month")			(against "once/month")			(against "once/month")		
once in half a month	-0.804	-8.15	***	-0.827	-8.34	***	-0.833	-8.44	***
once a week	-0.454	-6.01	***	-0.487	-6.39	***	-0.456	-6.09	***
daily	-0.011	-0.16		-0.013	-0.20		0.018	0.28	
Constant	-0.842	-2.59	***	-0.693	-2.11	**	-0.813	-2.53	***
Pseudo R^2	0.063			0.064			0.065		
Number of Observations	19345			19345			19345		

	Model 1			Model 2					
				(1)			(2)		
Marginal Effects	coef.	z		coef.	z		coef.	z	
LOSS	-0.099	-18.61	***	-0.099	-18.55	***	-0.098	-18.46	***
LA1				-1.880	-2.96	***			
LA2							-1.714	-5.37	***
FEMALE	-0.100	-13.74	***	-0.091	-11.50	***	-0.092	-12.62	***
AGE(x0.01)	-0.148	-5.58	***	-0.157	-5.89	***	-0.130	-4.89	***
INCOME(x0.01)	-0.016	-10.72	***	-0.015	-10.39	***	-0.014	-9.58	***
FREQ_TRADE_dummy	(against "once/month")			(against "once/month")			(against "once/month")		
once in half a month	-0.111	-8.17	***	-0.114	-8.36	***	-0.115	-8.46	***
once a week	-0.062	-6.02	***	-0.067	-6.41	***	-0.063	-6.10	***
daily	-0.001	-0.16		-0.002	-0.20		0.003	0.28	

Table 5: LOGIT Regressions Results Summary under Weighted Average Purchase Price WAPP1 and under the First-Bought First-Sold FIFO rule as the Reference Point

Panels A and B report regression results for "Model 1" and "Model 2" for the case when individual-specific reference points are replaced with the weighted average purchase price and the first-bought first-sold FIFO rule (i.e. shares which are purchased first are also sold first) as a reference point, respectively. The distinction between the domain of gains and the domain of losses is accordingly revised to reflect this change in the reference point. For details, please refer back to Table 3.

Panel A: Weighted Average Purchase Price WAPP1

	Model 1			Model 2					
				(1)			(2)		
	coef.	z		coef.	z		coef.	z	
LOSS	-0.79	-21.01	***	-0.55	-10.87	***	-0.59	-14.20	***
LA1 ·LOSS				-63.23	-6.83	***			
LA2 ·LOSS							-47.88	-9.51	***
Constant	-1.13	-45.68	***	-1.13	-45.68	***	-1.13	-45.68	***
Pseudo R^2	0.02			0.03			0.03		
Number of Observations	19992			19992			19992		

Marginal Effects	coef.	z		coef.	z		coef.	z	
LOSS	-0.114	-21.34	***	-0.111	-20.93	***	-0.112	-20.94	***
LA1				-3.908	-6.82	***			
LA2							-2.948	-9.48	***

Panel B: the First-Bought First-Sold FIFO

	Model 1			Model 2					
				(1)			(2)		
	coef.	z		coef.	z		coef.	z	
LOSS	-0.79	-20.93	***	-0.51	-10.10	***	-0.58	-13.94	***
LA1 ·LOSS				-74.42	-7.94	***			
LA2 ·LOSS							-53.29	-10.28	***
Constant	-1.15	-46.96	***	-1.15	-46.96	***	-1.15	-46.96	***
Pseudo R^2	0.02			0.03			0.03		
Number of Observations	19992			19992			19992		

Marginal Effects	coef.	z		coef.	z		coef.	z	
LOSS	-0.114	-21.25	***	-0.111	-20.79	***	-0.113	-20.99	***
LA1				-4.400	-7.92	***			
LA2							-3.138	-10.23	***

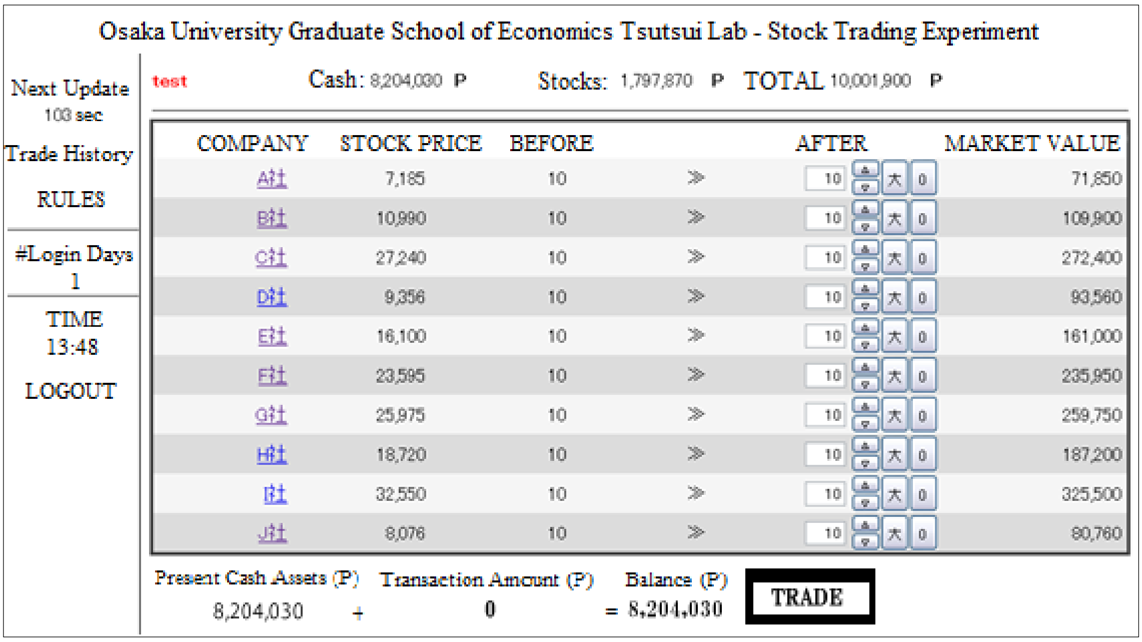

Figure 1: A screenshot of a transaction panel (translated from Japanese).

The screenshot in figure above provides information on the present composition of the subjects' portfolios, stock prices and cash holdings. Subjects use it also to order their buy and sell transactions, which are immediately executed. For instance, by changing the number of shares in the "After Transaction" column and clicking on "Trade", a corresponding order is completed.

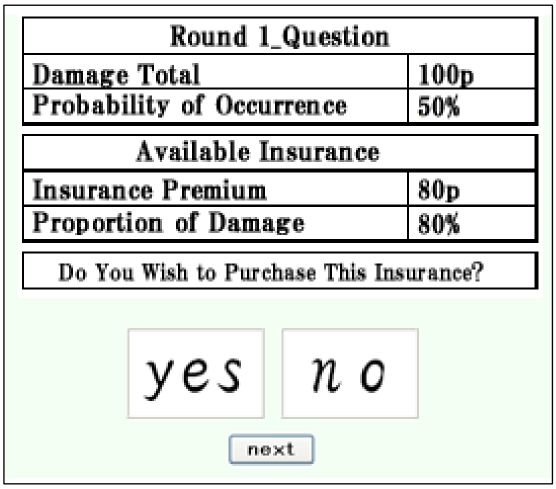

Figure 2: A screenshot from the "Insurance Buying Experiment" (edited from Japanese).
The display for this experiment shows an amount of potential damage with the probability of its occurrence as well as an insurance premium offer. The subject chooses either to purchase the insurance (”yes”) or to decline it (”no”).