Reference Point Adaptation: Tests in the Domain of Security Trading

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Abstract

According to prospect theory (Kahneman & Tversky, 1979), gains and losses are measured from current wealth, which serves as a reference point. We attempted to ascertain to what extent the reference point shifts following gains or losses. In questionnaire studies we asked subjects what stock price today will generate the same utility as a previous change in a stock price. From participants' responses we calculated the magnitude of reference point adaptation, which was significantly greater following a gain than following a loss of equivalent size. We also found the asymmetric adaptation of gains and losses persisted when a stock was included within a portfolio rather than being considered individually. In studies using financial incentives within the Becker, DeGroot, and Marschak (1964) procedure, we again noted faster adaptation of the reference point to gains than losses. We related our findings to several aspects of asset pricing and investor behavior.

Keywords: Prospect theory; Reference point; Asset pricing; Security trading

1 Introduction

The reference point plays a prominent role in prospect theory (Kahneman & Tversky 1979). In this theory outcomes are measured against current wealth, which serves as a reference for the evaluation of utility or "value." An important question is how this reference point is updated through time as a function of the outcomes of past decisions. In this paper, we test the adaptation of reference points in response to payoff outcomes in experimental settings in the domain of security trading.

By "adaptation of the reference point" we mean a shift in the reference point in the direction of a realized outcome. To illustrate the importance of reference point adaptation, consider a prospect-theory investor who purchases a stock at $30 per share, observes it drop to $20, and expects that the stock price will either go up or down by $5 with equal probability. If her reference point remains at the purchase price $30, she will hold on to the stock because people are risk-seeking in the loss domain. In contrast, if her reference point has adapted to the new price $20, she will sell the stock at $20 since, owing to loss-aversion, a zero-expected-value gamble is not attractive. On the upside, if the stock were to rise from $30 to $40, the extent of upward migration of the reference point would also affect the propensity to sell the stock. These simple examples illustrate that reference point adaptation affects risk-taking decisions.

Thaler (1980, 1985) introduced the concept of mental accounting, which has important implications for prospect theory. Mental accounting consists of the ways in which people mentally categorize financial transactions in order to monitor where their money is going, to assess the performance of their investments, and to plan future investment decisions. We hypothesize that adaptation of the reference point is integrally related to the way people mentally account for prior gains and losses. If investors fully adapt to the changes in stock prices by closing out their old mental accounts with all of the realized gains/losses, they will evaluate future prospects relative to the current stock price. This implies that prior gains or losses are segregated from the subsequent mental account. However, if investors do not fully adapt to the price change, a part of the prior gain or loss will be included in the mental account containing the future prospect.

Thaler (1999) points out that mental accounting does not have rigid rules like regular accounting. As a result people may be tempted to be "creative" in adjusting their accounting principles in order to feel good about themselves or about their pecuniary outcomes. Such hedonic considerations may influence how investors update the reference point in response to a price change. We examine two kinds of hedonic considerations.

First, consider again the adaptation of the reference point to a gain versus a loss. Following a gain, migration of the reference point toward the level of the new wealth will mean that a subsequent gain will be enjoyed more than if the reference point had not budged following the first gain. This is due to the fact that the value function is concave in the region of gains; diminishing returns render subsequent gains less valuable than initial ones. Thus a hedonic maximizer might adapt to gains in order to re-set the origin of the prospect theory value function close to the new level of wealth. On the other hand, the convexity of the value function in the region of losses might cause a value maximizer to resist reference point migration downward following a loss. If the reference point adapts to the first loss, a subsequent loss will be more painful than if the original reference point were to be maintained.

The second factor pertains to the fact that closing an account in the "black" generates immediate gratification, but closing an account in the "red" produces immediate misery (Prelec & Loewenstein, 1998). Closing an account re-sets the reference point and segregates the prior consequences from future ones. Due to the differential immediate hedonic consequences, investors will have more incentive to close a prior account after a gain than after a loss. This second factor is in addition to the consequence of closing the account on the hedonic experience of subsequent gains and losses.

The paper is organized as follows. Section I briefly reviews related literature. Section II presents questionnaire studies designed to test the adaptation of reference points after gains and after losses. Section III presents tests of reference point adaptation using studies employing monetary incentives. Section IV discusses the findings, and Section V concludes.

I. The Reference Point in Prospect Theory

Kahneman and Tversky (1979) proposed prospect theory as an alternative to the normative theory of expected utility maximization. Three aspects of prospect theory are most relevant to our research. First, people derive utility from gains and losses relative to a reference point, while traditional utility theory assumes that people derive utility from total wealth or consumption. Second, the value curve is concave in the domain of gains and convex in the domain of losses. Third, in the neighborhood of the reference point, the effect on value of a unit of loss is much larger than that of a unit of gain. Thus a loss has a larger effect than does a gain of equal absolute value. Most research suggests that losses have an effect approximately 2 to 2.5 times that of a gain (e.g. Tversky & Kahneman, 1991). In all these aspects of prospect theory, the reference point plays an important role.

Kahneman and Tversky (1979) suggest that several factors, such as status quo, social norms, and aspiration levels may determine the reference point. However, Kahneman and Tversky did not specify how the reference point changes over time. Since in reality individuals such as investors make multiple decisions over time, it is important to understand how reference points are updated after investors experience intertemporal outcomes. This topic has received only a modest amount of prior investigation.

One natural reference point is the price at which the stock was initially purchased. Spranca, Minsk, and Baron (1991) provide evidence that the starting point enjoys a privileged role. The price which began one's personal history with the stock provides a natural benchmark for assessing whether the investor's own action has brought about a profit or loss. This benchmark effect presumably makes the purchase price a salient candidate reference point. [Shefrin & Statman (1985) and Odean (1998) provide related discussion and evidence.] However recent papers such as Koszegi and Rabin (2004) and Yogo (2005) posit that a person's reference point is one's expectations about future outcomes, not the original purchase price.

The reference point is likely to migrate from the initial purchase price as a stock price changes over time. Investors may eventually update their reference points to the current price or partially update to a price between the initial price and the current price. Chen and Rao (2002) suggest that people's reference points shift after a stimulus is presented, but do so incompletely. However Chen and Rao (2002) only examined situations in which two outcomes occur with one being positive and the other being negative.

Gneezy (2002) inferred reference point adaptation from participants' decisions to sell their stocks when stock prices followed a random walk. He argued that, based on prospect theory, investors are risk averse in the gain domain and thus should sell only when the current stock price is above the reference point. His experimental results suggested that participants are most likely to use the historical peak as the reference point. However, Gneezy's design did not allow him to locate the reference point and compare the magnitude of adaptation between winners and losers, which are the emphases and main contributions of our paper.

Clearly, more empirical evidence is needed to learn how investors update their reference points. That is the goal of the present research.

II. Questionnaire Experiments

We used two approaches to test for reference point adaptation. In the first, subjects answered questions in hypothetical trading scenarios. In the second, we inferred the reference point adaptation from the trading decisions of subjects in a stock trading game, in which their monetary payoffs were directly tied to their trading profits. We will first present the questionnaire studies. In the questionnaires, we asked subjects what stock price today will generate the same utility for them as a previous change in the stock price. If the previous stock price is P_1 and the previous reference point is R_0, the difference between P_1 and R_0 should be the same as the difference between the price reported by subjects (P^*) and the new reference point R^*, assuming the shape of the prospect value function remains unchanged.

$$P^* - R^* = P_1 - R_0 \Rightarrow R^* - R_0 = P^* - P_1 \tag{1}$$

Through this equality, we can calculate the reference point adaptation.

The data are obtained from students in an introductory finance course at The Ohio State University who answered brief questionnaires in a classroom setting. The total number of respondents for each problem is denoted by N, and the average dollar amount in their answers and the calculated implied reference point adaptation are indicated in brackets. We used a between-subject design for the following two basic questions.

1. Basic questions

> Problem 1 (winner) [$N = 138$]: Two months ago, you bought a stock for \$30 per share. Last month, you were delighted to learn the stock was trading higher — at \$36 per share. This month, you decide to check the stock's price again. At what price would the stock need to trade today to make you just as happy with the stock's price this month as you were when you learned the stock had risen from \$30 to \$36 last month?
>
> [Average answer: \$40.24. Implied adaptation: \$4.24]
>
> Problem 2 (loser) [$N = 141$]: Two months ago, you bought a stock for \$30 per share. Last month, you were disappointed to learn the stock was trading lower — at \$24 per share. This month, you decide to check the stock's price again. At what price would the stock need to trade today to make you just as sad with the stock's price this month as you were when you learned the stock had dropped from \$30 to \$24 last month?
>
> [Average answer: \$21.49. Implied adaptation: \$2.51]

For the winner problem, the subjects on average believed that a gain to \$40.24 would give them the same pleasure as the last month's price increase to \$36: $V(\$40.24 - R_1) = V(\$36 - R_0)$. Given that the shape of the prospect value function remains unchanged, the new perceived gain $\$40.24 - R_1$ must be equal to the old perceived gain $\$36 - R_0$, as in equation (1). Hence, the reference point adaptation $R_1 - R_0$ should be \$4.24 ($\$40.24 - R_1 = \$36 - R_0 \Rightarrow R_1 - R_0 = \$40.24 - \$36 = \$4.24$) after the initial \$6 gain. In contrast, the subjects regarded the loss down to \$21.49 to be as painful as last month's price decrease to \$24. We can infer that the reference point must have adapted downward by \$2.51 (\$21.49 − \$24). Comparing the adaptation of \$4.24 after a gains and \$2.51 after a loss, the difference is \$1.73. Hence, adaptation after gains is greater than adaptation after losses.

2. Intervention with selling and repurchasing

Thaler (1985) discussed the consequences of the integration and segregation of multiple outcomes. For example, getting two \$50 parking tickets might have a different psychological impact than a single \$100 dollar ticket. If one fully adapts after the first ticket, then a second ticket is painful. Due to the asymptotic nature of the prospect theory's value function in the loss region, a single ticket costing \$100 would be less agonizing. In this example it is easy to segregate the two \$50 increments by assigning them to different tickets, and it is easy to integrate them by assigning the two components to the same ticket.

We attempted the same sort of strategy in our second set of scenarios. In order to facilitate the segregation of the second gain (or loss) from the first gain (or loss), we wrote the scenario so that following the first outcome the person sold the stock. The person then subsequently bought the stock at the same price at which he or she sold it, and a second gain (or loss) then occurred. Based upon Thaler's (1985) mental accounting theory, we expect the selling event to close the mental account of the first transaction and the repurchasing event to open a new mental account for the new transaction. Accordingly, compared to the prior basic scenarios, we expect the subjects to be more likely to reset their new reference point to the new purchase price and away from the initial purchase price when they sell the stock and later repurchase it at the same price. Using a between-subjects design, we asked subjects the following two questions.

> Problem 3 (winner, with sale and repurchase intervention) [$N = 66$]: Three months ago, you bought a stock for \$30 per share. Two months ago, you were delighted to learn the stock was trading higher — at \$36 per share. You sold the stock for \$36 per share. Last month, you thought it was still a good idea to invest in the same stock. So you bought it again at \$36 per share. This

month, you decide to check the stock's price again. At what price would the stock need to trade today to make you just as happy with the stock's price this month as you were when you learned the stock had risen from $30 to $36 two months ago?

[Average answer: $41.84. Implied adaptation: $5.84]

Problem 4 (loser, with sale and repurchase intervention) [$N = 60$]: Three months ago, you bought a stock for $30 per share. Last month, you were disappointed to learn the stock was trading lower — at $24 per share. You sold the stock for $24 per share. Last month, you thought it was still a good idea to invest in the same stock. So you bought it again at $24 per share. This month, you decide to check the stock's price again. At what price would the stock need to trade today to make you just as sad with the stock's price this month as you were when you learned the stock had dropped from $30 to $24 two months ago?

[Average answer: $20.93. Implied adaptation: $3.07]

We again found that adaptation was greater following gains than following losses. Furthermore we found that the sale/repurchase intervention resulted in an average adaptation of $4.52, compared to an average adaptation of only $3.37 without this intervention(See Table 1).

Table 1: Reference Point Adaptation Following Gains and Losses in the Basic Groups, the Groups with the Sale/Repurchase Intervention, and the Groups with Portfolios

Group	Gain	Loss	Mean
Basic Questions 1 & 2	$4.24	$2.51	$3.37
Sale/Repurchase Intervention Questions 3 & 4	$5.84	$3.07	$4.52
Portfolio Questions 5 & 6	$3.82	$1.55	$2.61

3. Robustness: The Presence of Portfolios

We also considered whether our results would hold in a few different settings. First, investors may behave differently when they hold portfolios instead of one single stock. When holding a portfolio, an investor may evaluate gains and losses of a portfolio rather than those of each individual stock in her portfolio. If so, it may be the trading outcome of the portfolio rather than the trading outcome of an individual stock that has an impact on the reference point. Accordingly, our results may have rather limited implication for stock markets since most investors usually hold portfolios instead of one stock. Hence, we examined whether people make different decisions on single stocks when they held portfolios. We assumed the investor held a portfolio of two stocks, one with a \$6 gain as in Problem 1 and one with a \$6 loss as in Problem 2.

> Problem 5 (portfolio-gain) [$N = 22$]: Two months ago, you bought 200 shares of stock A and 200 shares of stock B, each a price of \$30 per share. Last month, you were delighted to learn stock A was trading higher — at \$36 per share, and you were disappointed to learn stock B was trading lower — at \$24 per share. This month, you decide to check the stock's price again. At what price would stock A need to trade today to make you just as happy with stock A's price this month as you were when you learned stock A had risen \$6 from \$30 to \$36 last month?
>
> [Average answer: \$39.82. Implied adaptation: \$3.82]
>
> Problem 6 (portfolio-loss) [$N = 25$]: This was the same scenario as in Problem 5, but a different question was asked: At what price would stock B need to trade today to make you just as sad with stock B's price this month as you were when you learned stock B had dropped \$6 from \$30 to \$24 last month?
>
> [Average answer: \$22.45. Implied adaptation: \$1.55]

The mean adaptation for each of the six scenarios discussed thus far are displayed in Table 1. We subjected the results of these first six scenarios to a 2 (price movement: winner/loser) $\times$ 3 (group: basic questions 1&2/sale & repurchase questions 3&4/portfolio

questions 5&6) analysis of variance (ANOVA). The winner/loser main effect was significant [$F(1, 446) = 27.42$, $p < 0.0001$], with the adaptation for gains being far greater than the adaptation for losses ($4.67 versus $2.55). Also significant was the group main effect [$F(2, 446) = 5.74$, $p < 0.01$]. Tukey post tests revealed that the mean adaptation following the sale and repurchase intervention ($4.52) significantly exceeded the mean adaptation of the basic questions ($3.37), $q(270) = 3.10$, $p < .05$, and it also significantly exceeded the mean adaptation of the portfolio group, $q(270) = 5.15$, $p < .01$. On the other hand, the portfolio group's mean adaptation ($2.61) did not differ from that of the basic questions. The interaction did not approach significance ($F < 1$).

In short, we find that investors tend to shift reference points upward after prior gains and downward after prior losses. The size of the adaptation after gains appears to be greater than that after losses. Inserting a sale and repurchase, which we hypothesize closed the prior mental account, fostered significantly higher levels of adaptation following gains and losses.

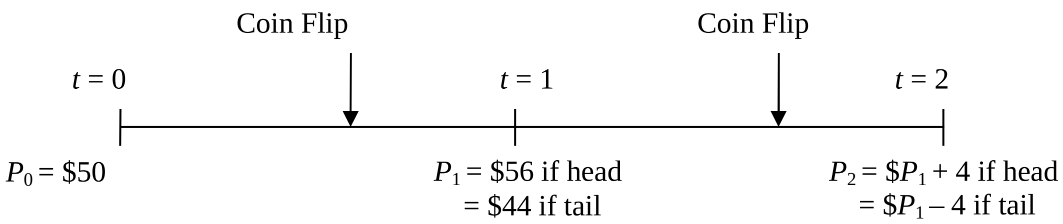
4. Robustness: Controlling for Expectations

We wanted to minimize the possibility that differences in expectations about future price movements were responsible for the results we have reported thus far. For example, subjects may form expectations about future stock prices based on prior price movements. If they hold a bold momentum view after a prior gain but a cautiously contrarian view after a prior loss, they may wishfully expect a gain after both prior gains and losses. As a result, they may report a price level that is further away from the purchase price of $30 after a prior gain than after a prior loss, but the difference in their indicated prices could be due to expectational biases rather than differences in reference point adaptations. We tried to minimize the use of expectational biases in the prior experiments by explicitly stating in the instructions "... that stock prices are not predictable by any means." To make the stochastic nature of future prices even more apparent, in the next experiment we had the participants witness a coin flip which would determine the future price.

We asked the following questions:

Problems 7 and 8:

At $t = 0$, you bought one share of stock A for \$50 per share. At $t = 1$, the experimenter flipped the coin: it is a head (tail). Now your stock is worth \$56 (\$44). You have a chance to sell your shares now through a private transaction to another investor or wait until the second coin flip and sell your share at P_2. So you have two options:



Option A: Sell your share to another investor through a private transaction for \$$X$.

Option B: Wait until the second period to sell your share at the second period stock price P_2.

The experimenter will flip a coin again, and the stock price will be \$60 (\$48) if it is a "head" or \$52 (\$40) if it is a "tail". Which stock price \$$X$ in Option A will make you exactly indifferent between the two options? Please indicate your minimum selling price \$$X$.

Problems 9 and 10: These were identical to Problems 7 and 8 except that we inserted the sale and repurchase intervention in precisely the same way that we added them in Problems 3 and 4.

By asking the above questions, we obtained a price that gave the investor the same utility as the gamble of \$60 (\$48) and \$52 (\$40) with equal probability. In this manner we hoped to achieve greater control over participants' expectations about subsequent price movement. We solved their implicit reference point by equating the utility from the gains of selling stock for \$$X$ and the expected utility from the gamble. Thus we inferred their reference points at date 1 (R_1) in the following manner:

$$V(X - R_1) = 0.5V(60 - R_1) + 0.5V(52 - R_1) \tag{2}$$

where X is the dollar amount they indicate, and R_1 is the implicit reference point. The value function is the cumulative prospect theory value function (Tversky & Kahneman, 1992)

$$V(x) = \begin{cases} x^{\alpha} & x > 0 \\ -2.25(-x)^{\alpha} & x < 0 \end{cases}$$

After solving equation (2) for the reference point, we obtained the magnitude of adaptation by taking the absolute deviation of the new reference point from the original reference point (the purchase price). Using $\alpha = 0.2$, we obtained the mean reference point adaptations displayed in Table 2.[1] The mean adaptation following a gain was \$6.38, and the mean adaptation following a loss was \$5.49. A 2 (Outcome: gain/loss) × 2 (Group: basic questions/sale-repurchase intervention) ANOVA revealed only a significant main effect for outcome [$F(1, 77) = 14.87$, $p < .0001$].

Table 2: Reference Point Adaptation Following Gains and Losses in the Basic Groups and the Groups with the Sale/Repurchase Intervention

	Outcome			
Group	Gain		Loss	
Basic Questions 7 & 8	\$6.34	(n = 15)	\$5.49	(n = 24)
Sale/Repurchase Intervention Questions 9 & 10	\$6.40	(n = 26)	\$5.49	(n = 16)

These results lead us to conclude that the more complete adaptation following gains is robust to a rather significant change in methodology. However the faster updating following the sale/repurchase intervention, which was manifested using the prior methodology, was absent with this new methodology. We will assess the magnitude of the sale/repurchase intervention once more when we extend our research to experiments involving actual monetary consequences.

In all of the above survey questions, the gains and losses were hypothetical. Some economists suggest that people may exhibit different behavior when they are provided with monetary incentives to make better decisions (see the discussion by Camerer & Hogarth, 1999). It is possible that the subjects when answering hypothetical questions may

[1]Our basis for choosing $\alpha = 0.2$ will be explained below.

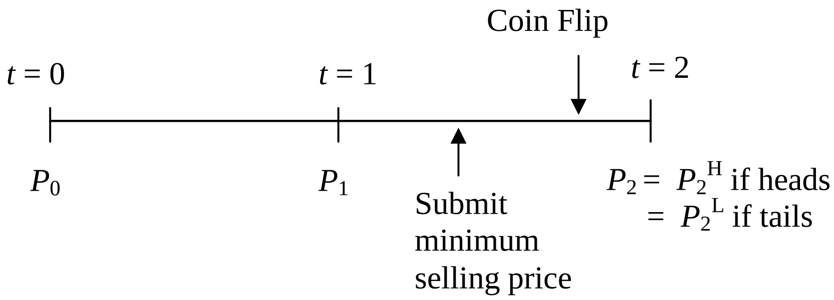
make different decisions compared to when their decisions influence their real payoffs, and their decisions under monetary incentives may mirror their real life investment decisions more closely. To address this concern, we designed experiments with real monetary incentives. The details of these experiments are discussed in the next section.

III. Stock Trading Experiments with Monetary Incentives

These experiments have two purposes. The first is to examine whether the asymmetric adaptation after gains or losses holds when investors' decisions involve monetary incentives. The second is to explore whether the selling and repurchase events used in questions 3, 4, 9, and 10 influence reference point adaptation when incentives are present.

The basic procedure of the trading experiment mirrors the last question of the previous section. Each round consists of three dates and two periods. At the beginning of the trading round, subjects are told that they purchased a stock at a certain price (P_0) and have held the stock for a week. They are then informed of the current price P_1, which is either higher or lower than their purchase price P_0. Also, they are informed of the two future possible prices of the stock in the next trading period (P_2). Before the realization of the second period price P_2, subjects have a chance to sell the stock to the experimenter by stating their minimum selling price. Following the Becker, DeGroot, and Marschak (1964) procedure (BDM), a buying price is randomly drawn between the two possible future prices P_2^H and P_2^L. If the randomly drawn buying price exceeds or equals the subject's minimum selling price, the subject sells the stock at the randomly drawn buying price. If the buying price is less than the minimum selling price, the subject holds the stock and sells it at the next trading period's price P_2 which will be determined by a coin flip.

Under the BDM procedure, it is optimal for the subjects to set their minimum selling price equal to their valuation of the gamble. Thus, the BDM procedure reveals through subjects' minimum selling prices their valuations of risky gambles, which in turn helps us infer how their reference point changes after they experience gains or losses.



Method

Procedure. Each subject traded 4 stocks in addition to a set of stocks which were inserted for the purpose of creating a time delay between the interventions of selling and repurchasing. Among the 4 stocks, two were winners and two were losers. The winner stocks, which were purchased at $20, went up to $26 after the first period. The subjects were informed that the stocks would have to be sold at either $30 or $22 with equal probability in the next trading period. We then asked them to indicate their minimum selling price. Our buying price was randomly drawn from the range of the low possible future price $22 and the high possible future price $30. If the minimum selling price was below or equal to a randomly drawn price, they would sell the stock for the randomly drawn price. Otherwise, they would have to hold the stock and sell it in the next trading period at a price of either $30 or $22 to be determined by a coin flip.

The loser stocks were purchased at $20 and went down to $14 with a future price of either $18 or $10 with equal probability. The BDM procedure ensures that value-maximizing investors should indicate a price such that they are indifferent between selling the stock for that price and taking the gamble in the next period. In other words, by obtaining the certainty equivalence, we are able to solve for the implied reference point using prospect value function.

One winner and one loser stock had the intervention of selling and repurchasing that we used in questions 3 and 4. For those two stocks, we introduced a time delay after the shares were sold but before they were repurchased. During the time delay, the subjects traded other stocks in some sessions and solved anagrams in other sessions. This time delay, which was between 10 and 25 minutes, was designed to help subjects segregate the prior outcomes.

In order to maximize the success of the BDM procedure, we explicitly instructed subjects about the reasoning as to why it is optimal to ask their true valuation of the stock, including illustrative examples showing how asking above or below one's valuation brings suboptimal outcomes. (The instructions are in Appendix A). All subjects in each session had a chance to gain experience in the trial periods and were paid according to their trading gains or losses in two randomly selected stocks.[2] This creates a pecuniary incentive for the participants to follow the optimal strategy. By randomly selecting the stocks whose results would govern the payments, we ensured that that the subjects would pay equal attention to all of the four stocks we are interested in. This procedure also minimized the influence of the gains and losses from other stocks.

The subjects were promised a $20 base payment for participation. In addition, they were told that their trading profit or loss would be added to the $20 participation fee to yield their final payment. They were also told that, at the end of the experiment, one of the stocks they have traded will be randomly drawn and its trading profit will count toward their final payoff. Further, since trading profits are not cumulative, their decisions should not be influenced by prior outcomes. The maximum gains or losses were $10. The trading profits were divided by two before joining the $20 participation payment, which made the range of the final payoff from $15 to $25.

In the first few sessions of the experiment, we conducted a brief survey after the games and asked subjects to rate their understanding of the procedure (1: very poor, 2: poor, 3: fair, 4: good, 5: very good, 6: excellent) and whether or not they were convinced about the optimal strategy in stating their minimum prices with BDM mechanism (1: definitely "no," 2: probably "no," 3: unsure, 4: probably "yes," 5: definitely "yes").

Participants. A total of 100 undergraduate students from introductory finance courses at the Ohio State University and DePaul University participated in the experiment.

Results

We found no significant differences in the reference point adaptation between the two groups of subjects who had different activities (anagrams versus other stock trading

[2]Among the two stocks that counted toward subjects' final payoff, one was randomly selected from the 4 stocks we studied and the other one was from the other stocks.

exercises) during the time delay. Therefore we collapsed over this factor.

We used a survey in the end of the first few sessions to check subjects' understanding of the experiments. A total of 46 subjects answered the survey. Subjects gave an average 5.3/6 rating to their understanding of the experimental procedure, and an average rating of 3.8/5 to their acceptance of the optimal strategy under the BDM mechanism. More than 71% of subjects said that they indeed reported their true minimum selling price. For those who claimed that they did not respond in such a manner as to reveal the true indifference price, they generally claimed that they systematically asked either higher prices or lower prices than their true minimum selling price. However, there was no clear pattern of biased reporting toward either higher or lower prices relative to the true minimum selling price.

After obtaining the reported minimum selling price (P^{min}), we inferred their reference points at date 1 (R_1) in the following manner:

$$V(P^{min} - R_1) = 0.5V(P_2^H - R_1) + 0.5V(P_2^L - R_1) \tag{3}$$

Though we explicitly instructed the subjects that a reasonable minimum selling price should be between the two possible future prices P_H^2 and P_L^2, a few subjects still reported a minimum selling price as either P_H^2 or P_L^2. We interpret these behaviors as inconsistent with that described in prospect theory.[3] For these observations there is no solution for the implied reference point for some minimum selling price, regardless of the value of α we pick. In addition, a few subjects reported a price that was 10 or 20 cents below P_H^2. or above P_L^2. For these observations, we generally find a solution for the implied reference point when we choose α relatively small α, such as 0.2. But we obtain no solution when α is large, close to the proposed value of 0.88 suggested by Tversky and Kahneman (1992).

To increase the range of minimum selling price that makes equation (3) solvable, we used $\alpha = 0.2$. We defined the amount of reference point adaptation as $|R_1 - P_0|$. As a

[3] In the prospect theory value function, utility increases in perceived gains (or decreases in perceived losses). Thus, the expected utility of the gamble cannot be equal to the utility of one possible outcome. Choosing to report a minimum selling price as P_H^2 suggests that the subject is extremely risk-seeking and she prefers to take the gamble in any circumstances. In contrast, choosing to report a minimum selling price as P_L^2 suggests that the subject is extremely risk-averse and she will take everything to avoid the gamble.

robustness check, we used a higher value of α (e.g. $\alpha = 0.5$) and the results appear to be even stronger though we had to throw away a few observations for which we could not find the solutions.[4] The following analyses are based solely on $\alpha = 0.2$. We discarded 9 observations from the loser-sell/repurchase intervention cell due to a procedural error. Five data points were not calculable due to the reasons mentioned above. Thus the 100 participants contributed 386 data points in this completely within-subject design.

Table 3 reports the average reference point adaptation for the 4 stocks. Our results show that reference points adapt faster to the past gains than losses by \$0.59. Also, the selling and repurchasing event increases the size of reference point adaptation in a significant way. After such an intervention is inserted, the reference point adapts faster by \$0.39.

Table 3: Reference Point Adaptation Using Financial Incentives Following Gains and Losses in the Basic Groups and the Groups with the Sale/Repurchase Intervention

	Outcome		
Group	Gain	Loss	Mean
Basic Questions	\$5.75	\$5.13	\$5.44
Sale/Repurchase Intervention Questions	\$6.10	\$5.55	\$5.83
Mean	\$5.93	\$5.34	

Using a 2(outcome: winner/loser) × 2(selling-repurchase intervention: present/absent) ANOVA, we find that the winner/loser effect is significant [$F(1{,}86) = 6.81$, $p = 0.01$] and the intervention effect is also significant [$F(1{,}86) = 15.22$, $p < 0.01$]. The interaction effect did not approach significance.

Discussion

The results of this experiment replicated the results presented in Table 1, which contains data obtained from participants who did not have financial incentives. Namely,

[4] We lose 5 observations for winner questions and 10 observations for the loser questions after we switch from $\alpha = 0.2$ to $\alpha = 0.5$. The deleted observations with higher value of α do not seem to bias the results in support of the asymmetric adaptation. In fact, we lose more observations from the low adaptation for losers which should increase the overall mean adaptation of the losers, thus mitigating the asymmetry.

adaptation was more complete following gains than losses, and the selling/repurchase intervention accelerated adaptation.

While we have documented reference point adaptation in dollar terms, the conclusion is identical if we interpret them in percentage returns. Without the selling/repurchase intervention, the reference point increases by 28.75% ($5.75/$20 = 0.2895) after a 30% increase ($6/$20 = 0.3) in stock price. Following a 30% decrease in stock price, the reference point decreases by 25.65% ($5.13/$20). Since both the winner and loser stock cases start with the same purchase price of $20, the amount of reference point adaptation in percentage returns is the dollar amount divided by $20. We have chosen to report all results in dollars rather than in percentage returns.

IV. General Discussion

Using questionnaire and money-incentive experiments, we found that people tend to adapt reference points upward after stock investment gains and downward after losses, and that the size of the adaptation after gains tends to be greater than that after losses. Such asymmetry in adaptation is observed in experiments with and without monetary incentives. It is robust to whether investors hold a single stock or a portfolio, to whether investors sold the stock after the price change or kept holding the stock.

We hypothesize that the faster adaptation to gains than to losses is related to mental accounting and hedonic maximization. In particular, the asymmetric adaptation can be at least partially explained by the tendency to integrate intertemporal gains and segregate intertemporal losses. Specifically, after experiencing gains, segregating part of the prior gains from the subsequent mental account increases hedonic utility by placing the remaining prior gains in the steeper region of the gain domain and also using it to cushion the future possible losses. In contrast, after experiencing losses, investors are inclined to keep it integrated so that it is evaluated in the flatter region in the loss domain in order to minimize hedonic disutility. We can illustrate the intuition through two simple examples. Our examples mirror the stocks in our experiment with monetary incentives.

Suppose investors purchased a stock at \$20, and later the stock price rose to \$26. In the next period, they have to sell the stock at either \$4 higher or lower from the current price \$26. That is, the future selling price is either \$30 or \$22 with equal probability. We assume that there are two mental accounts: in the old mental account, the reference point is \$20; in the new mental account, the reference point is $\$R_1$. Updating a reference point is equivalent to closing the old mental account at the new reference point, which produces the value of $V(R_1 - P_0)$. Then the total value from trading the stock is the sum of the values from both the old and new mental accounts:

$$V = V(R_1 - 20) + 0.5V(30 - R_1) + 0.5V(22 - R_1). \tag{4}$$

To show that adaptation is preferred to non-adaptation, let us compare two cases: in Case 1, the reference point adapts to \$22; in Case 2, it remains at \$20. When the reference point adapts to \$22, the overall value is

$$V_1 = V(22 - 20) + 0.5V(30 - 22) + 0.5V(22 - 22) = V(2) + 0.5V(8). \tag{5}$$

However, when the reference point remains at \$20, the overall value is

$$V_2 = V(20 - 20) + 0.5V(30 - 20) + 0.5V(22 - 20) = 0.5V(10) + 0.5V(2). \tag{6}$$

It is easy to show that $V_1 > V_2$ since

$$V_1 - V_2 = 0.5V(2) + 0.5V(8) - 0.5V(10) > 0. \tag{7}$$

because in the gain domain of the prospect theory value function, segregating gains generates higher utility. Thus, the value from the segregated two gains is greater than the value from a single lump-sum gain. Accordingly, after gains, adapting the reference point is preferred to no adaptation.

In contrast, suppose investors purchased a stock at \$20, and later the stock price dropped to \$14. In the next period, they have to sell the stock at either \$18 or \$10 with equal probability. Then the total value from trading the stock is still

$$V = V(R_1 - 20) + 0.5V(18 - R_1) + 0.5V(10 - R_1). \tag{8}$$

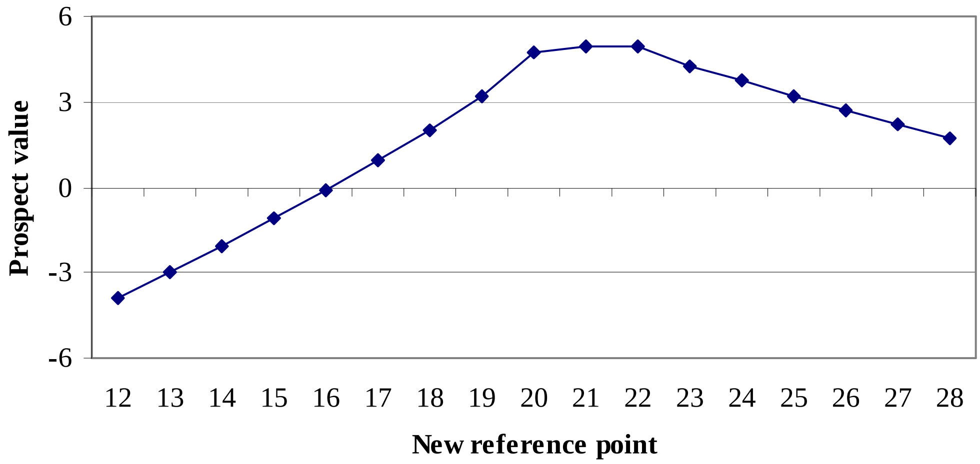
When we compare adaptation (Case 1) versus no adaptation (Case 2) in this case, it is easy to show that $V_1 < V_2$ since

$$V_1 - V_2 = 0.5V(-2) + 0.5V(-8) - 0.5V(-10) < 0. \tag{9}$$

In the loss domain, it is optimal to integrate losses, because integrating losses generates higher value than segregating them by updating the reference point.

To further illustrate that it is optimal for investors to adapt to gains rather than to losses when facing uncertainty, we calculated the prospect theory value for a range of possible reference points for the above two numerical examples. Consistent with our argument above, we will show that the maximum utility is achieved when reference points adapt upward after prior gains and when reference points stay unchanged after prior losses.

Figure 1: Total value of a gain from \$20 to \$26 plus a subsequent sale of the stock at either \$30 or \$22 with equal probability as a function of the new reference point.



Recall that the winner stock was purchased at \$20, rose to \$26, and would have to be sold at \$30 or \$22 with equal probability. In the prospect theory value function, we set $\lambda = 2.25$ and $\alpha = 0.88$, where λ is the ratio of the impact of the loss to that of a gain. Under these parameter values, we calculate the prospect theory value based on the following equation for a range of R_1.

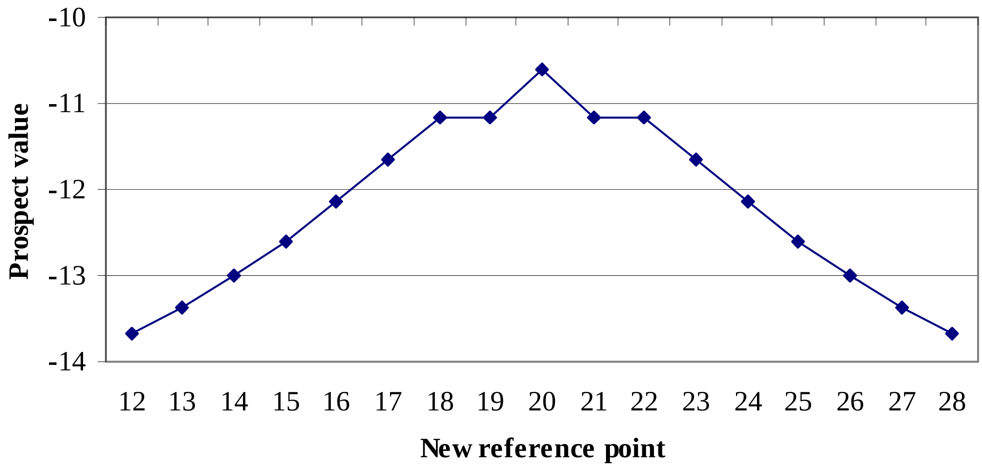
$$V = V(R_1 - 20) + 0.5V(30 - R_1) + 0.5V(22 - R_1). \tag{10}$$

As can be seen in Figure 1, the maximum total value would be achieved by setting the new reference point equal to \$22, the lowest possible future price. In other words, it would be optimal to adapt the reference point upward by \$2 after gains. Thus, the prior gain of \$6 (\$26 − \$20) would be segregated into two parts: \$2 (\$22 − \$20) goes to the old mental account and the remaining \$4 goes to the new mental account.

The loser stock was purchased at \$20, dropped to \$14, and would have to be sold at either \$18 or \$10 with equal probability. Using the same parameter values of the prospect theory value function, we calculate the value based on the following equation for a range of R_1.

$$V = V(R_1 - 20) + 0.5V(18 - R_1) + 0.5V(10 - R_1). \tag{11}$$

Figure 2: Total value of a loss from \$20 to \$14 plus a subsequent sale of the stock at either \$18 or \$10 with equal probability as a function of the new reference point.



In Figure 2, we show that in this case, the maximum total value is achieved by setting the new reference point equal to \$20. In other words, it is optimal not to adapt the reference point after a loss. Thus, to achieve maximal value the prior loss of \$6 would be fully integrated into to the new mental account.

If the hedonic consideration were the only factor underlying reference point adaptation, these examples suggest that one would never adapt to losses and the adaptation to gains would be small enough to maximize the likelihood that future prospects are in the gain domain. However, a sense of reality may force investors to take into account the current price to some extent. Therefore we concede that the tug of reality may increase the amount of reference point adaptation beyond that predicted in the prior two examples Therefore, we expect that there will be some adaptation in reality to both gains and losses, but with an asymmetry of gains and losses due to hedonic maximization.

Our suggestion that a greater proportion of prior gains than losses is likely to be segregated from the new mental account is consistent with the hedonic editing hypothesis proposed by Thaler (1985) which maintains that people mentally account for outcomes to make themselves as happy as possible. Another main contribution of our paper is that we have proposed a methodology to locate a reference point, which has enabled us to explicitly test the asymmetry in adaptation after gains and losses.

Relation to Prior Research

There are a few papers that have examined reference point adaptation through different approaches. Our model and results are also consistent with these studies.

Gneezy (2002) finds that subjects' selling behaviors in a stock trading experiment are best explained when the past price peak is assumed as the reference point. The reason why the past price peak becomes the reference point can be understood by asymmetric adaptation. Since investors tend to move reference points upward after gains more than downward after losses, after experiencing gains or losses, reference points tend to be closer to the higher of the two prices — the past period price and the current period price. When a reference point moves more quickly upward to a higher price compared to downward toward a lower price, after a number of periods it will eventually approach the past price peak.

Thaler and Johnson (1990) examine the change in people's risk seeking tendency after prior outcomes. They find that subjects become more risk seeking after prior gains, which they coin the "house money effect." They propose the quasi-hedonic editing rule to explain the house money effect. Under the quasi-hedonic editing rule, when facing a gamble after a prior gain, people segregate the future possible gain from the prior gain while they integrate the future possible loss with the prior gain. Due to segregation of gains and integration of losses, the gamble becomes more attractive. It is worth noting that under the quasi-hedonic editing rule, one uses two different reference points to evaluate a gamble: the current wealth is the reference point to evaluate the gain prospect of the gamble; the initial wealth is the reference point to evaluate the loss prospect.

Our framework with partial reference point adaptation can also shed light on the house money effect. Furthermore, our framework involves just one reference point to evaluate both the gain prospect and the loss prospect of the gamble. When one partially adapts to prior gains, the prior gain is segregated into two parts: one part goes to the old mental account; the other part goes to the current mental account. The remaining gain in the current mental account can serve as a cushion for the future possible loss, which reduces the incremental disutility of the loss prospect. Therefore, the gamble becomes more attractive conditional on a prior gain. Thus, partial reference point adaptation can serve as an alternative to the quasi-hedonic editing rule to explain the house money effect.

In addition, Thaler and Johnson (1990) also find that, conditioning on a prior gain, between a risky gamble and a sure outcome (which they call the "two-stage game"), subjects tend to prefer the gamble to the sure outcome. In contrast, when subjects were presented another scenario in which, instead of having a prior gain, the prior gain in the "two-stage game" is integrated with the future prospects of the gamble (which is called the "one-stage game"), subjects switched to prefer the sure outcome. In other words, subjects became more risk seeking when moving from the one-stage game to the two-stage game with a prior gain. In contrast, they are less risk seeking when moving from the one-stage game to the two-stage game with a prior loss. Based on these findings, Thaler and Johnson (1990) conclude that whether the question is framed as a static choice problem or a dynamic choice problem can change the way subjects code outcome payoffs and therefore their risk preferences.

We argue that partial reference point adaptation can also explain the above findings. In a one-stage game, there is no prior outcome and thus reference points do not update. However, in a two-stage game, the presence of prior outcomes forces reference points to adapt toward the outcome payoffs. In the case with a prior gain, reference points move upward, which segregates the prior gains intertemporally and increases the attractiveness of the gamble. In contrast, when there is a prior loss, reference points move downward, which segregates the prior losses intertemporally and decreases the attractiveness of the gamble. Taken together, due to adaptation toward prior outcomes, people exhibit increased risk preferences in the two-stage gamble with a prior gain but decreased risk preferences in the two-stage gamble with a prior loss.

Finally, the differential rates of adaptation between gains and losses would also have important implications on the inability to "make peace with one's losses," which is typically necessary if one is going to avoid succumbing to the sunk cost effect (Arkes & Blumer, 1985). We have shown that to maximize hedonic utility, people are unable to ignore sunk costs; they are unable to segregate prior losses from the consideration of future prospects. This will result in keeping the prior account open, integrating the current account with the prior one, and remaining in the southwest quadrant of the prospect theory value function where future losses are assuaged by the asymptote of the curve. These factors will contribute to the maladaptive economic behavior known either as the sunk cost effect or escalation of commitment (Staw & Ross, 1987).

In the gain region of the prospect theory value function we propose that updating and segregation of accounts is more likely to occur. This would explain the "hedonic treadmill" proposed by Brinkman, Coates, and Janoff-Bulman (1978). People seem not to be satisfied with improvements, which are quickly deemed insufficient. Quick adaptation of an individual's reference point in the direction of the initial improvement renders that improvement inadequate, motivating new efforts. Thus the individual views his current wealth position as being at the new reference point, where the marginal utility from a further gain and the marginal disutility of an incremental loss are at their greatest (see also Scitovsky, 1976.)

Implications for Investment Behavior

In recent years, there has been a surge of interest in the study of individual investor trading behavior. Among the various patterns that have been identified concerning individual investor behavior is the disposition effect (Shefrin & Statman, 1985), which has been extensively documented (e.g. Odean, 1998; Weber & Camerer, 1998; Genesove & Mayer 2001; Grinblatt & Keloharju, 2001; Dhar & Zhu, in press). The disposition effect is defined as the tendency to hold losers too long and to sell winners too soon. Note that our hypothesis concerning reference point adaptation would lead one to predict that there are positive hedonic consequences of closing mental accounts in the gain region and negative hedonic consequences of closing mental accounts in the loss region, which is entirely consistent with the disposition effect.

Weber and Camerer (1998) investigate the disposition effect in an experimental setting. They identify the disposition effect by assuming the purchase price or the most recent price as the reference points. Weber and Camerer conjecture that subjects may even rely upon multiple reference points in making selling decisions. We argue that the reference point in the current mental account is related to both the purchase price and any subsequent price that investors have experienced to the extent of how much the reference point has updated toward any of those prior outcomes. Depending on which past prices have had a stronger effect on the current reference point with which investors make their liquidation decision, one may find a stronger disposition effect by assuming one reference point rather than another.

In a recent paper, Karlsson, Loewenstein, and Seppi (2005) developed a model where investors select whether to pay attention to their current portfolio value. The authors assumed that paying attention increases the speed of reference point adaptation, and they test the predictions of their model that investors are more likely to pay attention to their portfolios when the market is up than down. Their results indicate that the reference point adapts faster in rising markets than in falling ones, consistent with our findings. However, our results suggest that reference points adapt faster to gains than losses irrespective of whether the aggregate market rises or falls, implying that differences in attention in up or down markets are not the sole cause of asymmetric reference point adaptation.

Several theoretical models of asset pricing (Barberis, Huang, & Santos, 2001; Barberis & Huang 2001; Grinblatt & Han, 2005) take into account of the adaptation of reference points. In these models, reference points migrate symmetrically toward new outcomes. If individual investors adapt their reference point asymmetrically to gains and losses as we hypothesize, this would have far-reaching consequences for these theories of asset pricing.

V. Conclusion

In prospect theory (Kahneman & Tversky, 1979), the reference point plays a prominent role. Whenever one outcome follows another, the hedonic consequences of the second one depend in part on the adaptation of one's reference point to the first one. Heretofore there has not been a systematic investigation of the magnitude of adaptation of the reference point to a gain or loss. The purpose of our research has been to address this issue.

Our results lead us to conclude that reference point adaptation occurs more completely to gains than to losses. This result was obtained under a variety of circumstances, including questionnaire studies, investigations using financial incentives, and scenarios that included portfolios as well as individual stocks. In addition, we obtained evidence that adaptation occurs more quickly if a stock is sold and then repurchased at the prior selling price. We hypothesize that the more complete adaptation under these circumstances is due to the fact that the sale closes the prior "mental account" (Thaler, 1999), thus segregating it from the subsequent one. With a new mental account thus initiated, the purchaser can more fully adapt to the prior one. Without the sale, the prior mental account is not closed, and a new gain or loss is integrated with the prior one, thus stalling a person's adaptation to the prior one.

We attempted to relate the asymmetric adaptation of gains and losses to several aspects of investor behavior, including the house money effect (Thaler & Johnson 1990), the disposition effect (Shefrin, 2000), the sunk cost effect (Arkes & Blumer, 1985), and the "hedonic treadmill" (Brickman, et al., 1978). We have suggested that our results may also inform theories of asset pricing, including those pertaining to the equity premium puzzle. We are not, of course, the first to suggest that one adapts quickly to gains. According to George Bernard Shaw, "There are two tragedies in life. One is to lose your heart's desire. The other is to gain it." Although he did not express his view in the following terms, apparently Shaw felt that the gain of one's heart's desire shifts one's reference point sharply upward, making the attainment of the prize eventually seem much less glorious than anticipated.

Appendix A: Instructions to Participants: Optimal Strategy in Stating the Minimum Selling Price

Before the second period, you have a chance to sell your stock by stating your minimum selling price. A buying price will then be randomly drawn from a known range of stock prices (ranging from the lowest to the highest second period price). If the randomly drawn price exceeds or equals your minimum selling price, you will sell the stock at the randomly drawn price. If the randomly drawn price is less than your minimum selling price, you will hold the stock until the second period, and you will sell your stock at the second period stock price determined by a coin flip.

You form your minimum selling price based on possible future stock prices. Your minimum selling price is equal to the number of dollars that someone would have to pay you to make you just barely willing to sell the stock, instead of holding it until the second period. Therefore, *your minimum selling price is equal to what the stock is worth to you*: You prefer holding the stock if someone offers you a price lower than your minimum selling price, and you prefer selling the stock if someone offers you a price higher than your minimum selling price.

Your best strategy in submitting your minimum selling price is truthfully reporting what the stock is worth to you: it is not your advantage to submit your minimum selling price higher or lower than what the stock is worth to you.

To see why, suppose you are willing to sell the stock at or above $55 because you think the stock is worth $55 to you. If you submitted $53 for your minimum selling price and the randomly drawn buying price was $54, you would be forced to sell your stock at $54, resulting in a one-dollar loss for you ($\$55 - \$54 = \$1$). That is, you would be forced to sell the stock for $54 even though it is worth $55 to you. Thus, you don't want to ask only $53. In fact, if you ask a minimum selling price lower than $55, there is always a possibility that the randomly drawn buying price is below $55, forcing you to sell your stock at a price lower than your valuation of the stock. So you never want to submit the minimum selling price lower than your true stock valuation.

Now suppose you set your minimum selling price higher than $55, say, $57. If the randomly drawn buying price was \$56, you will lose a chance to sell the stock at \$56, because the price you asked (\$57) is higher than the price being offered (\$56). Had you asked a price of \$55 instead of \$57, you would have sold your stock for \$56 and have made a \$1 profit (\$56 − \$55 = \$1). In fact, if you ask a minimum selling price higher than \$55, there is always a possibility that the randomly drawn buying price is between your stock valuation (\$55) and what you submit as your minimum selling price, thus preventing a sale. By asking above \$55, you throw away possible profits in this situation.

Therefore, you don't want to submit a higher price than your true minimum selling price. These arguments confirm that the optimal strategy is always to set your minimum selling price equal to what the stock is worth to you. The purpose of our game is to study the stock valuations of different people. *Your task in the game is to decide what the stock is worth to you, taking into account what you are told about the future possible prices of the stock.*

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