Prospect Theory and the Disposition Effect

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Abstract

This paper shows that prospect theory is unlikely to explain the disposition effect. Prospect theory predicts that the propensity to sell a stock declines as its price moves away from the purchase price in either direction. Trading data, on the other hand, show that the propensity to sell jumps at zero return, but it is approximately constant over a wide range of losses, and increasing or constant over a wide range of gains. Further, the pattern of realized returns does not seem to stem from optimal after-tax portfolio rebalancing, a belief in mean-reverting returns, or investors acting on target prices.

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I. Introduction

Empirical studies convincingly show that investors are reluctant to realize losses, i.e., there is a disposition effect.[1] However, it is not clear why this effect exists. Knowledge regarding the causes of the disposition effect has implications for theoretical modeling of trading behavior. It has important practical implications as well, because prescriptive advice crucially depends on the extent to which the effect is caused by preferences, beliefs, or psychological biases.

Studies on the disposition effect typically motivate it by the S-shaped value function of Kahneman and Tversky's (1979) prospect theory.[2] An investor with prospect theory preferences becomes more risk-averse after experiencing gains, and risk-seeking after experiencing losses. This change in risk perception is thought to cause the disposition effect. Prospect theory thus has the role of a pure preference-based explanation for the disposition effect.

The disposition effect could also be caused by a rational response to new information. Portfolio rebalancing, belief in mean-reverting stock returns, and private information (or private

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[1] Evidence of the disposition effect has been found among individual stock market investors (e.g. Schlarbaum, Lewellen, and Lease (1978), Odean (1998)), institutional stock market investors (Grinblatt and Keloharju (2001)), stock market investors receiving brokerage advice (Shapira and Venezia (2001)), futures traders (Heisler (1994), Frino, Johnstone, and Zheng (2004), Locke and Mann (2005)), home owners (Genesove and Mayer (2001)) and in a laboratory experiment (Weber and Camerer (1998)). Dhar and Zhu (2006) show that certain investor characteristics reliably predict the tendency to engage in this behavior.

[2] For example, Odean (1998) attributes the disposition effect mainly to prospect theory: "The disposition effect is one implication of extending Kahneman and Tversky's (1979) prospect theory to investments" (p. 1776). Odean also considers alternative theories. Grinblatt and Keloharju (2001) and Genesove and Mayer (2001) offer prospect theory as the sole theoretical motivation for their results.

interpretation of public information) about a stock's fundamental value are information-based rational motives for trading that can produce disposition effects. The effect could also be driven by investor psychology. The original disposition effect model of Shefrin and Statman (1985) has other ingredients besides prospect theory: mental accounting, regret aversion, and self-control. Each ingredient serves to explain some aspects of investor behavior.

This paper attempts to assess the relative importance of prospect theory and other explanations for the disposition effect. A key insight is that studying in more detail how the propensity to sell a stock varies as a (possibly nonlinear) function of stock price, allows more powerful inferences for the causes of the disposition effect. Taking the purchase price to be the reference price in the value function, prospect theory implies that the propensity to sell a stock should decline as the stock price moves away from the purchase price in either direction. To empirically estimate the propensity to sell I run logit regressions where the dependent variable is the decision to sell, versus to hold, a stock. The independent variables of interest are indicators for the holding-period capital gain/loss over various ranges (2%, 5%, and 10% wide, depending on specification). The regressions are run for different holding periods, and they include a host of control variables, such as past returns.

The study uses an extensive data set containing all common stock trades of all Finnish household investors from January 1995 to May 2000. It is similar to the one used in Grinblatt and Keloharju (2001), except that it covers a longer time period. Having data on all investors avoids possible worries of the results being specific to particular groups of investors.

The findings are summarized as follows. Counter to the prospect theory prediction, the propensity to sell a stock does not decline as gains or losses increase. Rather, it is increasing or constant in the domain of gains, and remarkably insensitive to return over wide segments of losses. There is a jump in the propensity to sell exactly at zero capital gains. The pattern holds for holding periods spanning from one day to three years. It weakens approximately monotonically as holding periods lengthen, but remains statistically significant up to holding periods of three years. In these longer horizons the magnitude of the effect is roughly half of that in horizons of a few weeks. There is also some evidence of decreased propensity to sell with large gains of over 70% and over 100%, consistent with a capital gains tax lock-in effect.

The pattern of return realization is not predicted by reasonable parameterizations of the S-shaped value function of prospect theory. Parameterizations that imply a sale following small gains are either unrealistic, or do not predict that gains are realized over a wide range, as is empirically the case. Hence it is unlikely that the disposition effect is driven by prospect theory preferences. The analysis in this paper limits to the case of a constant reference price, as often assumed in the finance literature linking the disposition effect with prospect theory. The reference price could also be dynamic. However, the empirical results show that a reservation price corresponding to zero capital gain does not increase with the holding period.[3]

Complementary to the findings in this paper, a contemporaneous paper by Barberis and Xiong (2008) finds that a model of a prospect theory investor faces difficulties in predicting the empirical results of Odean (1998) on the frequency of realizing gains versus losses.[4] Barberis and Xiong propose a new theory in which investors derive prospect theory utility only from realized gains and losses and ignore paper gains and losses. They find that this specification more readily predicts the disposition effect.

[3] The reservation price gives a price level above which the investor is content to sell the asset. The reference price (or a reference point) is the level of wealth over which gains and losses are determined in prospect theory.

[4] See also Hens and Vlcek (2005).

Turning now to alternative hypotheses, I first observe that portfolio rebalancing in the presence of capital gains taxes cannot explain the empirical pattern. Second, a belief in mean-reversion is not able to account for the results. An investor who is acting on mean-reversion would tend to sell stocks with paper losses, if the stocks have been performing well recently. Correspondingly, the mean-reversion investor would hold on to stocks with paper gains, if they have been performing poorly recently. This would produce a reversed disposition effect for these stocks. This is not what the results show, however. In contrast to the mean-reversion hypothesis, outperformance actually decreases selling for loss-making positions.

Third, It does not appear that holding on to losing shares is due to investors acting on target prices, based on their subjective assessment of the stock's fair value. If investors trade based on target prices, then one would not expect the purchase price to be a target price, but rather some higher price. However, as mentioned, the results show that selling probability jumps at zero capital gain. Furthermore, the pattern is similar for stocks whose price path has deviated greatly from the purchase price during the holding period, compared to those with only a small deviation. Larger deviations should give more reason to update target prices.

Overall, the explanations investigated in this paper seem to face difficulties in accounting for the disposition effect. However, new preference- or information-based explanations, such as the one proposed by Barberis and Xiong (2008), could be developed to meet the challenges that the empirical facts present. Meanwhile, a story based on the psychological motive for self-justification, expressed in terms of avoiding regret in Shefrin and Statman (1985), and in terms of self-deception in Hirshleifer (2001), could offer a simple alternative explanation for the results: investors essentially hold on to losing stocks to avoid confronting the fact that the investment decision was wrong. The sharp switch in the tendency to sell around zero capital gains is consistent with reluctance to close mental accounts at a loss (Thaler and Johnson (1990)). The results further show that investors hold on to losing shares with a tighter grip, if they have recently outperformed the market. Perhaps investors become more committed to holding a loser stock if they perceive they are approaching the goal of breaking even? Such behavior would be consistent with the literature on the escalation of commitment (Staw (1981)).

However, it should be stressed that this paper does not present a test that has the power to refute the psychological explanation. Since it has not passed such a test, the psychological explanation should not be categorically preferred. The development of models for selling decisions should continue, while bearing in mind the new empirical observations.

In the remainder of the paper, Section II develops the connection between prospect theory and the disposition effect. Section III presents the data and methods. The empirical results are described in Section IV. Section V addresses alternative hypotheses and Section VI concludes.

II. Prospect Theory and the Sell versus Hold Decision

A. Base Case Parameterization

The prospect theory value function has been used by financial economists modeling asset allocation and pricing (e.g. Benartzi and Thaler (1995), Barberis, Huang, and Santos (2001), Berkelaar, Kouwenberg, and Post (2004)). The general form of the prospect theory value function is:

(1)
$$v(x) = \begin{cases} x^{\alpha} & \text{if } x \geq 0 \\ -\lambda(-x)^{\beta} & \text{if } x < 0 \end{cases}$$

where x is the gain with respect to the reference point, λ is the coefficient for loss aversion, and α and β are coefficients for risk aversion and risk seeking, respectively. Based on experiments, Tversky and Kahneman (1992) estimate λ to be 2.25, and both α and β to be equal to 0.88. In addition to the value function, prospect theory contains other elements, such as framing and probability distortion, but they have received less attention in finance studies.

The prospect theory value function coupled with additional assumptions results in predictions for investors' selling behavior. First, assume that investors reflect past and anticipated gains and losses relative to the purchase price of the stock. Secondly, assume that investors do not integrate returns across stocks, that is, they consider each stock separately. Given these assumptions, the investor is risk-seeking in the domain of losses, and risk-averse in the domain of gains, for each stock. These assumptions are made, either explicitly or implicitly, in the finance literature linking empirical evidence on the disposition effect with prospect theory.

In what follows, I demonstrate the implications of prospect theory preferences for an investor's motivation to enter, and exit from, a stock position. Consider an asset with a normally distributed return having an expected value of 12% and a standard deviation of 25%.[5] Now consider an investor with preferences given by (1), such that x, the gain with respect to the reference point, is specified as the percentage rate of return.[6] The parameters of (1) are those

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[5] I use an investment horizon of one year motivated by Benartzi and Thaler (1995), who show that prospect theory is consistent with the historical equity premium if investors evaluate their portfolios annually. In prospect theory objective probabilities are replaced by subjective decision weights. I assume, however, that the decision weights are equal to objective probabilities. This assumption is typically made in finance applications.

[6] In the language of prospect theory, the coding of gains and losses is part of the editing phase of the choice process, and it can be affected by the features of the decision problem and the expectations of the decision maker. Coding gains and losses in relative terms is consistent with the preference homogeneity assumption of Tversky and Kahneman (1992). As an alternative, I repeat the analysis coding gains and losses in euro, assuming a reference

estimated by Tversky and Kahneman. To obtain the prospect value of holding the risky asset one takes the expectation of the value function over the distribution of the asset return with respect to the reference point, i.e.,

$$\text{(2)} \qquad \text{Prospect value} = \int_{-\infty}^{+\infty} v(x) f(x) dx$$

where f is a probability density function of the return with respect to the reference point at the end of the investment horizon. In this example numerical integration yields a positive prospect value of 3.37 for the risky asset.

Now assume that the investor buys into this position, and consider what happens to the prospect value as the price of the asset changes. If the value of the asset falls by 2%, the distribution of x shifts to the left by 2%, and the prospect value of holding the position falls to 1.5. However, the value of liquidating the position, that is, a certain return of –2%, has a prospect value of –4.1, and the investor is thus better off holding the asset. If the asset price increases by 2%, the prospect value of the position will be 5.2, and liquidation value 1.8, in which case the investor will also hold the position.

Panel A of Figure 1 shows the prospect theory value function with the canonical parameterization (alpha = 0.88, beta = 0.88, and lambda = 2.25). The figure also shows the prospect value of selling the asset minus the value of holding, for a range of asset prices. This difference is negative for all asset prices, and the investor is thus always better off sticking with the risky investment. To motivate a sale, the risky investment must be less favorable than in the

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level of wealth of €1,000 which roughly corresponds to the value of a typical position in a single stock. The results are qualitatively the same.

example above. However, if it is initially valued at less than the risk-free asset, the investor will not take the position. This point is also made by Gomes (2005).

Now consider what happens if other factors, e.g. liquidity needs, cause a need to sell stocks. The difference between the value of selling and the value of holding as a function of asset price may then become important. This difference, as shown in Figure 1, can then be thought of as the propensity to sell the position; there is a local maximum close to zero (at 0.85% return). Although the propensity to sell decreases in both directions, it decreases at a faster rate in the loss domain.

In sum, for conventional value function parameters, prospect theory predicts no realizations of gains up to 30% return. An exogenous factor is needed to induce a sale. Considering conventional return ranges, the likelihood of a sale is greatest when the price is close to the purchase price, and it declines in both directions. The likelihood of a sale is lower for moderate losses than for moderate gains, which is consistent with the disposition effect.

B. Sensitivity Analysis

In this section I more formally investigate the prospect theory predictions for the tendency to realize gains and losses by way of numerical simulations. The distribution for the risky asset return is a discretized normal distribution, over a support of ±3 standard deviation units of return in increments of 0.2 standard deviations. I vary the parameters of the return distribution, as well as the value function, going through all parameter combinations. Expected return takes values of 8% to 14% in two percentage point increments, and volatility takes values of 15% to 40% in five percentage point increments. For beta and alpha I use a range of 0.5 to 1.0 in increments of 0.05; for lambda a range of 1.0 to 3.0 in increments of 0.1. I limit the analysis to cases in which the prospect value of the investment is initially greater than 1.5, i.e., greater than that produced by a risk-free investment at approximately 1.6% interest rate. In addition to the one-year investment horizon, I also consider three-month and two-year horizons.

The simulation results show that selling the stock for a gain anywhere in the range of 0 to 30% does not produce a higher utility than holding, assuming realistic value function parameters. Sales are only predicted in this return range with alpha or beta below 0.7, or, alternatively, lambda below 1.6. Panel B of Figure 1 shows an example of such a value function, with the associated prospect value of selling the asset minus the value of holding.

These restrictions on the value function parameters can even be relaxed somewhat if I require investors to realize smaller gains, instead of requiring merely that some gains over the range of 0 to 30% are realized. For example, an investor who realizes a 7% gain can not have a lambda greater than 1.2 (with alpha and beta greater or equal to 0.7), and an investor who realizes a 5% gain can not have a beta greater than 0.6. This implies that if selling for such gains does produce a higher utility than holding, then investors do not have this kind of value function.

Even if the prospect value of selling minus holding is always negative for gains up to 30% (i.e., no sales are predicted in that range), are there reasonable scenarios in which it would be higher for a wide range of gains than it is at the purchase price of the stock? In such a case, given an exogenous reason to sell, these gains would be more likely realized than zero returns. I investigate this issue by calculating the value of selling minus holding at a 30% return.

To obtain such a result, lambda must be 1.8 or lower, and beta must be 0.8 or lower. Furthermore, in scenarios that do pass this test, value(selling) – value(holding) at 30% is not much higher than value(selling) – value(holding) at 0. The maximum difference is 0.68 prospect value units. To get some feel for the magnitude, note that one prospect value unit approximately corresponds to an extra return of 1%. The result is easier to obtain with a two-year investment horizon, so limiting to the annual horizon produces slightly tighter bounds: a maximum lambda of 1.6, and a maximum difference of 0.32 prospect value units.[7]

The following points should be kept in mind when considering the implications of these scenarios on the link between the prospect theory value function and the disposition effect. First, an exogenous factor such as a liquidity shock is needed to induce a sale; a changing perception over risk as a function of return is generally not sufficient. Secondly, risk seeking in the loss domain has received mixed empirical support: Myagkov and Plott (1997) demonstrate that it diminishes when the experiment is repeated, and Laury and Holt (2005) find no support for risk seeking when using moderate monetary payoffs instead of hypothetical payoffs. Hence, one should be cautious in assuming an even stronger tendency for risk seeking (i.e., a β coefficient lower than the benchmark value of 0.88).

Finally, it is easier to obtain a prediction for a reversed disposition effect, than it is to obtain a prediction in which the propensity to sell would be elevated for a wide range of gains. For example, the propensity to realize losses of 20% is higher than the propensity to realize gains of 20% assuming alpha = 0.95, beta = 0.88, and lambda = 2.0.

[7] The prospect value of selling minus holding usually peaks just above zero. The maximum point can be pushed to occur at higher gains by decreasing beta and lambda, but it never occurs for gains greater than 11%. In almost all of these scenarios the propensity to sell declines fast for gains beyond the maximum, and is less for 30% gains than what it is at zero.

III. Data and Methods

A. Data Sources and the Sample

The primary data source for this study is the registry of share holdings and daily trades from the Finnish Central Securities Depository (FCSD) during December 27, 1994 through May 26, 2000. By the beginning of the sample period almost all publicly held firms in Finland had joined the registry and it covered 97% of the total market capitalization. All trades by all Finnish individual investors in the stocks that are participating in the registry are recorded. The records represent official certificates of ownership, and are thus very reliable. An otherwise similar data set, but covering a shorter time span, is used in Grinblatt and Keloharju (2000 and 2001), where the data are described in more detail.

Data on stock returns and closing prices are obtained from the Helsinki Stock Exchange and in some cases from Datastream. The returns are adjusted for stock splits as well as for stock and cash dividends.

The main sample is based on sell transactions of all individual investors in the market, as well as their corresponding other portfolio holdings that are not sold at the time of sale. The purchase prices, and hence all gains and losses used in the study, as well as the purchase dates, are determined based on first-in-first-out (FIFO) inventory accounting. This is consistent with the practice by Finnish tax authorities in calculating capital gains tax liabilities for stocks. In most cases, however, there is only a single purchase matching a sell, and thus only one possible definition for the purchase price. Buys and sells by the same investor in the same stock during the same day are netted. This means that if an investor buys 500 stocks of company A, and sells 200 of them during the same day, the data show a buy of 300 and no sale for the day. Transaction costs and taxes are ignored in the calculation of gains and losses. Realized returns are based on actual transaction prices, paper returns are based on the day's closing prices.

A complete inventory of holdings at the start of the sample period is available for each investor, but purchase prices are known only for buys that occur during the sample period. Hence all of the initial inventory must be liquidated before a sale can be included in the analysis. Excluding all sell and hold observations where FIFO purchase prices can not be determined, leaves a total of 3,871,863 observations. Of these, 889,235 (23%) are sales, and 2,982,628 are stocks that are being held when another stock is sold.

B. Methods

Similar to Grinblatt and Keloharju (2001), I use logit regressions to estimate the propensity to sell versus to hold a stock. The dependent variable takes the value of one for sales and zero for holds, and it is observed on days when the investor sells some stock. The dependent variable is regressed on a set of capital gain interval dummies and various control variables described below. A capital gain interval dummy indicates whether the realized percentage capital gain/loss from a sale, or paper gain/loss in the case of stocks that are held, resides within a particular interval. For example, the dummy for [5, 10] is equal to one when capital gain is greater or equal to 5% but less than 10%, and zero otherwise. The intervals that are used vary in the different regression specifications. The pattern of estimated coefficients for the capital gain interval dummies can be interpreted as giving the propensity to sell as a function of capital gain.

I separately estimate logit regressions for different holding-period intervals. For example, the results for a 3-day holding-period are based on stocks bought three days ago that are either held or sold on the observation day. In the case of the three-day holding-period, the interval is just one day. However, the interval is wider for longer holding periods. For example, for the holding-period interval labeled ‘4 months’, I consider sell and hold observations during the fourth month in the life of a stock purchase, i.e., for stocks bought 63 to 84 trading days ago. These holding-period intervals extend from one day to three years.

The t-statistics from the regressions are not corrected for possible dependencies across investor/stock/day combinations. However, the assumption of complete independence is unlikely to hold. As an alternative to the baseline logit regressions, I experiment, using a subset of the data, with alternative models that address possible dependencies in different ways. I run linear probability models with stock fixed effects, logit models with investor level random effects, and logit models correcting standard errors for clustering at the stock level. In all these models I use quarterly dummies to pick up possible time effects. The results are similar to the baseline logit regressions. In the paper I report the baseline specifications due to their smaller computational demands.

C. Control Variables

In the regression analyses I use various control variables, following Grinblatt and Keloharju (2001) in many respects. I include daily stock returns for the date of sale, and for each of the four days before it, as well as stock returns over longer intervals, specifically for days –19 to –5, –39 to –20, and –59 to –40. The market returns over corresponding intervals are also included. As a proxy for the market return I use the Helsinki Stock Exchange Portfolio Yield Index.

I include dummies for each month of the sample (except one) to control for changing market conditions, calendar effects, and trends in individual investors’ trading activity. Dummy variables for being at the one-month high or low stock price at the time of sale, trailing three-month volatility of the stock, as well as the market, logarithm of the investor’s portfolio value, and the length of the holding period in days are also included.

Grinblatt and Keloharju (2001) control for the effect of the number of stocks in the investor's portfolio by including a separate dummy indicating one, two, three, and so on, stocks, up to 35. I use a more parsimonious specification which, nevertheless, has practically identical explanatory power. Consider a simple model where the investor decides to sell something and then randomly selects which stock to sell. The probability of choosing a particular stock to sell is then $1 / N$, where N is the number of different stocks in the portfolio. This simple model suggests the use of the reciprocal of N in the regressions. However, comparing the results with a $1 / N$ variable to those obtained with 35 dummies in explaining the propensity to sell, shows that the fit is not very good for low values of N. In particular, $N = 1$ stands out. I find that using a separate dummy for each case with one to six stocks, and $1 / N$ for seven or more stocks, produces a pattern of predicted sales as a function of N, which is nearly identical to the one produced by 35 separate dummies.[8]

IV. Results

A. Effect of Holding-Period Length and the Size of Gain or Loss

In this section I present the results for running logit regressions for the subsamples constructed based on the length of the holding period. Figure 2 shows the probability of a sale as a function of capital gain/loss derived from the regression marginal effects for four representative holding-period intervals. The capital gain interval dummies cover returns of –50%

[8] I also experiment with other functional forms. A cubic model produces a slightly better overall fit for N between 1 and 35. This is mostly due to the range of N from around 15 to 30. However, unlike the specification with $1 / N$, it is not directly connected to a model of selling propensity. Furthermore, the predicted values start to decline in the higher ranges of N and become completely unreasonable when N exceeds 50.

to +50% in two percent intervals. Note that observations are conditional on a sale occurring. The general level of these probabilities is therefore a function of the average number of stocks in investors' portfolios. For example, if investors on average held 2.5 stocks, the baseline probability of selling one of the stocks, conditional on selling something, would be 1 / 2.5 = 0.4.

The results show, in line with earlier studies, that the likelihood of a sale is much higher if a gain is realized. These results in Figure 2 are shown only for some representative holding-period ranges and use 2% capital gain intervals. Unreported results for 36 different holding-period intervals, ranging from 1 day to over 36 months, and using more coarse capital gain intervals (10% from zero to ±30% returns, 20% and 30% intervals thereafter), show that the effect remains significant up to holding-period horizons of three years, but weakens toward the longer holding periods. Avoiding realization of losses continues to be statistically significant for holding periods of over 36 months, but only for losses in excess of 20%.

There are some exceptions to the general tendency to realize gains: large capital gains relative to the length of the holding period are associated with a lower propensity to sell. The dummy for a capital gain in excess of 100% is negative and significant in most cases up to holding periods of 29 months. When holding periods between two weeks and two years are considered (i.e. the very short and long ends of the scale are excluded), an average value of –0.43 is obtained for the coefficient. For comparison, the corresponding figure for losses in the interval [–10, 0], is –0.61. The interval [70, 100] is either significantly negative, or not significantly different from zero, up to holding periods of seven months. For shorter holding periods the magnitude of the coefficient is roughly half that of small losses. The coefficient for the interval [50, 70] is negative up to holding periods of 10 weeks.

The negative effect on the propensity to sell by these larger capital gains is consistent with a capital gains tax lock-in effect. However, the effects found here are not as strong as in Ivković, Poterba, and Weisbenner (2005). This is probably because their analysis focuses on stock purchases worth over $10,000 and holding periods of over 12 months.

B. Prospect Theory and Reservation Prices

Table 1 shows the results for a 2% partition for the capital gain intervals in the range from –10% to 10%. There is a strong pattern: in all cases but one (6 months) up to 11 months the coefficient for a small loss (up to 2%) is significantly negative compared to the omitted dummy (a profit of 0 to 2%). This jump in the propensity to sell is consistent with the distribution of realized returns plotted in Grinblatt and Keloharju (2001), as well as the unreported analysis described in their footnote 5, p. 600.

The propensity to sell generally increases with the amount of gain. Figure 2 shows the results covering a larger range of returns (from –50% to 50%) for some representative holding-period ranges. The empirical return realization pattern is not commensurate with the prospect theory prediction using conventional parameterizations, which implies that the propensity to sell should decline as the stock price moves away from the purchase price in either direction. Therefore, changing risk perception alone can not account for the disposition effect.

These results also provide evidence on the possible evolution of reference points through time. Barberis, Huang, and Santos (2001) and Barberis and Huang (2001) model the reference price as increasing at the risk-free rate. As argued earlier, a reference price of zero does not generally induce a sale close to zero return (a reservation price close to purchase price), but an increase in the reference price of, say, 4% per annum, should still cause the reservation price to grow at 4%. This is nevertheless not supported by these data. The results show that coefficients for the two percent intervals in the range of 2% to 10% are all diluted in a similar manner as the holding period lengthens; the point of discontinuity in the propensity to sell does not move higher.

If anything, the reservation price may be declining. For holding periods beyond one year, the coefficients for [–2, –0] are insignificant, and some are positive. Yet the coefficients for [–4, –2], and other lower intervals, remain negative, and many significantly so. The largest decrease in the propensity to sell between adjacent 2% intervals occurs at zero, for holding periods from five days up to a year, in 19 out of 23 cases. For holding periods of one through four days, the largest decrease occurs at 2%, and for holding periods beyond one year it occurs more often on a negative than positive capital gain.

Reference price dynamics could be more complex. Arkes et al. (2008) find that the reference point moves with prior gains and losses, and that the adjustment is asymmetric: people more easily adapt to gains than losses. Testing for this type of dynamics requires conditioning on the price path, and provides an interesting topic for future research.

C. Prospect Theory with Liquidity Shocks

As shown in Section II, prospect theory fares somewhat better at predicting a weaker condition in which no sales occur solely based on changing risk perception, but in which the propensity to sell is nevertheless higher for a wide range of gains than it is at the purchase price. Selling would be triggered by a liquidity shock, and the investor would choose which stock to sell considering prospect value. However, prospect theory is unable to produce a large increase in the propensity to sell when comparing 30% gains to zero gains. The data, on the other hand, show a substantial increase. Note also that while prospect theory does more readily predict this weaker condition, the required value function parameters may still be unrealistic (see Section II for a discussion).

To further assess the explanatory power of prospect theory combined with liquidity shocks, I conduct an analysis of investors who hold only one stock. By definition, these investors do not get to choose which stock to sell when faced with a liquidity shock. Assuming liquidity shocks are at least not positively correlated with returns, these investors should not show an increased propensity to realize gains if their selling behavior is governed by prospect theory.

I test this prediction by counting the realizations of losses (returns in [–5%, 0[ ) and gains (returns in [0, +5%]), normalized by all realizations in [–5%, +5%]. The logit regression methodology used earlier is not applicable to single stock investors. I use data for holding periods of more than two weeks and less than three months. The results show that 65.2% of single stock investors' realizations in the return interval [–5%, +5%] are gains. Note that there are somewhat more gains than losses available for realization, 52.4% vs. 47.6%. The corresponding figure for investors with at least two different stocks to sell is 65.0%. The difference to 65.2% is insignificant in a test for the difference in proportions. The results are similar with alternative definitions of return intervals.

In sum, single-stock investors appear to behave like multi-stock investors with respect to small losses/gains, which does not support the idea that prospect theory combined with liquidity shocks determines selling behavior.

V. Alternative Explanations

A. Portfolio Rebalancing with Capital Gains Taxes

Capital gains taxation of individual stock market investors in Finland is implemented with a flat tax rate on realized capital gains.[9] Assuming zero transaction and short selling costs, Constantinides (1983) shows that the optimal strategy is to realize all losses as they occur and defer all capital gains. When there are short selling restrictions, Dammon, Spatt, and Zhang (2001) show that it is sometimes optimal to realize even substantial gains, and all losses should still be realized. The incentive to realize gains to rebalance the portfolio is inversely related to the size of the gain. Reaping the full benefit of loss realization is only possible if wash sales are allowed. In Finland wash sales were effectively allowed during the sample period: there was no explicit prohibitive regulation, and the tax authorities did not interfere, based on more general grounds (Grinblatt and Keloharju (2003)).

Therefore, normative behavior in the presence of capital gains taxes, short selling restrictions, and a goal of maintaining portfolio diversification entails realizing all losses, as well as realizing some of the gains, so that the likelihood of realizing a gain declines with the size of the gain. However, this is clearly not what the data show.

B. Belief in Mean Reversion

Investors may sell winning stocks and hold on to losing stocks simply because they expect prior returns to reverse in the future, i.e. stocks that have gone down would outperform those that have gone up (Odean (1998)). This idea is also motivated by experimental evidence (Andreassen

[9] During the sample period the capital gains tax rate was initially 25%. It was then raised to 28% in the beginning of 1996, and to 29% in the beginning of 2000.

(1988)). An investor who is acting on mean-reversion would tend to sell outperforming stocks, and hold underperforming stocks, regardless of whether this leads to realizing gains or losses. In particular, this applies also to stocks with paper losses and good recent performance, as well as stocks with paper gains and bad recent performance. Acting on mean-reversion would produce a reversed disposition effect for these stocks.

To test the impact of mean-reversion beliefs, the sample is divided into under- and overperforming stocks based on the past return of the stocks sold, or held. A one-month interval is used for measuring past returns, motivated by prior evidence of investor behavior (Odean (1999), Grinblatt and Keloharju (2000)).

Table 2 shows that investors are reluctant to realize losses, regardless of whether the stock outperforms or underperforms the market during the preceding month. There is again the abrupt change in the tendency to sell around zero capital gain for both groups. Overall, the signs of the significant coefficients are the same for positive and negative excess return stocks, except for very high capital gains (over 100%). Investors tend to sell recently underperforming stocks at a loss more than recently outperforming stocks at a loss. The differences are intensified for larger losses (over 20%) and for holding periods of 15 weeks and longer.

These results clearly reject the hypothesis that a belief in mean reversion induces investors to avoid realizing losses. Not only is the tendency to sell both outperforming and underperforming stocks greatly reduced with capital losses, as opposed to gains, but the tendency is reduced even more in outperforming stocks, compared to underperforming stocks. Grinblatt and Keloharju (2001) show that a belief in mean reversion cannot be the only cause for avoiding the realization of losses. My results further show that the effect of mean-reversion is not even marginally towards the hypothesized direction.

As a check of robustness, I repeat the analysis with alternative definitions of good and bad prior performance. For example, to classify prior performance as good, I require returns of over 5%, instead of zero; or instead of returns during only the past four weeks (days –19 to –1), I require that also the return over days –1 to –4 is positive. Most of the above analysis is also performed using raw returns in place of market-adjusted returns. I also run the analysis requiring positive performance based on both raw and market-adjusted returns simultaneously. The results remain similar.

C. Belief in Target Prices

An investor with private information about a stock's value may have a propensity to realize gains and avoid realizing losses (Lakonishok and Smidt (1986)). An informed investor will buy undervalued stocks, and sell as the market later incorporates the positive information in the stock price. Even if all investors have the same information, they may interpret it differently to reach a subjective estimate of the stock's value (Harris and Raviv (1993)).

Assume that the investors' interpretation of new information correlates positively with that of the market, but not perfectly so. As an example, consider the target prices issued by security analysts in their recommendations. Brav and Lehavy (2003) show that the analysts' consensus target price changes less often than the market price, but the changes are correlated with market price changes. The cumulative price changes of the stock are a direct measure of what the market perceives the net effect of the new information to be. Therefore, the further the market price deviates from the purchase price, the more likely it is that the investor's subjective valuation also changes. Even if the stock later returns to purchase price, subjective value is likely to be different than initially, because the market price and the investor's subjective valuation level do not move in lockstep.

In sum, the following two predictions can be derived from the subjective valuation hypothesis. First, the target price should be above purchase price. Second, as the price moves significantly in either direction, the investor's original target price is more likely to lose its status as a reservation price.

The results presented earlier already refute the first prediction by showing that selling probability jumps at the purchase price. To test the second prediction, I divide the sample, based on how far the price deviates from the purchase price during the holding period. I locate the minimum and maximum prices during the holding period (excluding the date of sale), and calculate the absolute value of the distance from the purchase price to the highest or lowest point, whichever is farther from the purchase price.[10] I then divide the observations into terciles based on the price deviation. For example, the maximum absolute deviation is at least 33.9% for the high deviation group, and less than 15.2% for the low deviation group, for holding periods of five to eight weeks. The number of observations is, however, different in these groups because of differences in the number of missing observations.

The results in Table 3 show no marked differences in the propensity to sell losers between the groups of low and high price deviations during the holding period. This provides further evidence against the idea that holding on to losing stocks is due to investors acting based on preset target prices. The effect is statistically more robust in the low deviation group. Higher t-

[10] This measure correlates with return volatility, but there are nevertheless important differences. To highlight these, consider an arithmetic binomial price process, with price changes either plus or minus one unit for each step. A price path of 20 alternating positive and negative steps has the same volatility as another path with 10 successive positive steps followed by 10 negative steps, yet the greatest deviation from the starting point is one unit in the former case but 10 units in the latter.

statistics are probably to some extent explained by the fact that almost all observations in that group fall within the range covered by the dummy coefficients, from –20% to 20%, while many of the observations in the high deviation group fall outside the range.[11]

The results for positive capital gains show that winners are more readily sold in the low deviation group. The tendency is exacerbated for smaller gains and shorter holding periods. This finding might be explained by investors increasing their target prices for stocks with high deviations from the purchase price. Even if one is willing to accept this conjecture, the target price explanation would face difficulties, as investors do not seem to be willing to lower their target prices below purchase price.

D. Discussion of Psychological Factors

In the original treatment of the disposition effect in Shefrin and Statman (1985), also other factors besides prospect theory preferences can cause the disposition effect. In particular, they present a purely psychological explanation. According to it, investors seek pride and try to avoid regret, and these feelings are triggered by the final outcome from the investment, i.e., the proceeds from the sale. Realizing a loss would prove that their purchase decision was wrong, and investors want to avoid recognizing this. This leads to a disposition to realize gains and defer the realization of losses. Hirshleifer (2001) expresses a similar idea in terms of self-deception: investors avoid realizing losses because they avoid recognizing indicators that signal low decision ability. These ideas are closely related to psychological self-justification, originating from the research on cognitive dissonance (Festinger (1957)).

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[11] There is also a significantly negative coefficient estimate of –0.82 for a return in excess of 20% in the high deviation group for holding periods of 5 to 8 weeks. This is driven by a very small number of observations with a

Some aspects of mental accounting (Thaler (1980), Tversky and Kahneman (1981)) are also related to this discussion. According to Shefrin and Statman (1985), having to close a mental account at a loss is "the major obstacle standing in the way of loss realization" (p. 781). Thaler (1998) argues that a realized loss is more painful than a paper loss, as it involves 'declaring' the loss to oneself. Thaler and Johnson (1990) find that people have a strong desire to break even when losing.

Literature on organizational behavior describes how people can become entrapped in a losing course of action (see e.g. Staw (1981)). That literature argues that a major contributor to remain entrapped is the belief that one is very close to the goal (see e.g., Rubin and Brockner (1975)). Arkes and Blumer (1985) observe that people give higher estimates on the probability of success for a project, if it involves sunk costs. Self-justification is one of the leading explanations for these behaviors (Brockner (1992)).

As others have argued before, this psychological view is consistent with the existing evidence on the disposition effect. This paper has not, however, attempted to present conclusive tests of its validity, nor derived finer implications that could perhaps differentiate between the various psychological aspects. Nevertheless, two facets of the results of this paper seem to lend themselves to a psychological interpretation. First, the switch in the tendency to sell around zero capital gains is consistent with a reluctance to close mental accounts at a loss. Second, the increased tendency to hold on to recently outperforming stocks trading below purchase price is consistent with hoping to draw near the goal.

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return in excess of 20%, as the maximum deviation *excluding the date of sale* is capped at 15.2% in this group.

VI. Conclusion

Prospect theory, in a form typically used in the finance literature, is unlikely to explain the disposition effect. First, the empirical propensity to sell a stock is increasing or approximately constant as the gain increases, whereas a reasonable parameterization of a prospect theory value function predicts that the propensity to sell will decline as the gain increases. Second, the empirical propensity to sell is approximately constant in the domain of losses, while prospect theory again predicts it will decline as the loss increases. Prospect theory combined with exogenous liquidity shocks does predict that more gains are realized than losses. But even in that case, prospect theory predicts that the propensity to sell declines as the stock price moves away from the purchase price in either direction, a prediction that is clearly rejected by the data.

Alternative rational explanations of the disposition effect do not fare well either. The empirical realization pattern is very different from that predicted for an investor considering taxes and portfolio rebalancing. Holding on to losing shares is not motivated by a belief in mean-reverting returns; the marginal tendency to realize a loss is actually smaller if a stock has recently outperformed the market. Finally, it does not appear that holding on to losing shares is due to investors acting on target prices, based on their subjective assessment of the stock's fair value.

Given the evidence discussed above, the question of what causes the disposition effect remains. Overall the findings seem consistent with a psychological interpretation of the disposition effect offered by e.g. Shefrin and Statman (1985) and Hirshleifer (2001). According to it, investors essentially hold on to losing stocks to avoid confronting the fact that the investment decision was wrong. This is an application of self-justification theory. However, although the results are consistent with the psychological story, the present paper has not subjected it to a test by which it can be refuted. Therefore, while rational explanations face challenges in accounting for the evidence, pronouncing them dead would be premature.

This work points out the need for further research in the following areas. First, while this paper has concentrated on average behavior, investor heterogeneity should be analyzed in this respect. For example, in the model of Grinblatt and Han (2005) there are two types of agents – disposition and rational investors. Investors may also differ in regard to the causes of the disposition effect. Secondly, theoretical models of the disposition effect should aim not only at explaining why more gains than losses are realized, but at accounting also for the patterns documented in this paper.

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Table 1

Capital Gain Interval Dummies for Various Holding Periods in Sell vs. Hold, 2% Ranges

The table reports coefficients (Panel A) and t-values (Panel B) from a logit model estimated by maximum likelihood. The data sample is based on the trades of all Finnish household investors during January 1995 to May 2000, and consists of the returns from stocks held (paper returns), and sold (realized returns), for those investor-date combinations where at least one stock is sold. The dependent variable is 1 for the (investor, date, stock) triplet if the investor sells the stock that day, otherwise 0. Capital gains and purchase dates are calculated with FIFO accounting. Independent variables are the capital gain interval dummies reported in the table, as well as unreported additional capital gain interval dummies in 10% intervals to +/–30%, dummies for >30% and <–30% capital gain, and control variables described in Section III.C. A capital gain interval dummy indicates whether the percentage capital gain resides within a particular interval. Realized returns are based on actual transaction prices, paper returns are based on the day's closing prices. 'Holding interval' refers to a range of values for time since purchase. For example, '4 months' includes stocks bought 63 to 84 trading days ago, counting back from the day of the observation. The median Nagelkerke R-Square is 0.34, and it ranges between 0.31 and 0.46. Asterisks mark the statistical significance levels (** for 1% and * for 5%, respectively).

Panel A: Coefficient Values										
	Coefficients for Capital Gain Interval Dummies, Ranges Specified in Brackets									
Holding interval	[-10, -8]	[-8, -6]	[-6, -4]	[-4, -2]	[-2, -0]	[2, 4]	[4, 6]	[6, 8]	[8, 10]	N
1 day	-0.53**	-0.54**	-0.51**	-0.68**	-0.75**	0.87**	1.21**	1.29**	1.35**	54,690
2 days	-0.23**	-0.3**	-0.54**	-0.57**	-0.62**	0.71**	0.92**	1.20**	1.18**	46,726
3 days	-0.36**	-0.35**	-0.41**	-0.44**	-0.48**	0.57**	0.86**	0.99**	1.11**	43,691
4 days	-0.16	-0.58**	-0.42**	-0.44**	-0.49**	0.66**	0.81**	1.03**	0.95**	39,944
5 – 6 days	-0.34**	-0.46**	-0.47**	-0.51**	-0.55**	0.49**	0.72**	0.80**	0.89**	74,212
7 – 8 days	-0.42**	-0.36**	-0.62**	-0.45**	-0.50**	0.36**	0.62**	0.85**	0.78**	68,406
9 – 10 days	-0.50**	-0.48**	-0.49**	-0.58**	-0.54**	0.30**	0.55**	0.68**	0.83**	63,476
2 weeks	-0.61**	-0.68**	-0.61**	-0.57**	-0.52**	0.21**	0.40**	0.58**	0.67**	144,400
3 weeks	-0.60**	-0.52**	-0.61**	-0.49**	-0.49**	0.34**	0.49**	0.57**	0.61**	130,252
4 weeks	-0.52**	-0.59**	-0.57**	-0.47**	-0.50**	0.25**	0.37**	0.59**	0.48**	114,199
5 weeks	-0.63**	-0.60**	-0.42**	-0.51**	-0.36**	0.28**	0.4**	0.47**	0.64**	101,792
6 weeks	-0.69**	-0.52**	-0.56**	-0.50**	-0.45**	0.28**	0.37**	0.48**	0.62**	93,738
7 weeks	-0.62**	-0.73**	-0.70**	-0.48**	-0.62**	0.15*	0.28**	0.44**	0.46**	85,895
8 weeks	-0.61**	-0.70**	-0.63**	-0.60**	-0.46**	0.22**	0.29**	0.42**	0.42**	79,829
9 – 10 weeks	-0.86**	-0.78**	-0.77**	-0.65**	-0.53**	0.04	0.15**	0.24**	0.36**	140,793
11 – 12 weeks	-0.61**	-0.67**	-0.57**	-0.39**	-0.41**	0.18**	0.35**	0.36**	0.42**	120,940
13 – 14 weeks	-0.75**	-0.60**	-0.56**	-0.47**	-0.49**	0.11	0.29**	0.27**	0.32**	107,495
15 – 16 weeks	-0.61**	-0.56**	-0.36**	-0.33**	-0.26**	0.32**	0.38**	0.46**	0.5**	92,185
17 – 18 weeks	-0.54**	-0.50**	-0.59**	-0.59**	-0.42**	0.17*	0.14	0.31**	0.24**	83,674
4 months	-0.54**	-0.56**	-0.50**	-0.47**	-0.4**	0.14*	0.18**	0.22**	0.28**	167,718
5 months	-0.53**	-0.49**	-0.40**	-0.27**	-0.22**	0.27**	0.27**	0.35**	0.37**	147,739
6 months	-0.60**	-0.12	-0.21**	-0.28**	-0.13	0.44**	0.23**	0.34**	0.56**	141,530
7 months	-0.59**	-0.43**	-0.32**	-0.44**	-0.34**	0.17*	0.04	0.04	0.34**	122,823
8 months	-0.53**	-0.28**	-0.40**	-0.24**	-0.29**	0.10	-0.12	0.3**	0.15	108,426
9 months	-0.46**	-0.46**	-0.60**	-0.34**	-0.47**	0.02	0.18	0.22*	0.24*	97,756
10 months	-0.40**	-0.27*	-0.34**	-0.20	-0.36**	0.09	0.16	0.13	0.10	95,165
11 months	-0.34**	-0.23*	-0.48**	-0.28*	-0.36**	0.13	-0.19	-0.08	-0.18	91,738
12 months	-0.49**	-0.23	-0.31*	-0.13	-0.17	0.04	0.32**	0.34**	-0.50**	86,121
13 – 14 months	-0.44**	-0.20*	-0.22*	-0.15	0.00	0.29**	0.08	0.11	0.04	143,113
15 – 16 months	-0.52**	-0.31*	-0.30*	-0.36**	-0.16	0.04	0.05	-0.03	0.12	108,500
17 – 18 months	-0.41**	-0.10	-0.59**	-0.29*	-0.12	0.01	0.12	0.05	0.21	79,208
19 – 20 months	-0.40**	-0.22	-0.12	-0.33*	0.17	0.24	0.22	0.28*	0.37**	63,321
21 – 23 months	-0.32*	-0.50**	-0.38*	-0.16	0.11	0.34*	0.17	0.32*	0.33*	78,705
24 – 29 months	-0.76**	-0.77**	-0.21	-0.41**	-0.26	0.10	0.08	0.14	0.05	109,689
30 – 35 months	-0.29	-0.62**	-0.55**	-0.85**	-0.13	0.08	0.33	0.31	0.56**	59,271
Over 36 months	-0.31	-0.23	0.32	-0.14	-0.12	0.02	-0.29	-0.04	0.13	61,788

Table 1 Continued

Panel B: T-Statistics										
	T-Statistics for Capital Gain Interval Dummies, Ranges Specified in Brackets									
Holding interval	[-10, -8]	[-8, -6]	[-6, -4]	[-4, -2]	[-2, -0]	[2, 4]	[4, 6]	[6, 8]	[8, 10]	N
1 day	-6.3	-7.8	-9.1	-14.6	-19.3	24.9	28.8	25.2	21.5	54,690
2 days	-2.8	-4.3	-8.8	-10.8	-13.0	16.8	19.5	22.2	18.4	46,726
3 days	-4.2	-4.9	-6.6	-7.7	-9.4	12.2	17.3	17.7	17.9	43,691
4 days	-1.8	-7.3	-6.2	-7.2	-8.4	13.0	14.8	17.0	14.1	39,944
5 – 6 days	-5.4	-7.9	-9.0	-10.9	-12.0	12.2	16.9	16.9	17.5	74,212
7 – 8 days	-6.5	-5.9	-11.0	-8.7	-9.8	7.9	13.1	16.9	14.4	68,406
9 – 10 days	-7.1	-7.3	-8.2	-10.3	-9.6	5.9	10.7	12.8	14.9	63,476
2 weeks	-12.5	-14.8	-14.5	-14.7	-13.6	6.2	11.9	16.2	17.7	144,400
3 weeks	-11.0	-10.3	-12.4	-10.8	-10.8	8.7	12.2	14.2	14.5	130,252
4 weeks	-8.7	-10.3	-10.8	-9.4	-9.5	5.6	8.3	13.1	10.0	114,199
5 weeks	-9.6	-9.6	-7.2	-8.8	-6.4	5.6	7.8	8.8	11.9	101,792
6 weeks	-9.4	-7.5	-8.6	-8.0	-7.2	5.2	6.5	8.4	10.7	93,738
7 weeks	-8.3	-10.0	-9.9	-7.2	-9.0	2.6	4.7	7.2	7.3	85,895
8 weeks	-7.7	-8.8	-8.3	-8.2	-6.4	3.4	4.6	6.5	6.4	79,829
9 – 10 weeks	-13.7	-13.0	-13.1	-11.6	-9.6	0.8	3.1	4.8	7.1	140,793
11 – 12 weeks	-8.9	-9.8	-8.8	-6.5	-6.4	3.1	6.1	6.2	7.2	120,940
13 – 14 weeks	-9.8	-8.5	-8.0	-6.9	-7.0	1.8	4.7	4.4	5.1	107,495
15 – 16 weeks	-7.0	-6.5	-4.5	-4.2	-3.3	4.5	5.2	6.4	6.9	92,185
17 – 18 weeks	-6.2	-5.7	-6.7	-6.7	-4.9	2.2	1.8	4.1	3.2	83,674
4 months	-8.4	-8.9	-8.1	-7.6	-6.5	2.4	3.3	4.1	5.1	167,718
5 months	-7.2	-6.8	-5.5	-3.9	-3.2	4.3	4.3	5.5	5.9	147,739
6 months	-7.3	-1.5	-2.7	-3.7	-1.7	6.3	3.2	5.0	8.1	141,530
7 months	-6.8	-5.2	-3.9	-5.4	-4.0	2.1	0.5	0.5	4.4	122,823
8 months	-5.8	-3.0	-4.4	-2.6	-3.1	1.1	-1.4	3.5	1.7	108,426
9 months	-4.2	-4.3	-5.7	-3.3	-4.2	0.2	1.9	2.2	2.5	97,756
10 months	-3.6	-2.5	-3.1	-1.9	-3.1	0.9	1.6	1.3	1.0	95,165
11 months	-2.9	-2.0	-3.9	-2.4	-2.8	1.1	-1.6	-0.7	-1.5	91,738
12 months	-4.0	-1.9	-2.4	-1.1	-1.4	0.4	2.8	3.1	-4.1	86,121
13 – 14 months	-4.6	-2.1	-2.1	-1.5	0.0	3.2	0.9	1.2	0.4	143,113
15 – 16 months	-4.4	-2.6	-2.4	-3.0	-1.3	0.3	0.4	-0.3	1.1	108,500
17 – 18 months	-3.1	-0.8	-4.2	-2.2	-0.8	0.0	1.0	0.4	1.6	79,208
19 – 20 months	-2.7	-1.5	-0.8	-2.3	1.3	1.9	1.6	2.0	2.8	63,321
21 – 23 months	-2.2	-3.4	-2.5	-1.0	0.7	2.3	1.1	2.2	2.2	78,705
24 – 29 months	-5.8	-5.6	-1.7	-3.0	-1.9	0.7	0.7	1.1	0.4	109,689
30 – 35 months	-1.6	-3.3	-2.8	-4.8	-0.7	0.4	1.8	1.6	2.9	59,271
Over 36 months	-1.2	-0.9	1.3	-0.6	-0.4	0.1	-1.1	-0.2	0.6	61,788

Table 2

Capital Gain Interval Dummies for Subsamples Formed Based on Positive versus Negative Prior Performance

The table reports coefficients (Panel A) and t-values (Panel B) from a logit model estimated by maximum likelihood. The data sample is based on the trades of all Finnish household investors during January 1995 to May 2000, and consists of the returns from stocks held (paper returns), and sold (realized returns), for those investor-date combinations where at least one stock is sold. The dependent variable is 1 for the (investor, date, stock) triplet if the investor sells the stock that day, otherwise 0. Capital gains and purchase dates are calculated with FIFO accounting. Independent variables are the capital gain interval dummies reported in the table, as well as unreported control variables described in Section III.C. A capital gain interval dummy indicates whether the percentage capital gain resides within a particular interval. Realized returns are based on actual transaction prices, paper returns are based on the day's closing prices. The left (right) side of the Table presents results for cases where the return in excess of market over days –1 to –19 is positive (negative). 'Holding interval' refers to a range of values for time since purchase. The median Nagelkerke R-Square is 0.30, and it ranges between 0.26 and 0.37. Asterisks mark the statistical significance levels (** for 1% and * for 5%, respectively).

Panel A: Coefficient Values								
	Excess Return > 0 in Prior Four Weeks				Excess Return < 0 in Prior Four Weeks			
Holding Interval, Weeks	5 to 8	9 to 14	15 to 24	25 to 42	5 to 8	9 to 14	15 to 24	25 to 42
Dummies for Capital Gain Intervals								
<-70		-1.28	-2.23**	-2.00**	-1.72**	-1.23**	-0.39	-0.92**
[-70, -50]	-1.56**	-1.73**	-1.59**	-1.17**	-0.86**	-0.94**	-0.22**	-0.14*
[-50, -30]	-0.90**	-1.28**	-1.17**	-1.04**	-0.81**	-0.86**	-0.46**	-0.25**
[-30, -20]	-0.87**	-1.07**	-1.00**	-0.78**	-0.84**	-0.91**	-0.46**	-0.30**
[-20, -10]	-0.90**	-0.98**	-0.92**	-0.84**	-0.76**	-0.81**	-0.46**	-0.53**
[-10, -5]	-0.79**	-0.88**	-0.84**	-0.73**	-0.73**	-0.70**	-0.46**	-0.37**
[-5, 0]	-0.67**	-0.64**	-0.68**	-0.52**	-0.66**	-0.58**	-0.34**	-0.37**
[5, 10]	0.35**	0.22**	0.20**	0.28**	0.23**	0.14**	0.19**	0.06
[10, 20]	0.44**	0.40**	0.32**	0.28**	0.28**	0.15**	0.26**	0.14**
[20, 30]	0.44**	0.37**	0.27**	0.23**	0.32**	0.27**	0.30**	0.13**
[30, 50]	0.43**	0.30**	0.23**	0.29**	0.31**	0.25**	0.21**	0.27**
[50, 70]	0.25**	0.19**	0.16**	0.24**	0.35**	0.29**	0.19**	0.25**
[70, 100]	-0.08	0.20**	0.05	0.06	0.20	0.33**	0.13*	0.19**
>100	-0.35**	-0.17**	-0.46**	-0.56**	0.27	0.24**	-0.25**	-0.16**
Panel B: T-Statistics								
<-70		-1.2	-2.6	-5.5	-2.8	-10.2	-1.6	-6.5
[-70, -50]	-2.9	-8.3	-11.8	-13.0	-13.0	-15.7	-3.6	-2.5
[-50, -30]	-9.1	-17.8	-18.8	-18.2	-19.4	-20.5	-10.1	-6.0
[-30, -20]	-14.3	-19.1	-17.9	-15.7	-22.1	-21.1	-10.7	-7.8
[-20, -10]	-20.8	-23.3	-20.3	-20.6	-24.5	-23.9	-13.3	-15.7
[-10, -5]	-19.7	-20.9	-16.8	-14.7	-22.7	-20.1	-12.2	-9.6
[-5, 0]	-19.6	-17.2	-15.2	-10.7	-21.9	-17.1	-9.0	-9.7
[5, 10]	13.0	7.3	5.5	6.9	7.5	4.3	5.3	1.5
[10, 20]	17.4	14.4	9.9	7.7	9.4	5.0	7.8	4.2
[20, 30]	15.0	11.8	7.8	6.3	7.2	6.9	8.2	3.7
[30, 50]	13.9	9.4	6.9	8.2	6.2	6.0	5.6	7.5
[50, 70]	6.3	4.6	4.1	6.1	4.0	4.7	3.8	5.5
[70, 100]	-1.8	4.2	1.1	1.6	1.6	4.9	2.3	4.0
>100	-6.3	-3.2	-9.6	-15.3	1.9	3.3	-4.9	-3.7
N	162,869	166,146	169,144	218,493	179,239	183,128	200,200	258,022

Table 3

Capital Gain Interval Dummies for Subsamples Formed Based on High versus Low Deviation from Purchase Price

The table reports coefficients (Panel A) and t-values (Panel B) from a logit model estimated by maximum likelihood. The data sample is based on the trades of all Finnish household investors during January 1995 to May 2000, and consists of the returns from stocks held (paper returns), and sold (realized returns), for those investor-date combinations where at least one stock is sold. The dependent variable is 1 for the (investor, date, stock) triplet if the investor sells the stock that day, otherwise 0. Capital gains and purchase dates are calculated with FIFO accounting. Independent variables are the capital gain interval dummies reported in the table, as well as unreported control variables described in Section III.C. A capital gain interval dummy indicates whether the percentage capital gain resides within a particular interval. Realized returns are based on actual transaction prices, paper returns are based on the day's closing prices. The left side presents results for the high deviation group, the right side for the low deviation group. Deviation from purchase price is the absolute distance, as a percentage, from the purchase price to the highest or lowest price, whichever gives greatest distance. The date of sale is excluded. The cut-off points, e.g. 15.2% and 33.9% for 5 to 8 weeks, divide observations into three groups based on the deviation, so that group size is equal before excluding observations with missing values. 'Holding interval' refers to a range of values for time since purchase. The median Nagelkerke R-Square is 0.34, and it ranges between 0.27 and 0.36. Asterisks mark the statistical significance levels (** for 1% and * for 5%, respectively).

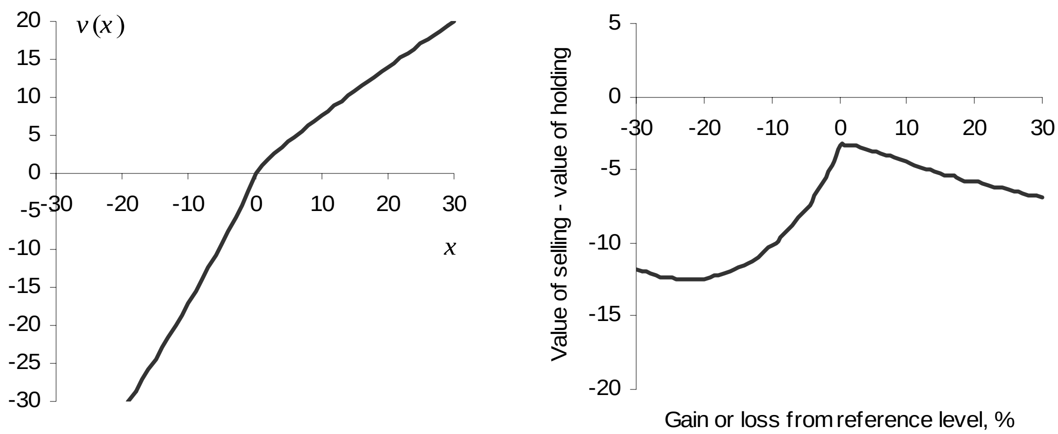
	High: Deviation from Purchase Price During Holding Period at Least				Low: Deviation from Purchase Price During Holding Period at Most			
	33.9 %	42.9 %	49.6 %	53.3 %	15.2 %	18.8 %	21.6 %	27.3 %
Holding Interval, Weeks	5 to 8	9 to 14	15 to 24	25 to 42	5 to 8	9 to 14	15 to 24	25 to 42
Panel A: Coefficient Values								
Dummies for Capital Gain Intervals								
<-20	-0.94**	-0.85**	-0.82**	-0.68**	0.68*	0.18	0.03	-0.02
[-20, -10]	-0.83**	-0.76**	-0.64**	-0.24	-0.52**	-0.62**	-0.41**	-0.61**
[-10, -5]	-0.65**	-0.72**	-0.45**	-0.56**	-0.66**	-0.62**	-0.56**	-0.42**
[-5, 0]	-0.72**	-0.58**	-0.48**	-0.16	-0.63**	-0.52**	-0.57**	-0.43**
[5, 10]	-0.17	0.14	-0.15	0.08	0.30**	0.20**	0.20**	0.21**
[10, 20]	0.01	0.19	0.03	0.54**	0.34**	0.32**	0.29**	0.23**
>20	0.11	0.22*	0.05	0.52**	-0.82**	-0.08	0.09	0.21**
Panel B: T-Statistics								
<-20	-10.87	-9.64	-8.39	-5.34	2.31	0.94	0.31	-0.46
[-20, -10]	-8.02	-6.41	-5.18	-1.42	-11.70	-15.48	-11.03	-18.36
[-10, -5]	-4.98	-5.08	-3.13	-2.65	-21.19	-18.12	-16.88	-11.58
[-5, 0]	-4.98	-4.30	-3.26	-0.92	-24.31	-18.07	-18.26	-12.17
[5, 10]	-1.46	1.23	-1.14	0.45	12.38	7.30	6.79	6.24
[10, 20]	0.14	1.94	0.25	3.85	11.69	10.97	9.57	7.06
>20	1.22	2.51	0.55	4.14	-6.50	-1.01	1.57	5.20
N	91,884	117,382	155,954	158,756	139,989	141,178	153,620	158,666

Figure 1

Prospect Theory Value Function and the Incremental Utility from Selling a Risky Asset

The graphs on the left show the value function $v(x)$ from (1), where x is the gain or loss. The graphs on the right show the value of selling less the value of holding, i.e., v(realized gain or loss) – v(prospect), as a function of the gain or loss from the reference level. In Panel A, the asset has an expected return of 12% and a volatility of 25%. The value function parameters are the following: $\alpha = 0.88$, $\beta = 0.88$, $\lambda = 2.25$. In Panel B, The asset has an expected return of 8% and a volatility of 40%. The value function parameters are the following: $\alpha = 0.75$, $\beta = 0.60$, $\lambda = 2.1$.

Panel A.



Panel B

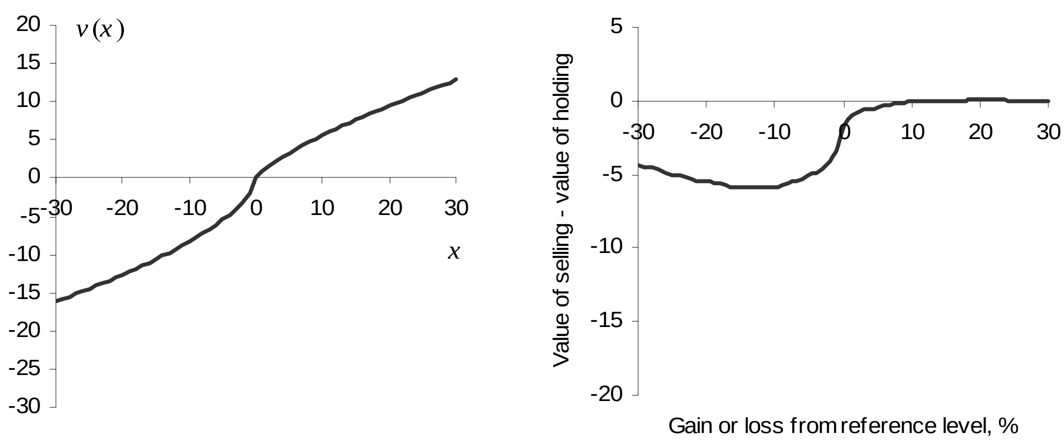


Figure 2

The Propensity to Sell as a Function of Capital Gain

The propensity in each 2% return interval is calculated as the base rate probability of selling a particular stock conditional on selling some stock, plus the marginal effect of the sale occurring in that return interval taken from logit regressions, setting all continuous variables to their mean values and dummy variables to zero. Results for four different holding-period intervals are depicted, as indicated by the figure legend. The dependent variable in the regression is 1 for the (investor, date, stock) triplet when the investor sells the stock, otherwise 0. Independent variables are the capital gain interval dummies ranging from –50 to +50% returns, in two percentage points increments, shown in the figure, as well as the control variables described in Section III.C. A capital gain interval dummy indicates whether the realized percentage capital gain resides within a particular interval. Parameters are estimated by maximum likelihood. The sample is based on the trades of Finnish household investors during January 1995 to May 2000.