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Investors' previous experiences with a stock affect their willingness to repurchase that stock. Using detailed trade data from two brokers, the authors document that investors are reluctant to repurchase stocks previously sold for a loss and stocks that have risen in price subsequent to a prior sale. The authors propose that this behavior reflects investors' emotional reactions to trading and their attempts to distance themselves from negative emotions (e.g., disappointment, regret). Investors are disappointed when they sell a stock for a loss and regret having ever purchased the stock; these negative emotions deter investors from later repurchasing stocks they sold for a loss. Having sold a stock, investors are disappointed if the stock continues to rise and regret having sold the stock in the first place; these negative emotions deter investors from repurchasing stocks that go up since being sold. Thus, investors engage in reinforcement learning by repurchasing stocks whose previous purchase resulted in positive emotions and avoiding stocks whose previous purchase resulted in negative emotions.

Keywords: disappointment, regret, counterfactuals, individual investors

Once Burned, Twice Shy: How Naive Learning, Counterfactuals, and Regret Affect the Repurchase of Stocks Previously Sold

On average, the active trading of common stocks by individual investors reduces portfolio returns. Yet many investors persist in trading. Possible explanations for this financial welfare-reducing behavior are that investors trade for entertainment rather than return, that active investors are overconfident about their personal trading abilities, or that investors are unaware of the disadvantages of active trading compared with the alternative of buying and holding a well-diversified portfolio (e.g., through a mutual fund). We propose that one way in which investors are able to sustain their appetite for active trading is by making trades that enhance the emotional experience of trading, by either increasing pleasure or reducing pain, without improving performance.

Investors have a great deal of control over the selection and timing of their stock trades. So while individual investors appear unable to forecast how alternative trades will affect their portfolio returns, they may have a sense of how these trades will affect them emotionally. For example, investors tend to sell stocks that they hold for a gain more readily than those they hold for a loss (i.e., the disposition effect), even if this strategy leads to higher taxes or

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lower subsequent returns (Odean 1998).[1] One explanation for such behavior is that selling for a loss triggers strong negative emotions of regret and disappointment: regret over ever having bought the stock and disappointment over selling the stock for a loss. The act of selling focuses attention on the loss and makes it certain. The negative affect associated with continuing to hold a position for a loss may be mitigated by a lack of attention and by the hope that the stock will rebound.

We analyze the trading behavior of investors who previously owned and sold a stock and investigate whether their experience with a stock affects their subsequent willingness to repurchase that stock. We depict these repurchase decisions in Figure 1. Consider the node *Sold for Gain/Down since Sold*. At this node, an investor is pleased with her initial purchase (having sold for a gain) and with her subsequent sale (having seen the stock drop subsequent to being sold). At this node, investors are likely to repurchase a stock, because the repurchase would intensify and prolong the positive emotions associated with the initial purchase, subsequent sale, and price change after the sale. The investor is repeating an action—buying the stock—that previously resulted in positive emotions; she is engaging in reinforcement learning. In contrast, consider the node *Sold for Loss/Up since Sold*. At this node, an investor regrets his initial purchase (having sold for a loss) and regrets his subsequent sale (having seen the price increase subsequent to the sale). The investor therefore avoids repurchasing because doing so intensifies and prolongs the negative emotions associated with the initial purchase, subsequent sale, and the price change after the sale. This investor is avoiding an action—buying the stock—that previously resulted in negative emotions. We develop formal hypotheses based on the assumption that investors are drawn to stocks that reinforce positive emotions and avoid purchasing stocks that reinforce negative emotions.

Empirically we establish two previously undocumented patterns in the stock purchases and stock selections of individual investors. The first pattern shows that investors who previously have owned and sold a stock are less likely to buy that stock again if they lost money on the prior sale (Figure 1, *Sold for Loss* nodes). Analyzing trading records for 66,465 individual investors with accounts at a large discount brokerage and 596,314 individual investors with accounts at a large retail brokerage, we find that investors are significantly less likely to buy a stock that they sold in the previous year if that sale was for a loss rather than for a gain. We propose that this behavior is, at least in part, motivated by the instinct to avoid the pain of disappointment and regret. An investor who sells a stock for a loss is likely to be disappointed that the stock underperformed her expectations. She also is likely to regret having purchased the stock to begin with. Thus, the purchase of this stock leads to a painful experience, and people instinctively avoid repeating behavior that previously resulted in pain. Furthermore, repurchasing a previous loser provides a salient reminder of the previous loss whenever the investor reviews her portfolio holdings, thus prolonging and intensifying her feelings of disappointment and regret.

The second pattern we document arises when an investor previously sold a stock for a gain and then is less likely to repurchase that stock if its price has gone up rather than down since she sold it (Figure 1, *Sold for Gain* nodes). We propose that this behavior also is driven by investors' desire to minimize disappointment and regret. If an investor sells a stock and later repurchases it at a higher price, she faces two salient counterfactuals: The stock could have gone down after she sold it rather than up, and she could have been wealthier if she had held onto the stock rather than selling it and buying it back later at a higher price. These counterfactuals engender feelings of disappointment and regret: disappointment because the stock went up after she sold it and regret because her decision to sell and repurchase resulted in her being poorer than she would have been if she had not sold in the first place. However, if she sells a stock and later repurchases it at a lower price, she feels good because the stock went down rather than up after she sold it, and thus her decisions to sell and repurchase resulted in her being wealthier than she would have been had she held on to the stock. Furthermore, even if the stock falls in price after she buys it, her loss would have been even greater had she not sold and later repurchased.

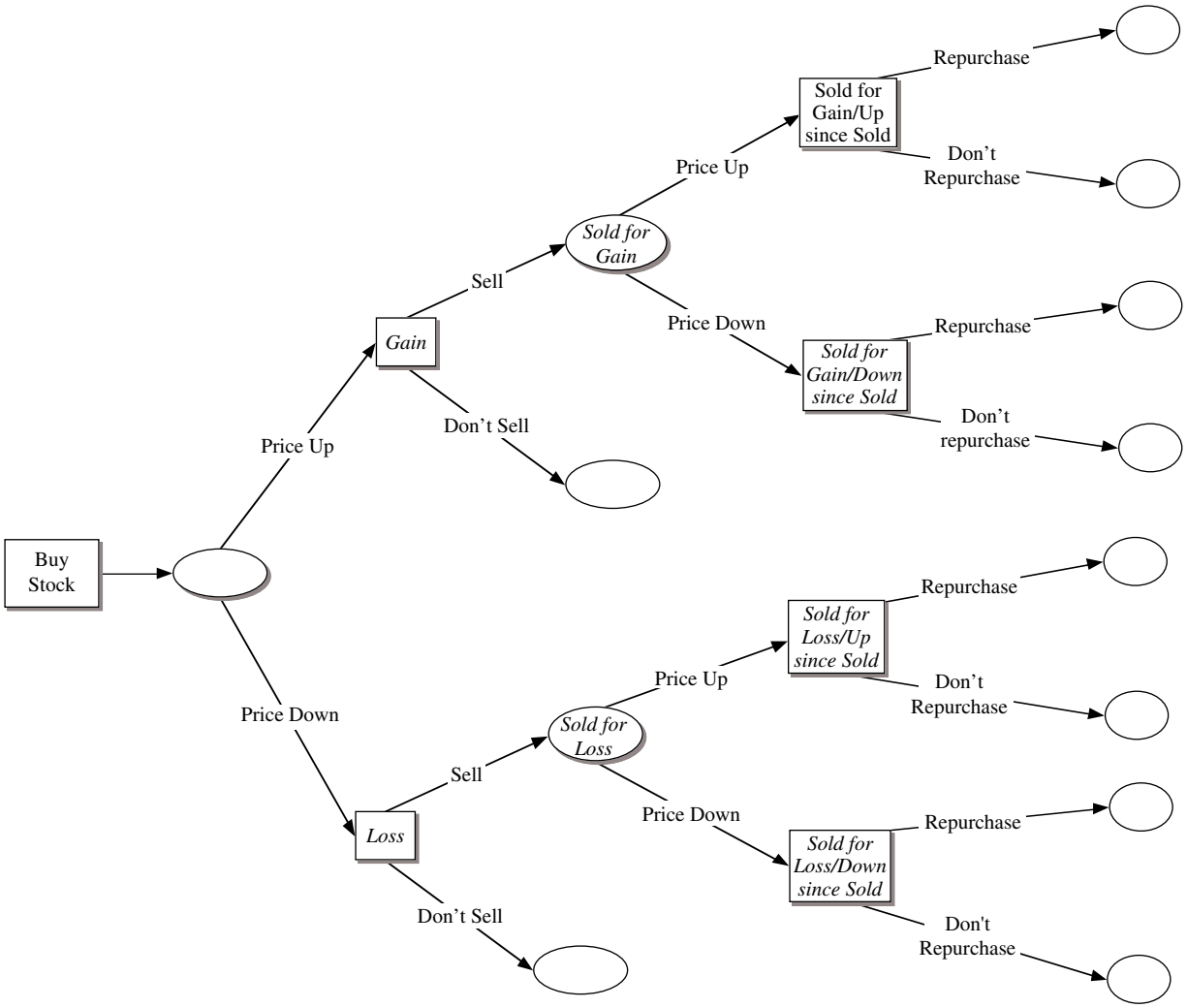
Our field data do not enable us to determine definitively the psychological mechanisms that drive these trading patterns. We are however able to test several alternative explanations for the observed trading patterns. These patterns are not tax motivated, because we find them in both tax-deferred and taxable accounts. Furthermore, the tendency to repurchase stocks that have dropped in price since being sold does not appear to be driven by a general belief that stocks mean revert; the investors who exhibit this behavior tend to choose recent winners when buying stocks that they have not owned previously. The repurchase patterns cannot be due to superior information, because investors do not earn reliably higher returns from this behavior. On the contrary, after factoring in commissions and other costs associated with trading, the majority of these investors would be significantly better off buying and holding index funds rather than trading common stocks. Thus, the ability to mitigate the pain of losses by repurchasing prior winners, avoiding prior losers, and avoiding stocks that have gone up in price since they sold them potentially lowers investors' economic welfare by reducing their motivation to move to more suitable investments.

Weber and Welfens (2011) offer laboratory-based support for our contention that the tendency to repurchase stocks that have dropped in price since being sold for a profit is driven by counterfactual thinking. Participants in their experiments repurchased stocks sold for a profit that were down since their sale in an experimental market in which returns were clearly not mean reverting and no participants had superior information. Furthermore, they were more prone to repurchase stocks that had gone down in price since being sold when the decision to sell was voluntary—and thus susceptible to regret—than when the sale was forced.

The psychological mechanisms we propose for the behaviors we document are intended to explain these behaviors for many investors most of the time. We do not claim though that the repurchase effects we document

[1] Jegadeesh and Titman (1993) show that stocks with strong (weak) returns in the recent past (3–12 months) go on to earn strong (weak) returns. This trend may help explain why stocks that individual investors sell for a gain tend to outperform the losers they keep.

Figure 1
DECISION TREE



always result from identical motivations or that a single trade by a single investor can have only one motivation.

HYPOTHESIS DEVELOPMENT AND PRIOR RESEARCH

Counterfactuals, Disappointment, and Regret

People frequently compare actual outcomes in life to mental simulations of what might have been, otherwise known as counterfactuals (Kahneman 1995; Kahneman and Tversky 1982). The salience of such counterfactuals increases with their "closeness" to reality, that is, the ease with which elements of reality can be cognitively altered to construct the counterfactual (Kahneman and Miller 1986; Roese and Olson 1995). Certain features of actual scenarios are more readily mutable and give rise to easily imagined counterfactuals. For example, a passenger who misses a flight by 5 minutes generally experiences more regret than one who misses a flight by 30 minutes (Kahneman and Tversky 1982).

Counterfactuals also can play a role when investors choose among risky alternatives. The outcomes of investment choices are likely to be compared with two particularly salient counterfactuals: alternative outcomes that could have occurred with the same choice (e.g., an investor who buys a stock that goes down imagines that he would be wealthier if the stock had gone up) and outcomes from alternatives that could have been chosen but were not (e.g., an investor who buys a stock that goes down imagines that he would be wealthier had he not bought the stock). Comparisons of the imagined outcome with other outcomes of the chosen gamble lead to disappointment or elation; comparisons of the imagined outcome with an outcome of an unchosen gamble represent regret or rejoicing (Mellers and McGraw 2001).[2] As Mellers et al. (1997, p. 423) explain, "Regret theory captures the anticipated emotional reaction

[2]Throughout this article, we use the term "rejoicing" to denote the positive counterpart of regret, following Loomes and Sugden (1982). Other authors, including Shefrin and Statman (1985) and Muermann and Volkmann (2006), instead use "pride" to denote the positive counterpart of regret.

to an outcome when one learns that a different choice would have produced a better outcome . . . . Disappointment theory captures the anticipated emotional reaction to an outcome when one learns that another state of the world would have produced a better outcome" (also see Bell 1982, 1985; Loomes and Sugden 1982, 1986; Tsiros and Mittal 2000). Thus, an investor anticipates that if he buys a stock at a higher price than he sold it, he will be disappointed that the stock price did not drop after the sale and will regret choosing to sell the stock before it went up. If the stock goes up after he sells it, the investor could be disappointed with the outcome, regretful of his choice, or both, even if he does not repurchase that particular stock. However, actually trading the stock focuses the investor's attention on his previous choices, which makes them more mutable and salient (for a discussion of attention and mutability, see Kahneman and Miller 1986).

Similarly, consumers who have missed an opportunity to purchase an item at a deep discount are less likely to buy that same item at a smaller discount later (Tsiros 2009). This behavior does not arise simply because the item was sold more cheaply in the past; rather it arises because of the missed opportunity. The juxtaposition of a current inferior opportunity with a superior foregone opportunity triggers a comparison of the actual choice with the better but unrealized choice, thus evoking regret (Fujikawa, Niedermeier, and Ross 2006; Tykocinski and Pittman 1998, 2001; Tykocinski, Pittman, and Tuttle 1995). As Arkes, Kung, and Hutzel (2002, p. 378) explain, "One might feel regret over one's past failure to take advantage of the bargain. It might be aversive to prolong or exacerbate the regret by considering anew the purchase of the same item. Inaction toward the second purchase opportunity thus would represent an escape from currently experienced regret."

We propose that regret plays a similar role in the repurchase decisions of investors. The investor who buys a stock that she previously sold for a loss prolongs and exacerbates her experienced regret and disappointment—regret that she chose to buy a stock that she subsequently sold for a loss rather than not buying it, and disappointment that the purchase resulted in a loss rather than a gain. Similarly, an investor who repurchases a stock—even one originally sold for a profit—at a higher price than he sold it regrets his decision to sell rather than continue to hold the stock and is disappointed that the stock went up rather than down after he sold it. Repurchasing this stock intensifies and prolongs his regret and disappointment by focusing his attention on his (*ex post*) mistake to sell at a lower price than the repurchase price.

Hypothesis Development

Most investors have a good deal of latitude in deciding which stocks to purchase and when to sell. Thus, investors are able to eschew or postpone trades that they anticipate will trigger regret or disappointment and instead choose trades that cause rejoicing and elation.

Consider the investor choices in Figure 1. The investor buys a stock, the stock goes down or up, and the investor must decide to sell or not sell. Suppose the stock has gone down since the investor bought it (Figure 1, *Sold for Loss*). If the investor derives utility from gains and losses (e.g., Kahneman and Tversky 1979) rather than total wealth and frames gains and losses in terms of individual investments rather than changes in total portfolio value or total wealth (Thaler 1985), selling for a loss has negative utility. The investor is disappointed that the stock has not performed better and likely regrets purchasing it. If she realizes this loss by selling the stock, her disappointment and regret will become more salient through the sale and no longer can be mitigated by the hope that the stock will recover. If the stock has gone up since the investor bought it (Figure 1, *Sold for Gain*), selling triggers rejoicing and elation. Empirical evidence on the disposition effect is consistent with investors' choosing to experience rejoicing and elation sooner and postpone disappointment and regret by selling for a gain more readily than for a loss.

Suppose an investor sells a stock for a gain and later considers repurchasing that stock (Figure 1, *Sold for Gain* nodes). The stock is associated with past rejoicing and elation. Simple reinforcement learning can cause investors to repurchase such a stock. Furthermore, thinking about repurchasing the stock may remind the investor of these positive past emotions, and reinstating the stock in his portfolio may serve as a continuing reminder. If, however, the investor sold the stock for a loss (Figure 1, *Sold for Loss* nodes), the stock is associated with the emotional pain of disappointment and regret. In this case reinforcement learning can cause investors not to repurchase such a stock. Furthermore, thinking about repurchasing the stock may remind the investor of these negative past emotions, and reinstating the stock in her portfolio may prolong and exacerbate the experienced regret and disappointment of that loss. We believe that investors are likely to avoid trades that intensify and prolong negative emotions and engage in trades that intensify and prolong positive emotions; thus, we hypothesize that investors are less likely to repurchase stocks previously sold for a loss than those previously sold for a gain. Our null hypothesis is that investors are neither more nor less likely to repurchase stocks previously sold for a loss than those sold for a gain.

Suppose that an investor is considering repurchasing a stock at a higher price than he sold it (Figure 1, *Up since Sold* nodes). Repurchasing this stock focuses the investor's attention on the stock's return since the sale. He is disappointed that the stock's price has risen and regrets that he sold the stock when he did. If he reinstates the stock in his portfolio, he admits that he has a long-term interest in owning this stock, which intensifies the counterfactual that he would have had the same portfolio position today and been wealthier if he had not sold. However, if the stock has gone down since she sold it (Figure 1, *Down since Sold* nodes), repurchasing intensifies feelings of rejoicing and elation. We hypothesize that investors are less likely to repurchase stocks that have gone up, rather than down, since they were sold. Our null hypothesis—assuming investors are unaffected by emotional considerations—states that investors are neither more nor less likely to repurchase stocks that have gone up versus down since the sale.

Our hypotheses thus predict that investors avoid repurchasing stocks sold for a loss that are now trading at a higher price (Figure 1, *Sold for Loss/Up since Sold*) and more readily repurchase those sold for a gain that are now trading at a lower price (Figure 1, *Sold for Gain/Down since Sold*). Negative emotions of disappointment and regret tend to be more powerful than their positive

counterparts of elation and rejoicing (Mellers, Schwartz, and Ritov 1999; Summers and Duxbury 2007). Thus, we expect negative counterfactuals to reduce repurchase activity for both stocks sold for a gain that can be repurchased at a higher price (Figure 1, *Sold for Gain/Up since Sold*) and those sold for a loss that can be repurchased at a lower price (Figure 1, *Sold for Loss/Down since Sold*). We do not offer a conjecture as to whether the regret and disappointment associated with having sold for a loss will be more or less influential than the regret and disappointment associated with having sold before a stock price increase.

Prior Research on Buying and Selling in Response to Past Returns

Prior research has examined how investors choose which stocks to buy and which to sell. Perhaps the best-established pattern is the disposition effect, or the tendency of investors to sell winners more readily than losers (Barber et al. 2007; Dhar and Zhu 2006; Feng and Seasholes 2005; Grinblatt and Keloharju 2001; Jackson 2003; Odean 1998; Shefrin and Statman 1985). This behavior reduces investors' economic welfare. For example, Odean (1998) finds that, on average, profitable investments that investors sell go on to outperform the losing investments they hold. Furthermore, in taxable accounts, realizing gains rather than losses generally leads to higher capital gains taxes. In short, the pattern is both common and bad for investors.

Shefrin and Statman (1985) argue that as a result of mental accounting (Thaler 1985), investors likely focus on the gains and losses of their individual investments rather than aggregate portfolio performance; Kahneman and Tversky's (1979) prospect theory implies that investors facing a loss on a specific investment become risk seeking with respect to that investment. Therefore, investors hold on to losing positions that they might otherwise sell. Shefrin and Statman also point out that selling for a loss induces regret, and that investors may hold on to losing investments to avoid regret.

Researchers have had mixed results generating the disposition effect from prospect theory in theoretical models. Hens and Vlcek (2007), Kaustia (2010), and Barberis and Xiong (2009) develop models in which, for reasonable parameter values, prospect theory preferences do not imply a disposition effect. However, Barberis and Xiong find that for preferences defined over realized gains and losses, prospect theory preferences can predict a disposition effect. Li and Yang (2009) develop a model in which the prospect theory preferences lead to a disposition effect.

Elster (1998) and Loewenstein (2000) urge economists to consider the role of emotions in economic behavior. Several recent articles in turn consider the role of regret and rejoicing in the disposition effect. Muermann and Volkman (2006) develop a portfolio choice model in which anticipated regret and rejoicing can explain the disposition effect. Baucells, Weber, and Welfens (2011) demonstrate that counterfactuals and regret may help determine investors' reference points, suggesting that both regret and prospect theory play roles in the disposition effect. Summers and Duxbury (2007) find no disposition effect in experimental markets when participants do not actively choose the stocks in their portfolios. They conclude that rejoicing and regret—not elation and disappointment alone—are necessary to generate a disposition effect. Ackert and Deaves (2010) offer a detailed discussion of explanations of the disposition effect.

Although the disposition effect leads investors to sell stocks with strong recent performance, they also tend to buy stocks they do not own that exhibit strong recent performance (Barber et al. 2007; Barber, Odean, and Zhu 2009; Jackson 2003; Odean 1999). Although both buying and selling activity for a stock increase with past returns, selling is more responsive to recent returns, whereas buying is more responsive to past returns measured over longer periods. Thus, individual investors tend to be net sellers of stocks with positive recent returns (Barber, Odean, and Zhu 2009; Grinblatt and Keloharju 2001; Odean 1999). Odean (1998) finds though that the preference for buying shares of stocks with positive recent performance does not hold for stocks that investors currently own.

Choi et al. (2009) find that investors overextrapolate from their personal experience when making savings decisions; investors whose 401(k) accounts have experienced greater returns or lower variance increase their saving rates. De, Gondhi, and Pochiraju (2010) show that individual investors trade more actively when their most recent trades are successful. Kaustia and Knupfer (2008) document that investors are more likely to subscribe to initial public offerings (IPOs) if their personal experience with IPO investments has been profitable. Malmendier and Nagel (2011) establish that investor age cohorts that have experienced high stock market returns throughout their lives are less risk averse and more likely to invest in stocks. Our finding that investors are more likely to repurchase a stock if they sold that stock for a gain is consistent with these examples of reinforcement learning by individual investors.

DATA

We focus on investors' common stock trades. We exclude investments in mutual funds (both open- and close-end), American depository receipts, warrants, and options. We analyze two data sets of investor trades. A large discount brokerage firm provided the first data set. It includes trading and position records for the investments of 78,000 households from January 1991 through December 1996. (Barber and Odean [2000] provide a more complete description of these data.) The data include all accounts opened by each household with the discount brokerage firm. Sampled households were required to have an open account with the discount brokerage firm in 1991. Roughly half the accounts in our analysis were opened before 1987, and half opened between 1987 and 1991. Of the 78,000 households sampled from the large discount brokerage house, 66,465 had positions in common stocks during at least one month; the remaining accounts held cash or investments other than individual common stocks. Roughly 60% of the market value in these households' accounts was held in common stocks. More than 3 million trades were in all securities; common stocks accounted for slightly more than 60% of all trades. During our sample period, the average household held 4.3 stocks with a total value of $47,334, though these figures are positively skewed. In December 1996, households held more than $4.5 billion in common stock. Purchases (1,082,107) exceeded sales (887,594) slightly during

our sample period, though the average value of stocks sold ($13,707) was slightly higher than the average value of stocks purchased ($11,205). As a result, the aggregate values of purchases and sales were roughly equal ($12.1 and $12.2 billion, respectively). The average value of trades is positively skewed.

The second data set contains information from a large retail brokerage firm with trading data for 30 months and position data for 18 months, both ending in June 1999. Using client ownership codes supplied by the brokerage firm, we limit our analysis to the 596,314 investors with nondiscretionary accounts (i.e., accounts classified as individual, joint tenants with rights of survival, or custodians for minors) and with at least one common stock trade during our sample period. Roughly 45% of the value of these accounts was held in common stocks (i.e., mutual fund and bond holdings are more common at the large retail brokerage). Trades in all securities exceeded 13.5 million; common stocks accounted for slightly more than 45% of all trades. Among the households with one common stock trade and month-end positions, the average household held 6.5 stocks with a total value of $123,413. We restrict our analysis to their common stock trades: 3,439,954 purchases with a mean value of $15,233 and an aggregate value of $52.4 billion and 2,766,543 sales with a mean value of $22,236 and an aggregate value of $61.5 billion.

RATIO ANALYSIS

Repurchases of Stocks Sold for a Gain Versus Stocks Sold for a Loss

To test whether investors are less likely to repurchase stocks that they previously sold for a loss than stocks that they previously sold for a gain, it is not sufficient to compare the number of purchases of stocks previously sold for a loss to the number of purchases of stocks previously sold for a gain. In an upward-moving market, investors are likely to have sold more stocks for a gain than for a loss; even if the market is not trending upward, investors are likely to sell more stocks for a gain than for a loss due to the disposition effect. Suppose that investors have previously sold more stocks for gains but are indifferent to repurchasing their prior winners and losers. These investors tend to repurchase more stocks previously sold for a gain than stocks previously sold for a loss simply because they have more opportunities to do so. Therefore, to test whether investors demonstrate a preference for repurchasing stocks that they previously sold for a gain rather than those they previously sold for a loss, we must look at the frequency with which they repurchase prior winners and losers relative to their opportunities to repurchase each.

We begin our analysis at the account level. Starting one year after the beginning of each data set (i.e., January 1992 at the discount brokerage, and January 1998 at the retail brokerage), we look at each day on which an investor made a purchase of any stock. We observe whether any of the stocks purchased on that day had been sold by the same investor during the previous 252 trading days (i.e., one year). If so (and when the data allow us to do so), we determine whether the last time the investor sold this stock, the sale was for a gain or a loss (based on the average share-weighted purchase price). We count the number of repurchases of stocks previously sold for a gain (winners repurchased) and the number of stocks previously sold for a loss (losers repurchased). We then count the number of those stocks sold for a gain during the last year that the investor could have repurchased on this day (opportunities to repurchase winners). This calculation includes stocks sold for a gain during the past year that were repurchased on the day in question and stocks sold for a gain during the past year that could have been repurchased that day but were not. Similarly, we calculate the number of opportunities to repurchase losers on this day. On days when an investor makes no purchases, we record zero actual winners repurchased, actual losers repurchased, opportunities to repurchase winners, and opportunities to repurchase losers.

For each account, we tabulate and aggregate over time the number of stocks sold for a gain that were repurchased, relative to the number of opportunities to repurchase stocks that were sold for a gain. We perform the same aggregation for the number of stocks sold for a loss that were repurchased, relative to the opportunities to repurchase stocks sold for a loss. We sum these tabulations for all investors at each brokerage firm and then calculate two ratios:

$$(1)\qquad \frac{\#\text{ of prior winners repurchased}}{\#\text{ of opportunities to repurchase prior winners}} = \text{Proportion of prior winners repurchased,}$$

and

$$(2)\qquad \frac{\#\text{ of prior losers repurchased}}{\#\text{ of opportunities to repurchase prior losers}} = \text{Proportion of prior losers repurchased.}$$

Our first hypothesis is that investors are less likely to repurchase a stock that they previously sold for a loss than they are to repurchase a stock they previously sold for a gain. This implies that proportion of prior losers repurchased (PLR) should be less than the proportion of prior winners repurchased (PWR). If past price patterns do not reliably predict future returns, investors' expectations should be unaffected by whether they have made or lost money on a stock in the past, and our null hypothesis would be PLR = PWR. If investors sometimes sell stocks for a tax loss, with the intention of to repurchase these same stocks subsequently, we would expect that for taxable accounts, PLR > PWR. Our null hypothesis of PLR = PWR captures both alternatives.

Repurchase of Stocks that Have Gone Up Versus Gone Down Since Being Sold

To test our second hypothesis, regarding whether investors are less likely to repurchase stocks that have increased in price since the sale rather than stocks that have decreased, we calculate the proportion of stocks that have gone up in price since being sold and that are repurchased (PUR), as well as the proportion of stocks that have gone down in price since being sold and that are repurchased (PDR), in a manner analogous to the calculations of PWR and PLR. Starting one year after the beginning of each data set, we look at each day on which an investor made a purchase. We observe whether any of the stocks

purchased on that day were sold by the same investor during the previous year.[3] If so, we determine whether the stock was repurchased at a higher, lower, or equivalent price compared with the price at which this investor most recently sold it. We count the numbers of times stocks were repurchased at a higher price (i.e., increased in price since being sold and repurchased) and repurchased at a lower price (i.e., decreased in price since being sold and were repurchased). We ignore stocks repurchased at the same price. To calculate the number of unrealized opportunities to repurchase stocks that have gone up or down since being sold, we examine every stock sold by the investor during the previous year, note the price at which the stock was previously sold, and determine whether its price is up, down, or the same compared with the most recent sale. If the high price of the day (or actual repurchase price for repurchased stocks) is lower than the most recent sales price, it is an unrealized opportunity to repurchase a stock that has gone down in price; if the low price of the day (or actual repurchase price for repurchased stocks) is greater than the most recent sales price, it is an unrealized opportunity to repurchase a stock that has gone up since being sold. We ignore unrealized opportunities to repurchase a stock if, on the day of the opportunity, the stock traded both above and below the price at which the investor sold it.

For each account, we tabulate and aggregate over time the number of stocks that went up since being sold and were repurchased, relative to the number of realized and unrealized opportunities to repurchase stocks that went up since being sold. We perform the same aggregation for the number of stocks that went down since being sold and were repurchased, relative to all opportunities to repurchase these stocks. We sum these tabulations for all investors at each brokerage firm. We then calculate two ratios:

$$\frac{\text{\# of stocks up since being sold repurchased}}{\text{\# of opportunities to repurchase stocks up since being sold}} = \text{Proportion of stocks up since being sold repurchased,} \quad (3)$$

and

$$\frac{\text{\# of stocks down since being sold repurchase}}{\text{\# of opportunities to repurchase stocks down since being sold}} = \text{Proportion of stocks down since being sold repurchased.} \quad (4)$$

Our second hypothesis posits that investors are less likely to repurchase stocks up since being sold than stocks down since being sold, which implies that the proportion of stocks up since being sold that are repurchased (PUR) is less than the proportion of stocks down since being sold that are repurchased (PDR). If past price patterns do not predict cross-sectional differences in future risk-adjusted returns, investors should be indifferent between repurchasing stocks that have gone up or down since they were sold, and our null hypothesis is PUR = PDR.

Investors who sold a stock before a decline may take their fortuitous timing as evidence that they have superior information about that stock and, for this reason, buy it again. We do not dispute that some investors hold such beliefs; however, we find no evidence that investors earn superior returns by repurchasing stocks that have lost value since they were sold. We discuss these and other alternative explanations for our findings in detail after presenting our main results.

[3]We restrict our analysis to stocks for which we know the purchase price. Thus, we analyze the same repurchases in Tables 1–3.

RESULTS

Repurchase of Stocks Sold for a Gain Versus Stocks Sold for a Loss

In Table 1, we present our calculations of PWR and PLR for both the discount broker and the retail broker data sets. Investors might be unwilling to repurchase stocks that were sold for a loss within 30 days of a sale, because doing so would prevent them from claiming the loss for tax purposes. To determine whether this or other tax considerations influence our results, we calculate the proportions separately for taxable and tax-deferred accounts.[4] With both the large discount broker and the large retail broker and for both taxable and tax-deferred accounts, investors repurchase stocks previously sold for a gain at significantly higher rates than stocks previously sold for a loss.

On average, the proportion of previous winners repurchased is approximately double the proportion of previous

[4]In unreported analyses, we also calculate these proportions but exclude any repurchases within 30 days of the most recent sale of a stock. Doing so does not qualitatively change our results. This check supports our conclusion that the pattern is not influenced by tax considerations.

Table 1
PREFERENCES FOR REPURCHASING STOCKS PREVIOUSLY SOLD FOR A GAIN VERSUS A LOSS

	Large Discount Broker		*Large Retail Broker*	
	Taxable	*Tax-Deferred*	*Taxable*	*Tax-Deferred*
Winners repurchased	37,739	11,837	85,071	39,077
Unrealized opportunities to repurchase winners	1,027,337	276,820	589,936	216,311
Proportion of prior winners repurchased (PWR)	.0354	.0410	.1260	.1530
Losers repurchased	10,445	2,800	21,591	7,631
Unrealized opportunities to repurchase losers	664,997	158,172	211,524	65,002
Proportion of prior losers repurchased (PLR)	.0155	.0174	.0926	.1051
Difference (PWR – PLR)	.0200	.0236	.0334	.0479
t-statistic (PLR = PWR)	11.0	6.3	13.6	11.0

Notes: All counts are incremented only on days with purchases. The t-statistics test the null hypotheses that differences in proportions are equal to 0, assuming that all purchases and nonpurchases result from independent decisions.

losers repurchased in the large discount broker data set (e.g., in taxable accounts, PWR/PLR = .0354/.0155 = 2.28) and almost 40% greater in the large retail firm data set (e.g., PWR/PLR = .1260/.0926 = 1.36). The differences are large and reliably different from 0 for both data sets, which is noteworthy because the brokerage firms cater to substantially different investors and were sampled during different market conditions. The large discount broker caters to do-it-yourself investors; the retail broker targets somewhat wealthier investors who might value the occasional advice of a broker. The large discount broker was sampled during the early 1990s, whereas the retail broker was sampled during the peak of the Internet bubble. Overall, our results provide strong support for our first hypothesis: Investors avoid stocks sold for a loss and return to those sold for a gain.

We make some conservative assumptions in our calculation of test statistics in Table 1. Specifically, for the t-statistics in Table 1, we calculate the standard error for the difference in the proportions PWR and PLR as follows:

$$\sqrt{p(1-p)\left(\frac{1}{\text{NRPW}}+\frac{1}{\text{NRPL}}\right)}, \tag{5}$$

where NRPW (NRPL) is the number of repurchases of prior winners (losers), and p is the number of repurchases of prior winners and prior losers divided by the number of opportunities to repurchase prior winners and prior losers. The usual calculation for the standard error under the null hypothesis PWR = PLR would have the number of opportunities to repurchase gains and losses in the denominator, that is,

$$\sqrt{p(1-p)\left(\frac{1}{\text{NORPW}}+\frac{1}{\text{NORPL}}\right)}, \tag{6}$$

where NORPW (NORPL) is the number of opportunities to repurchase prior winners (losers). However, the latter calculation assumes that all observations are independent. This independence assumption will not hold perfectly. For example, suppose an investor chooses not to repurchase the same stock on repeated occasions. It is likely that the decision not to repurchase on one date is not independent of the decision not to repurchase on another date. This lack of independence inflates the test statistics but does not bias the observed proportions. To be conservative in our calculations of statistical significance, we only count realized repurchases as independent observations when calculating standard errors.

Repurchase of Stocks Up Versus Stocks Down Since Being Sold

In Table 2, we present our calculations of the proportion of stocks that have decreased in value since being sold that were repurchased (PDR) and the proportion of stocks that have increased in value since being sold that were repurchased (PUR). To determine whether our results are influenced by tax considerations, we again calculate the proportions separately for taxable and tax-deferred accounts. Consistent with our second hypothesis, in both the large discount broker and the large retail broker and for both taxable and tax-deferred accounts, investors repurchase stocks that increased in value since being sold at roughly half the rate that they repurchase stocks that decreased in value since being sold (e.g., within taxable accounts at the large discount broker, PUR/PDR = .0232/.0467 = .50). The difference between these proportions (PDR − PUR) is large and reliably different from 0.

Table 2
PREFERENCES FOR REPURCHASING STOCKS UP VERSUS DOWN SINCE BEING SOLD

	Large Discount Broker		*Large Retail Broker*	
	Taxable	*Tax-Deferred*	*Taxable*	*Tax-Deferred*
Stocks down since being sold and repurchased	26,602	8,345	57,538	25,505
Unrealized opportunities to repurchase stocks down since being sold	692,045	170,402	289,104	99,188
Proportion of stocks down since being sold that were repurchased (PDR)	.0370	.0467	.1660	.2045
Stocks up since being sold and repurchased	21,582	6,292	49,124	21,203
Unrealized opportunities to repurchase stocks up since being sold	1,000,289	264,590	512,356	182,125
Proportion of stocks up since being sold that were repurchased (PUR)	.0211	.0232	.0875	.1043
Difference (PDR − PUR)	.0159	.0235	.0785	.1003
t-statistic (PUR = PDR)	10.6	7.9	39.7	30.9

Notes: All counts are incremented only on days with purchases. The t-statistics test the null hypotheses that the differences in proportions are equal to 0, assuming that all purchases and nonpurchases result from independent decisions.

Interaction Between Outcome and Direction of Price Change Since Last Sale

In Table 3, we present results separately for stocks that have gone down versus up since being sold, conditional on whether they were sold for a gain or a loss. These results correspond to the four right-most nodes in Figure 1. The tendency of investors to repurchase stocks that have lost value since last being sold applies almost exclusively to stocks that were sold for a gain. Investors who lost money when they sold their position are reluctant to buy that stock again, regardless of whether it has gone up or down since they sold it. Looking only at stocks previously sold for a

Table 3
INTERACTION EFFECTS OF SOLD FOR GAIN/LOSS AND UP/DOWN SINCE SOLD ON PREFERENCES FOR REPUCHASING STOCKS

	Large Discount Broker		*Large Retail Broker*	
Panel A: Stocks Previously Sold for a Gain	*Taxable*	*Tax-Deferred*	*Taxable*	*Tax-Deferred*
Stocks down since being sold and repurchased	22,009	7,122	48,779	22,440
Unrealized opportunities to repurchase stocks down since being sold	407,237	105,251	206,949	74,642
Proportion of stocks down since being sold that were repurchased (PDR)	.0513	.0634	.1907	.2311
Stocks up since being sold and repurchased	15,730	4,715	36,292	16,637
Unrealized opportunities to repurchase stocks up since being bold	620,100	171,569	382,987	141,669
Proportion of stocks up since being sold that were repurchased (PUR)	.0247	.0267	.0866	.1051
Difference (PDR − PUR)	.0265	.0366	.1042	.1261
t-statistic (PDR = PUR)	13.7	9.8	45.3	34.2
Panel B: Stocks Previously Sold for a Loss	*Large Discount Broker*		*Large Retail Broker*	
	Taxable	*Tax-Deferred*	*Taxable*	*Tax-Deferred*
Stocks down since being sold and repurchased	4,593	1,223	8,759	3,065
Unrealized opportunities to repurchase stocks down since being sold	284,808	65,151	82,155	24,546
Proportion of stocks down since being sold that were repurchased (PDR)	.0159	.0184	.0963	.1110
Stocks up since being sold and repurchased	5,852	1,577	12,832	4,566
Unrealized opportunities to repurchase stocks up since being sold	380,189	93,021	129,369	40,456
Proportion of stocks up since being sold that were repurchased (PUR)	.0152	.0167	.0902	.1014
Difference (PDR − PUR)	.0007	.0018	.0061	.0096
t-statistic (PDR = PUR)	.3	.4	1.5	1.3

Notes: All counts are incremented only on days with purchases. The t-statistics test the null hypotheses that the differences in proportions are equal to 0, assuming that all purchases and nonpurchases result from independent decisions.

loss in both taxable and tax-deferred accounts at both brokerages (see Table 3, Panel B), the PDR and PUR values are very similar, and their differences are not statistically significant. The tendency of investors not to repurchase stocks previously sold for a loss, even when those stocks can be repurchased at a lower price than they were sold, is consistent with the experimental finding that the negative effects of regret and disappointment on post-choice evaluations are greater than the positive effects of rejoicing and elation (Inman, Dyer, and Jia 1997).

When we look at stocks that previously were sold for a gain (Table 3, Panel A), the story is quite different. In taxable accounts at the large discount brokerage, the PDR equals .0513, whereas PUR is equal to .0247. This difference is reliably different from 0 and supports our hypothesis ($t = 13.7$, $p < .01$). The results are qualitatively similar for the retail brokerage and in tax-deferred accounts; relative to their opportunities to do so, investors repurchase stocks previously sold for a gain that have gone down at about twice the rate that they repurchase stocks previously sold for a gain that have gone up.

HAZARD RATE ANALYSIS

Cox Proportional Hazard Rate Model

The preceding results reflect comparisons of the ratios of repurchases with opportunities to repurchase. Although these analyses provide strong evidence for our hypotheses, they do not reveal how the magnitudes of gains and losses might affect investor behavior. Magnitudes of gains and losses and magnitudes of price changes after a sale are potentially important because they may lead to more intense emotions. For example, greater realized losses may cause more intense regret and disappointment, thereby further depressing repurchase rates. To assess whether the magnitudes of gains or losses and price changes after a sale affect investors' repurchase behavior, we estimate Cox (1972) proportional hazard rate models. In related works, Feng and Seasholes (2005), Ivkovic, Poterba, and Weisbenner (2005), Seru, Shumway, and Stoffman (2010), and Shumway and Wu (2005) have used proportional hazard rate analysis to examine selling behavior, that is, the disposition effect. Specifically, we estimate models of the form

$$h(t, x(t)) = h_0(t)\exp(\beta_1 x_1 + \cdots + \beta_p x_p), \quad (7)$$

where $h(t, x(t))$ is the hazard rate at time t, conditional on a set of p observed predictors in period t (denoted $x(t)$). The baseline hazard rate, $h_0(t)$, is the hazard rate when all predictors take a value of 0. The β coefficients are estimated from the data. The hazard rate is the probability density function of the hazard event at time t, conditional on survival to time t (i.e., not observing the hazard event before time t). In our analyses, the hazard event is the repurchase of a stock subsequent to the stock being sold, and time is measured in days subsequent to the original sale. The hazard rate for a particular stock being repurchased by a particular investor is therefore conditional on the covariates for that stock and investor at time t.

For the kth covariate, we report estimates of the hazard ratio, assuming a one-unit increase in the covariate:

$$\exp(\beta_k) = \frac{h_0(t)\exp(\beta_1 x_1 + \cdots + \beta_k(x_k + 1) + \cdots + \beta_p x_p)}{h_0(t)\exp(\beta_1 x_1 + \cdots + \beta_k x_k + \cdots + \beta_p x_p)}. \quad (8)$$

The hazard ratio, $\exp(\beta_k)$, is the ratio of hazard rates for two stocks with the same covariates, except that x_k is one unit larger for the stock whose hazard rate is in the numerator. Thus, if x_k is a dummy variable, the hazard ratio is the ratio of the hazard when the dummy variable takes on a value of 1 to the hazard when its value is 0, and all other covariates are the same.

The Cox model makes no assumptions about how the baseline hazard rate changes over time, nor does it estimate the baseline hazard rate. However, the model assumes that hazard ratios do not change with time. For example, the model makes no assumptions about how the unconditional rate of repurchasing stocks changes from day 50 to day 100, but it assumes that if having sold a stock for a gain rather than a loss increases the hazard rate of repurchase by 20% on day 50, then it increases the hazard rate of repurchase by 20% on day 100.

Stocks Sold for a Gain Versus Stocks Sold for a Loss

We first look at how the magnitudes of gains and losses at the time that an investor sold a stock affect the repurchase rate, conditional on whether the stock has gone up or down since being sold. To do so, we create dummy variables for the size of the gain or loss at the time of sale, using a series of return categories that span four percentage points each. (The results are similar for different return categories.) The return categories span a broad range, as follows: $r \leq -42\%$; $-42\% < r \leq -38\%$; . . . ; $-2\% < r \leq 2\%$; . . . ; $58\% < r \leq 62\%$; and $62\% < r$.

For example, we create a dummy variable that equals 1 if the return at the time of the sale is greater than −2% and less than or equal to 2%; another dummy variable equals 1 if the return is greater than 2% and less than or equal to 6%. These covariates are static, because the return at the time of the sale does not change subsequent to the sale. We include a time-varying covariate equal to 1 if a stock's current price is greater than it was at the time of the sale, and 0 otherwise. We also include two unreported control variables: the log of the ratio of the dollar value of all trades of the stock in question during the previous calendar year to the total dollar value of all trades of all stocks during the previous calendar year (volume data come from the Center for Research in Security Prices database) and the inverse of the number of days the investor held the stock before the original sale. Both control variables are statistically significant in all analyses.

Figure 2, Panels A and B, contains the graphs of the hazard ratios for our covariates for investors at the large discount brokerage and the large retail brokerage, respectively. All ratios refer to the hazard rate for the specified covariates, divided by the hazard rate for the case in which the stock was originally sold for a profit of approximately 0 (i.e., $-2\% < r \leq 2\%$) and the stock has lost value since the sale. Hazard ratio estimates for stocks currently trading above the sale price are graphed in gray; those for stocks currently trading below the sale price are in black. The 95% confidence intervals for the hazard ratio estimates appear as gray dotted lines.

The hazard ratio graphs for both brokerage firms are remarkably similar. The likelihood of repurchasing a stock is highly dependent on whether the stock was originally sold for a gain or a loss. Regardless of whether a stock is up (gray line) or down (black line) since the original sale, a sharp kink appears in the hazard rates at the middle of both graphs, when stocks move from the domain of losses to the domain of gains. If a stock originally sold for a loss (left-hand side of both graphs), the likelihood of repurchase drops nearly linearly with the magnitude of that loss, whereas if the stock originally sold for a gain (right-hand side of both graphs), the likelihood of repurchase does not increase (or even drops slightly) with the magnitude of the gain. If investors are not repurchasing stocks originally sold for a loss because of regret and disappointment, the magnitudes of regret and disappointment appear to matter. In contrast, investors appear equally willing to repurchase a stock that caused greater or lower rejoicing and elation. The sharp kink at the point that losses change to gains is consistent with loss aversion.

Stocks Up Versus Down Since Being Sold

We next look at how the magnitude of the price change a stock has experienced since an investor sold it affects the repurchase rate, conditional on whether the stock was sold for a gain or loss. To facilitate this analysis, we create dummy variables for the returns on the stock since it was sold, using a series of return categories that span four percentage points, as follows: $r \leq -42\%; -42\% < r \leq -38\%; \ldots; -2\% < r \leq 2\%; \ldots; 58\% < r \leq 62\%$; and $62\% < r$.

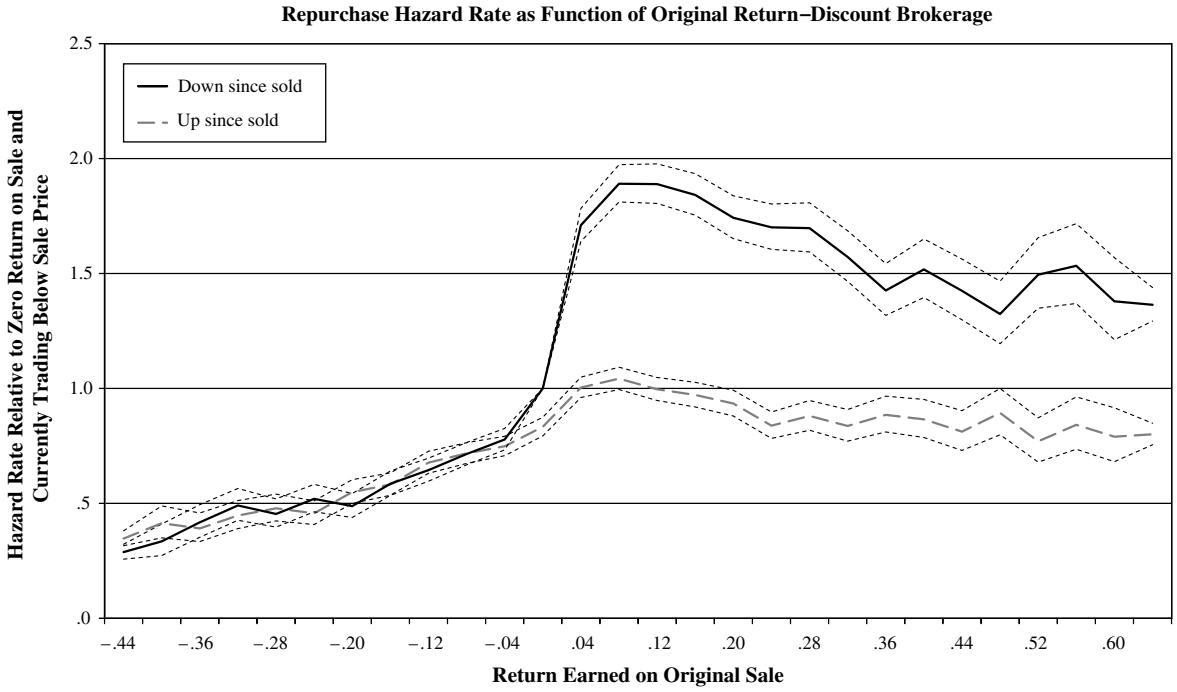
For example, we create a dummy variable that is equal to 1 if the return to the stock since the sale is greater than −2% and less than or equal to 2%. These covariates are time varying, because the return since the sale can change every day. We include a static covariate that equals 1 if a stock was originally sold for a gain and 0 otherwise. We again include unreported controls for the stock's share of total trading volume and the investor's holding period.

In Figure 3, we graph the hazard ratios for our covariates for the investors at the large discount brokerage (Panel A) and large retail brokerage (Panel B). All ratios refer to the hazard rate for the specified covariate, divided by the hazard rate for the case in which the stock was originally sold for a profit of approximately 0 (i.e., $-2\% < r \leq 2\%$) and the stock has lost value since the sale. Hazard ratio estimates for stocks originally sold for a loss are graphed in black; those for stocks originally sold for a gain are gray. The 95% confidence intervals for the hazard ratio estimates are again the gray dotted lines.

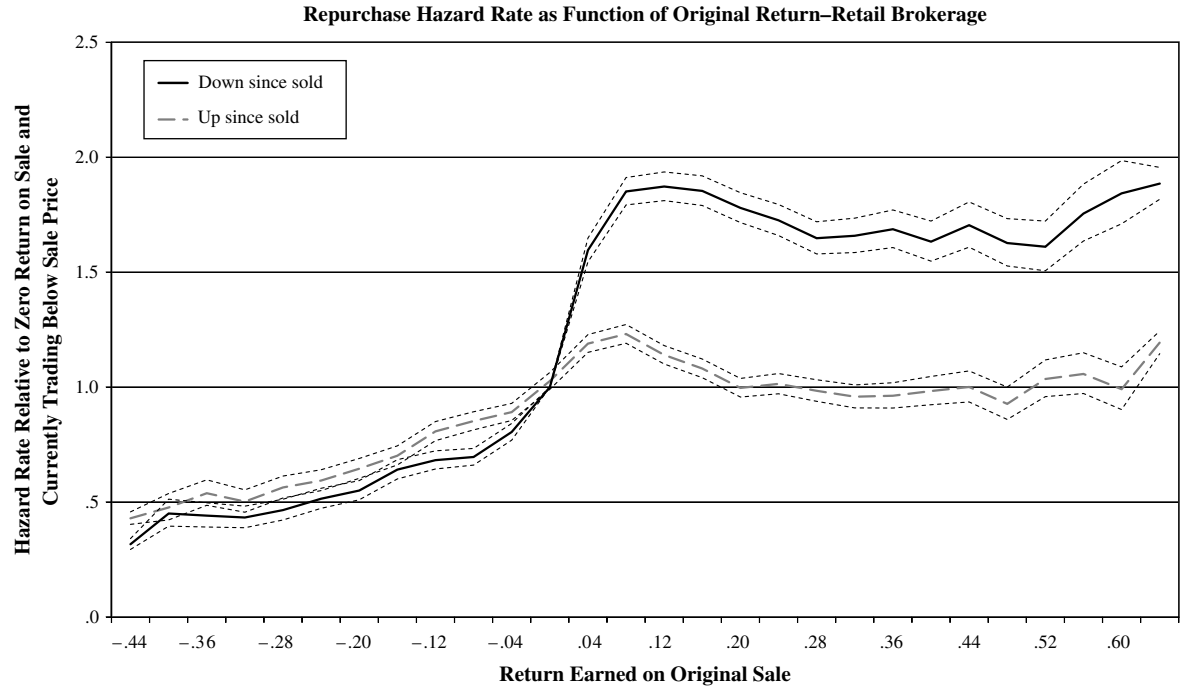
The hazard ratio graphs for both brokerage firms are remarkably similar. For all levels of returns since the original sale, stocks that originally sold for a gain (gray line) are repurchased at higher rates than those originally sold for a loss (black line). Repurchase rates go up slowly as the magnitude of a stock's gain since the sale increases (right-hand side of both graphs), regardless of whether the stock was originally sold for a gain or loss. In the domain of losses, repurchase rates depend on whether the stock was originally sold for a gain or loss. If a stock originally sold for a loss, repurchase rates increase similarly in the domain of losses (down since sold) and gains (up since sold). However, if the stock originally sold for a gain, the repurchase rates increase dramatically in the domain of losses. For stocks originally sold for a gain, repurchase rates are always much higher if the stock's return since

Figure 2
HAZARD RATIO BY RETURN EARNED ON ORIGINAL SALE

A: Large Discount Broker, 1992–1996



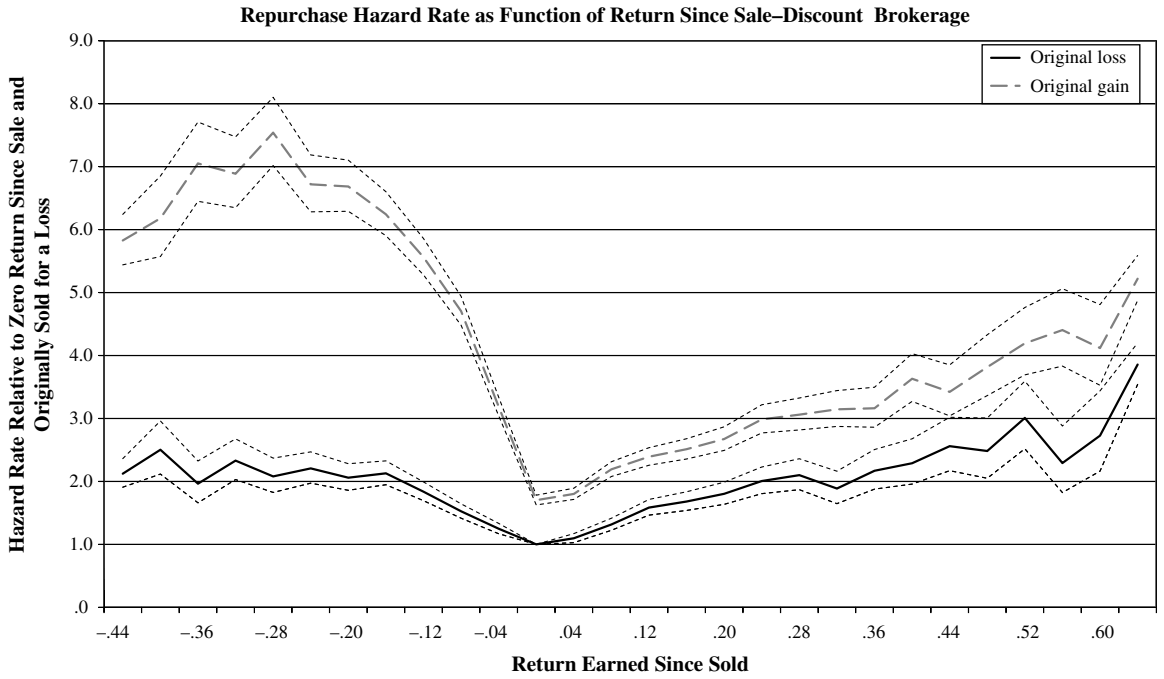
B: Large Retail Broker, 1998–1999



Notes: Gray dashed lines indicate the stock price increased since being sold; black solid lines indicate the stock price decreased since being sold. Dotted lines refer to the 95% confidence interval.

Figure 3
HAZARD RATIOS BY RETURN ON STOCK SINCE SOLD

A: Large Discount Broker, 1992–1996



B: Large Retail Broker, 1998–1999

Notes: Gray dashed lines indicate stock sold for a gain; black solid lines indicate stocks sold for a loss. Dotted lines reflect the 95% confidence interval.

the sale is negative rather than positive but of the same absolute value (e.g., −10% versus 10%). Again the magnitudes of regret and disappointment appear to have a greater influence on investors' behavior than the magnitudes of rejoicing and elation. However, for very large drops in price since the sale, repurchase rates start to drop. It may be that though investors like to repurchase stocks at a lower price than they sold, they also believe that past returns can be indicative of future returns. Thus, the emotional gains from repurchasing a stock that has dropped 50% since it was sold in the past year may be somewhat offset by the fear that it will continue to drop.

ALTERNATIVE EXPLANATIONS FOR THE RESULTS

Investors prefer to repurchase stocks that they previously sold for a gain but that have gone down in price since they were sold. We argue that this behavior is driven by negative emotions, such as disappointment and regret, as well as their positive counterpart emotions, referred to in the literature as elation and rejoicing. Investors who buy a stock and sell it for a loss experience painful emotions, and simple reinforcement learning deters them from repeating the behavior that previously caused them pain. Keeping these stocks out of their portfolios allows investors to avoid painful reminders of their past failures. If an investor sells a stock for a gain and repurchases it at a higher price, she faces two salient counterfactuals: (1) If the stock had gone down, she could have repurchased it at a lower price, and (2) if she had not sold the stock, she would hold the same portfolio that she does today but be wealthier. These counterfactuals are sources of disappointment and regret. If the investor does not repurchase the stock, these painful counterfactuals are less salient and likely less prominent in her mind. If, however, the investor sells a stock for a gain and repurchases it at a lower price, her actual situation dominates the counterfactuals that suggest (1) if the stock had gone up instead of down, she might be buying it at a higher price, and (2) if she had not sold the stock, she would own the same portfolio as she does today but be less wealthy. Buying this stock triggers emotions of elation and rejoicing.

We argue the behavior we have documented is motivated by emotional drivers, but there are other plausible explanations, three of which we test in this section. One alternative explanation for our findings is that investors might repurchase stocks previously sold for a gain at a lower price because such stocks subsequently outperform the market by enough to warrant this trading activity. Another alternative explanation that we test is that investors might repurchase stocks sold for a gain at a lower price because they believe that they have superior skill or information about these stocks. Finally, a third alternative explanation is that investors may repurchase such stocks because they believe that individual stock prices are mean reverting. In the next three subsections, we provide evidence that these alternative explanations are not the primary causes of the repurchase behavior we have documented. However, we do not claim that they might not play a role in some investors' decisions.

Alternative Explanation 1: Skill Versus Emotion-Driven Repurchases

In general, individual investors do not exhibit stock-picking ability (Barber et al. 2009; Barber and Odean 2000, 2001; Odean 1999). For investors without stock-picking ability, repurchasing previous winners that have gone down since being sold is unlikely to improve their performance. We test whether investors benefit financially from repurchasing stocks previously sold for a gain that have gone down in price since being sold by calculating returns earned on such stocks, subsequent to their repurchase. This particular category of repurchases is consistent with a skill story, because the investor earned a gain on the sale and repurchased the stock at a lower price than the price for which the stock was sold. To differentiate the skill story from our hypothesis, we estimate the returns on these stocks subsequent to repurchase. The skill story predicts that these stocks will earn strong returns, whereas our hypothesis predicts, at best, average performance.

We calculate risk-adjusted returns under the capital asset pricing model (CAPM). To determine if any observed abnormal returns can be explained by investment style—that is, by stock characteristics known to affect returns—we also employ a four-factor model that includes market, size, value, and momentum factors (Carhart 1997; Fama and French 1993). We obtain these factors from Kenneth French's online data library (available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html). For this analysis, we combine the discount and retail brokerage data sets. The constructed portfolio invests a dollar in each stock repurchased and holds each investment for 252 trading days (i.e., one year). On each day, the portfolio comprises n stocks repurchased in the preceding 252 trading days. We calculate the portfolio return (R_t^r) as follows:

$$R_t^r = \sum_{i=1}^{n} x_{it} R_{it} \Big/ \sum_{i=1}^{n} x_{it}, \tag{9}$$

where R_{it} is the return on repurchased stock i on day t, and x_{it} is 1 (i.e., a \$1 investment) on the day following a repurchase but is the compound return on the stock from the day following the repurchase to date $t-1$ on all other days (i.e., growth in the invested dollar). The same stock can enter the portfolio multiple times on the same day (with differing weights x_{it}) if it has been repurchased on many days or by many investors in the preceding 252 trading days. Thus, the weight of the stock in the portfolio is proportional to the intensity with which the stock has been repurchased during the prior year.

For each portfolio, we obtain the daily returns on the portfolio and estimate time-series regressions for the CAPM,

$$(R_t^r - R_{ft}) = \alpha + \beta(R_{mt} - R_{ft}) + \varepsilon_t, \tag{10}$$

and the four-factor model,

$$(R_t^r - R_{ft}) = \alpha + \beta(R_{mt} - R_{ft}) + sSMB_t + hHML_t + wWML_t + \varepsilon_t, \tag{11}$$

where R_t^r is the return on the repurchase portfolio, R_{ft} is the return on T-bills, R_{mt} is the return on a value-weighted market index, SMB_t is the return on a value-weighted portfolio

Table 4
PERCENTAGE RETURN PERFORMANCE AND STYLE TILTS OF REPURCHASED STOCKS THAT PREVIOUSLY WERE SOLD FOR A GAIN AND DECREASED IN VALUE

		Coefficient Estimate on:			
	Intercept	$R_{mt} - R_{ft}$	*SMB*	*HML*	*WML*
CAPM	−.028**	1.401*			
	(−2.04)	(81.23)			
Four-factor model	−.005	1.265*	.475*	−.662*	−.029
	(−.49)	(61.02)	(17.86)	(−19.73)	(−1.11)

*Significant at 1% (two-tailed test).

**Significant at 5% (two-tailed test).

Notes: R_t^r is the return on the repurchase portfolio, R_{ft} is the return on T-bills, R_{mt} is the return on a value-weighted market index, SMB_t is the return on a value-weighted portfolio of small stocks minus the return on a value-weighted portfolio of big stocks, HML_t is the return on a value-weighted portfolio of high book-to-market (value) stocks minus the return on a value-weighted portfolio of low book-to-market (growth) stocks, and WML_t is the return on a value-weighted portfolio of recent winners minus the return on a value-weighted portfolio of recent losers.

of small stocks minus the return on a value-weighted portfolio of big stocks, HML_t is the return on a value-weighted portfolio of high book-to-market (value) stocks minus the return on a value-weighted portfolio of low book-to-market (growth) stocks, and WML_t is the return on a value-weighted portfolio of recent winners minus the return on a value-weighted portfolio of recent losers. (The WML factor is labeled UMD, up minus down, in French's data library.)

We report our results in Table 4. Using the CAPM, stocks repurchased since being sold for a gain that decrease in price since the sale underperform by 2.8 basis points per day, or seven percentage points per year ($p < .05$). The style-adjusted results show that these repurchases tend to feature high beta, small growth stocks. With this investment style, the abnormal performance, though nominally negative, is not reliably different from 0. We conclude that these purchases are not motivated by superior skill or information.

It is also worth noting that the returns we estimate in Table 4 are before-transaction costs. Barber and Odean (2000) report that at the discount brokerage house, the average round-trip trade in excess of $1,000 costs 3% in commissions and 1% in bid–ask spreads. These transaction costs would further detract from the performance of repurchased stocks.

Alternative Explanation 2: Perceived Skill Versus Emotion-Driven Repurchases

If an investor sells a stock that subsequently declines in value, the investor may erroneously infer that he has the ability to time trades of that specific stock (particularly if he sold for a gain). Because he believes he has the ability to time trades in this stock, he may be more inclined to buy the stock again than if the stock price had appreciated after he sold it and he had inferred his ability to be low. Thus, the tendency to repurchase stocks that have dropped in price since they were sold could be driven not by emotions, as we propose, but by an attribution bias in which investors make incorrect inferences about their ability.

To distinguish between our explanation and the alternative explanation we explore here, we consider experimental evidence provided by Weber and Welfens (2011), as well as field-based evidence about how investors behave in a different situation from which they might infer their skill levels. In Weber and Welfens's (2011) experiments, participants receive cash and make purchase and sales decisions for shares in a risky asset over three trading periods. They earn rewards according to the terminal value of their shares and their terminal cash holdings. After each period, the share price of the risky asset increases by €.12 or decreases by €.10 with equal probability. In one condition, the respondents make their own purchase and sale decisions for all three periods; in a second condition, their first- and second-period trades are mandated, and they decide only their third-period trades. In the first condition, those who sell for a gain are far more likely to repurchase a stock if it is trading at a lower price, rather than at a higher price, compared with the price at which they sold it. This finding is consistent with the behavior we document. However, the distribution of returns is known (and simple), so the experimental participants cannot learn, or reasonably believe they are learning, more about the risky asset from their own experience. In the second condition, in which respondents do not choose their first two trades, there is only a small and statistically insignificant tendency to repurchase stocks that have gone down in price since they were sold, rather than those that have gone up. In the first condition, participants likely felt regret if they repurchased at a higher price than they sold, because they could have made the choice not to sell. In the second condition, they may have felt disappointment that the stock price went up rather than down after they sold; however, they should not feel regret, because they did not make the choices that led to their current situation. Weber and Welfens's finding that regret—not disappointment—drives the repurchase effect is similar to Summers and Duxbury's (2007) finding that regret, but not disappointment, is necessary to generate the disposition effect in a laboratory setting.

As a complement to Weber and Welfens's (2011) experimental evidence, we look at the tendency of the investors in our two data sets to buy additional shares of stocks they already own. If investors infer stock-specific ability from their trading outcomes, an investor who buys a stock that subsequently drops in value should infer that her ability is low, whereas an investor who buys a stock that gains value after the purchase should infer that her ability is high. Thus, an investor who receives feedback that she is a skilled stock picker (i.e., stock price rises subsequent to her purchase) is more likely to continue buying the stock than an investor who receives negative feedback about her ability (i.e., stock price drops subsequent to her purchase).[5]

[5]Daniel, Hirshleifer, and Subramanyam (1998) theorize that if investors buy a stock on the basis of private information and that information gets confirmed by public information, investors become overconfident about their private information and drive prices higher than would have otherwise been the case. Analyzing a data set of 10,000 individual investor accounts at a large discount brokerage for the period 1987–1993, Odean (1998) finds that investors are more likely to repurchase a stock they currently own if its price has decreased, rather than increased, in value, since they purchased it. Most investors in our data sets hold extremely undiversified portfolios of common stocks, but some investors may purchase additional shares of stocks that have lost value to rebalance their portfolio.

If repurchase behavior is driven by counterfactual reasoning and the desire to avoid regret, the prediction goes the other way: An investor who buys a stock that has gone up in price will feel regret if she buys additional shares at the higher price, because doing so will highlight the missed opportunity to buy those additional shares at the original, lower, price. Thus, investors will be less likely, not more likely, to buy additional shares of a stock that they already own if the price of the stock has gone down since they first bought it.

We test to determine whether investors are more or less likely to buy additional shares of a stock that they currently own, conditional on whether the stock has gone up since it was purchased, using similar methodologies to those we previously discussed. We thus calculate the proportion of stocks currently held for a gain that are purchased again (PGPA) and the proportion of stocks currently held for a loss that are purchased again (PLPA), in a manner analogous to our previous calculations. Our analysis begins at the account level. Starting at the beginning of each data set, we look at each day on which an investor made a purchase. We then observe whether this investor purchased additional shares of a stock already in the portfolio. If so, we determine, if possible, whether the stock was purchased again at a higher or lower price than the average purchase price previously paid. Among stocks currently held by an investor, stocks purchased at a higher price represent those stocks currently held for a gain that are purchased again; stocks purchased at a lower price are stocks currently held for a loss and purchased again. To calculate the number of opportunities to purchase additional shares of stocks currently held for either a gain or a loss, we examine every stock in the portfolio and determine whether it is currently held for a gain or a loss (relative to the average purchase price). If the high price of the stock that day (or actual repurchase price for stocks purchased again) is lower than the average price previously paid for the stock, we count it as an opportunity to purchase additional shares at a lower price. If the low price of the stock that day (or actual purchase price for stocks purchased again) is higher than the average price previously paid, we count it as an opportunity to purchase additional shares at a higher price.

For each account, we tabulate and aggregate over time the number of currently owned stocks trading at a price above the average purchase price at which additional shares are purchased. We compare it to the number of opportunities to purchase additional shares of currently owned stocks at a price above the average purchase price. We do the aggregation for the number of currently owned stocks trading at a price below the average purchase price that are purchased again and compare it to the number of opportunities to purchase additional shares of currently owned stocks trading at a price below the average purchase price. We sum these tabulations for all investors at each brokerage firm and then calculate two ratios for each firm:

$$(12)\quad \frac{\#\text{ of stocks currently held for a gain purchased again}}{\#\text{ of opportunities to purchase stocks held for a gain again}} = \text{Proportion of gains purchased again,}$$

and

$$(13)\quad \frac{\#\text{ of stocks currently held for a loss purchased again}}{\#\text{ of opportunities to purchase stocks held for a loss again}} = \text{Proportion of losses purchased again.}$$

Our expectation, based on counterfactual reasoning, is that investors are more likely to purchase additional shares of a currently owned stock that has gone down in price since originally being purchased than to purchase additional shares of a currently owned stock that has gone up in price since originally being purchased (i.e., PLPA > PGPA); the formal null hypothesis is that PLPA = PGPA. If past price patterns do not predict cross-sectional differences in future risk-adjusted returns, investors should be indifferent between repurchasing stocks that have gone up or down since they were purchased.

The results in Table 5 show that for taxable accounts at the large discount brokerage, the PGPA is .0555, whereas the PLPA is .0828; the difference in the proportions is statistically significant (t = 19.9). At the large retail brokerage

Table 5
PREFERENCES FOR PURCHASING ADDITIONAL SHARES OF CURRENTLY OWNED STOCKS

	Large Discount Broker		*Large Retail Broker*	
	Taxable	*Tax-Deferred*	*Taxable*	*Tax-Deferred*
Stocks currently held for a loss purchased again	75,698	21,296	201,536	85,490
Unrealized opportunities to purchase additional shares of stocks currently held for a loss	837,979	173,707	1,440,845	581,594
Proportion of losses purchased again (PLPA)	.0828	.1092	.1227	.1282
Stocks currently held for a gain purchased again	60,186	15,967	168,497	72,444
Unrealized opportunities to purchase additional shares of stocks currently held for a gain	1,025,190	230,596	1,762,406	815,761
Proportion of gains purchased again (PGPA)	.0555	.0648	.0873	.0816
Difference (PLPA – PGPA)	.0274	.0445	.0354	.0466
t-statistic (PLPA = PGPA)	19.9	15.3	35.2	30.6

Notes: All counts are incremented only on days with purchases. The t-statistics test the null hypotheses that the differences in proportions are equal to 0, assuming that all purchases and nonpurchases result from independent decisions.

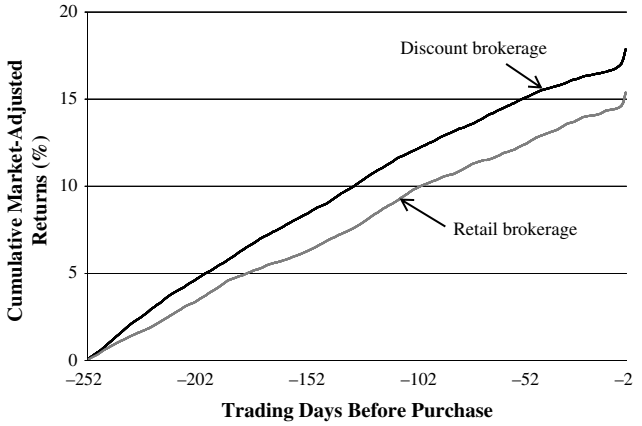
and for tax-deferred accounts, the results are qualitatively similar and statistically significant.[6]

Investors exhibit a clear preference for purchasing additional stocks they currently own when the stocks are trading at a lower price than the average purchase price rather than when the stocks are trading at a higher price. This finding is consistent with the preference for repurchasing stocks that they previously sold when the stocks were trading at a lower price than the original sale price, rather than when the stocks were trading at a higher price. However, the tendency to purchase additional shares of a stock on which the investor has lost money could be at odds with the tendency to avoid repurchasing stocks sold for a loss. There is, however, a salient difference between purchasing additional shares of a stock that has decreased in value since being purchased and repurchasing a stock that the investor previously sold for a loss. Once a stock is sold for a loss, the investor can choose to put that stock out of her mind and not even consider buying it again. However, the investor who still owns a stock will find it much harder to forget about that stock. If he buys additional shares at a lower price, he can be happy that he spread his purchases out and achieved a lower average purchase price than if he had simply bought all the shares initially; if he buys additional shares at a higher price, he will regret that he did not simply buy more shares at the original price.[7] Buying additional shares of stocks that went down after the initial purchase is consistent with investors choosing trades that reduce regret and disappointment but not with investors purchasing additional shares of stocks for which they have received a positive signal about their skill.

Alternative Explanation 3: Mean Reversion Versus Emotion-Driven Repurchases

Investors are more likely to repurchase a stock that they previously sold if that stock is now trading for less than the price at which they sold it. An alternative to our emotion-based explanation for this phenomenon is that investors may (rightly or wrongly) believe that stock returns are mean reverting. Investors with this belief prefer to buy stocks with poor recent performance. As we discussed previously, Weber and Welfens (2011) obtain a repurchase effect in an experimental setting in which respondents know with certainty that returns are not mean reverting. We test this alternative; if investors simply believe that stock returns are mean reverting, their belief is likely to apply to both stocks they have previously owned and other stocks. We therefore partition investors who exhibit a preference for buying stocks at a lower price than they sold them for (i.e., for whom PDR > PUR), then determine whether this group of investors tends to select stocks with poor recent performance when they buy stocks that they did not own during the past year. To do so, we calculate the mean market-adjusted return on purchases in event time, where day 0 is the purchase date for stocks purchased by these investors but not owned during the previous year. The means are cumulative, beginning one year (252 trading days) before the purchase.

Figure 4
EQUALLY WEIGHTED CUMULATIVE MARKET-ADJUSTED RETURNS FOR STOCK PURCHASES NOT SOLD IN THE PREVIOUS 12 MONTHS



In Figure 4, we find that for both the discount and retail brokerage houses, cumulative market-adjusted returns before purchase are on average strongly positive for stocks not owned during the past year. In general, investors chase performance rather than bet on mean reversion. Only when they have previously owned, or currently own, a stock do they buy after poor performance. Thus, having different experiences with a stock can cause two investors to treat that same stock differently. A widespread belief in mean reversion cannot explain these results.

DISCUSSION

In the previous section, we provided evidence that the tendency to repurchase stocks previously sold for a gain at a lower price than they had been sold for is not driven primarily by a well-founded belief that this behavior is profitable, by the belief that the investor has skills with respect to such stocks, or by the belief that stock returns are mean reverting. As Weber and Welfens (2011) report, this repurchase effect is observed in experimental settings in which it does not lead to greater profits, investors cannot learn about a stock, and returns do not mean revert. Furthermore, this repurchase effect does not lead to superior returns. The investors in our data sets do not more readily buy additional shares of stocks currently owned when they have timed their purchase well, nor do they behave as if returns are mean reverting when buying stocks they do not or have not owned.

Although the repurchase effect does not depend on beliefs about skill and future performance, this finding does

[6]It is unlikely that an investor who bought a stock that declined in value would take it as an indication of his or her superior information about the stock. Nevertheless, in unreported results, available on request, we calculate the CAPM and four-factor risk-adjusted returns for a portfolio of currently owned stocks repurchased at a lower price and find a negative risk-adjusted return of just over 7% per year for the CAPM ($t = 2.49$, $p < .01$). The four-factor alpha is negative but not reliably so.

[7]Weber and Welfens (2011) also replicate in the laboratory the tendency of investors to purchase additional shares of stocks that have gone down but not those that have gone up since being sold. As with the repurchase effect, Weber and Welfens find that this pattern is more likely when participants make their initial purchase and sale decisions and thus are vulnerable to regret.

not mean that investors do not entertain such beliefs when deciding which stocks to repurchase. Admitting that trades are emotionally motivated may conflict with an investor's self-image as a reasonable person, resulting in cognitive dissonance (Festinger 1957). A belief in his or her own particular ability to time trades for stocks sold at a profit and repurchased for less may help resolve any such dissonance.

If the stock market were a level playing field and trading were costless, we might argue that the ability to enhance the emotional experience of investing by both choosing and timing repurchases in a way that makes the investor feel good increases welfare. However, the enhanced emotional experience often comes with a price tag, for two reasons: First, the playing field is not level. On average, institutional investors gain through trading, whereas individual investors lose. Second, commissions and other transaction costs make trading costly. Barber et al. (2007) document that, as a group, individual investors in Taiwan lose the equivalent of 2% of gross domestic product in trading losses to institutions, market timing losses, commissions, and transaction taxes. Barber and Odean (2000) show that the U.S. discount brokerage clients we have studied reduce their annual returns by approximately 1.8 percentage points through trading. On average, these investors earn significantly lower net returns than they would receive from a market-wide index fund.

Emotions also may make investors vulnerable to manipulation. For example, we document (see Table 5) that investors at both the discount and retail brokerages are more likely to buy additional shares of the stocks they own if those stocks are trading below their original purchase price. We argue that this trading pattern is motivated—at least in part—by a desire to reduce regret. Retail brokers often advise clients to "average down," that is, buy additional shares in stocks that have dropped since purchase; the broker may be making investing more emotionally palatable for the client, and at the same time lowering the reference point by which the client judges gains, losses, and the broker's advice. Manipulating the emotional experience of investing serves investors poorly if it helps sustain suboptimal investment practices, such as excessive trading and underdiversification.

CONCLUSION

Analyzing trading records for hundreds of thousands of individual investors at a large discount brokerage and large retail brokerage, we have established two previously undocumented patterns in the purchase selections of individual investors. Both patterns hinge on investors' prior experience with a stock. Investors are less likely to repurchase (1) stocks previously sold for a loss and (2) stocks that have gone up in price since they were last sold. Investors are most likely to repurchase a stock if they previously sold it for a gain and can repurchase it at a lower price.

We argue that repurchasing stocks that were sold for a gain results from naive learning, whereby investors repeat actions that previously resulted in emotional pleasure, including elation and rejoicing, that results from buying a stock and selling it for a profit, while they avoid actions that previously led to emotional pain, such as the disappointment and regret that result from buying a stock and selling it for a loss. Because many investors view their portfolios regularly, they also may desire to avoid painful reminders of their prior losses. We argue that the reluctance to repurchase stocks that have increased in price since they were sold helps investors avoid disappointment and regret. Investors who buy a stock at a higher price than they previously sold it for are disappointed that the stock rose after they sold it and regret the decision to sell. Investors who buy a stock at a lower price than they previously sold it for experience the joy of knowing they are better off than if they had never sold that stock.

The phenomena identified here remind us that stock trading, similar to many other economic behaviors, is affected by emotions. It makes emotional sense that investors repurchase stocks that have decreased in value since being sold. Investors who do so feel the pleasure of making a choice that results in a better outcome than what might have been had they not previously sold the stock, while investors who repurchase at higher prices feel regret from knowing that they could have done better. Similarly, avoiding what has been a source of pain in the past is one of the most basic instincts that humans possess. Investors are unlikely to wish to repeat or be reminded of actions linked to their previous failures. Thus, it is not surprising that investors are attracted to stocks that have treated them well in the past but shy away from stocks by which they were once burned.

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