PSYCHOLOGICAL FACTORS, STOCK PRICE PATHS, AND TRADING VOLUME†

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We examine the relation between the trading volume of a stock, expressed as a percentage of shares outstanding, and aspects of the stock's past price path. We find that volume is significantly higher (in both economic and statistical terms) in weeks when the current price exceeds the highest price attained in the prior year. The evidence is consistent with this highest prior price serving as a reference point used by investors in making trading decisions. The effect is robust to the inclusion of other factors known to affect volume.

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In this paper, we examine the relation between a stock's weekly trading volume and aspects of the stock's past price series. Specifically, we test whether volume is sensitive to whether the current price is above the past range of prices at which the stock has traded. We document a substantial increase in volume when a stock is trading above the highest price attained during the year ending 20 trading days before the current week.

The increase in volume is robust to inclusion of controls for contemporaneous and prior stock returns, market-wide volume, earnings announcements, dividend announcements, and firm fixed effects. Compared to the results for the disposition effect documented by Ferris, Haugen and Makhija (1988), the effect of the fifty-two week high is strong. The maximum price attained in the prior period has a large significant effect while other candidate price thresholds' effects (such as the 25th percentile, the median and the 75th percentile of the distribution of past prices) are much smaller. To further identify the effect, we control for the general firm-level relation between price and volume. The increase in volume when the stock price is above the prior maximum is distinct from the more general positive correlation between price and volume. The effect is more pronounced the longer the time since the prior maximum was attained, suggesting that potential trading activity is pent up between highs and released when a stock reaches a new high. Further, trading volume tends to decrease the longer price is above a previous high, consistent with the notion that the effect is most pronounced early after the prior maximum is exceeded and dissipates over time. Finally, we find that the effect is stronger for NASDAQ stocks where individual ownership is greater, than for NYSE and AMEX stocks, consistent with a negative relation between investor sophistication and reliance on reference points.

Our research contributes to the literature in several ways. First, it builds on research in behavioral finance suggesting that individuals focus on past stock price behavior in making trading decisions. For example, studies like Shefrin and Statman (1985) and Ferris et al. (1988) document investor trading behavior consistent with a focus on reference points equal to the stock price at the time of purchase. In the context of option exercise, Heath, Huddart and Lang (1999), Core and Guay (2001), and Poteshman and Serbin (2001) argue that past high prices also explain financial decision making. Unique features of option exercise may limit generalizability of these findings to other contexts. We provide evidence that extreme prices affect trading behavior in US equity markets as a whole.

Second, we provide evidence on the role of behavioral factors on market volume. As discussed in Statman and Thorley (1999), determinants of trading volume are poorly understood; models of rational utility-maximizing economic agents do not fit observed patterns well. As Statman and Thorley note, behavioral models offer predictions about the causes of volume. For example, Odean (1998b) develops a model in which trader overconfidence is reflected in high volume. Barber and Odean (2002) present evidence that small individual investors are net purchasers of stocks on days when stocks are in the news, experience extreme volume, or experience extreme returns. Our results are generally consistent with the notion that a fixation on an extreme point in a stock price path affects trading decisions.

Third, our evidence suggests a reason for the prominence of past maximums—the widely-reported 52-week high—in the business press. The ubiquity of the fifty-two week high is remarkable, given there is little reason to believe that it is helpful in making investment decisions. The *Wall Street Journal*, for example, reports only a small set of data on each stock, so it is striking that a statistic as apparently useless as the prior maximum is reported. Highs may be prominently reported because they satisfy some demand—investors are interested in knowing prior extreme share prices and the media responds to that demand. Causality may well run in the other direction, however. Because the media report these data, investors may use them in reaching trading decisions because it is too difficult or costly to gather more relevant or useful information. The publication of the number makes it a candidate for a reference point and may even suggest to investors that it is useful in decision making. Some investors who have held their shares for a long time or who bought shares at a range of prices may not recall the cost of their position. Such investors may conveniently set a reference point equal to a readily-accessible statistic like the previous high. While we do not attempt to disentangle these factors, there appears to be an increase in volume around fifty-two week highs, suggesting that a significant fraction of investors condition their trading on this event.

In the next section, we discuss the related research and motivate our enquiry. Then, we present the data and analysis, followed by robustness tests and conclusions.

1. Background

Much of the research in behavioral finance centers on the notion of value functions, developed within Kahneman and Tversky's (1979) prospect theory. They argue that standard expected utility theory does not explain many observed phenomenon and suggest an S-shaped utility function that is convex to the left and concave to the right of a reference point. Individuals define gains and losses relative to the reference point, and are risk-seeking when faced with loss outcomes and risk-averse when faced with gain outcomes. The insight from that model has been used in the finance literature to predict individual trading behavior. One implication of prospect theory is that investors are more likely to close positions with gains than they are to close positions with losses.

While prospect theory provides predictions based on the location of outcomes relative to the reference point, the theory does not prescribe the location of the reference point. Laboratory studies in the psychology literature assume a reference point based on the status quo, while empirical research in behavioral finance focuses on the disposition effect, where the reference point is assumed to be the purchase price of the stock. Shefrin and Statman (1985) coined the term disposition effect and showed it to be an important determinant of trading behavior by investors at a retail brokerage. Odean

(1998a) documents similar effects for a large database of investors at a discount brokerage and Heisler (1994) finds evidence of the disposition effect among futures traders. In an examination of the disposition effect, Ferris et al. (1988) provide evidence that trading volume, in their sample of 30 small stocks, is higher when firms pass a price level at which there was previous high volume. In their design, the previous high volume indicates a price level at which a large number of investors purchased the stock. Hence, evidence of higher volume when the stock price exceeds this level is consistent with investors setting a reference point equal to the purchase price of the stock.

While the notion that the purchase price is a reference point has empirical support, research on learning and memory suggests that individuals are also likely to remember extreme observations (Fredrickson and Kahneman 1993; Fiske and Taylor 1991). As a result, individuals may focus on extreme observations when making investment decisions. Gneezy (1998), who examines trading behavior in an experimental setting, finds evidence that the maximum stock price attained over some prior period may be a more salient reference point than the purchase price.

Research on stock options also provides evidence that the prior maximum is an important determinant of exercise behavior. Heath et al. (1999) examine determinants of exercise using detailed option grant and exercise records for more than 50,000 employees at seven companies and find that exercise concentrates at times when the stock price is above the fifty-two week high. This suggests a greater willingness to sacrifice an uncertain payoff for cash when the stock is trading above its historical high, since employees exercising options typically cash out immediately. Core and Guay (2001) find consistent results in an examination of a broad cross-section of firm-level option exercise data. Poteshman and Servin (2001) examine exercise decisions of investors in traded options, focusing on cases in which exercise is clearly irrational. They find that early exercise in those cases is correlated with whether the stock is at a high relative to the prior year. In addition, they document that the reference point effect is more pronounced for discount and full service customers than for firms' proprietary traders, which they attribute to differences in sophistication. Similarly, Huddart and Lang (2002) examine employee stock option exercise behavior across levels in the organization and report that lower-level employees' exercise decisions are more sensitive to prior maximums in their trading decisions, consistent with differences in sophistication across levels within a firm.

While the evidence on stock option exercise and past highs is strong, it is not clear whether these results extend to traded equities markets. Employee stock option exercise decisions differ from equities trading decisions. In the latter case, the purchase price may serve as a reference point. In the former case, there is no corresponding purchase price since employees are granted stock options; employees do not purchase them. Further, the stock price at the option grant date is not a plausible reference point since exercise near or below that price is clearly uneconomic. Also, the holders of employee stock options, who receive options as part of a broader compensation package, may differ from investors who choose to actively trade in equities markets.

However, there are reasons to believe that prior maximums might serve as powerful reference points for the market more generally. As noted above, Gneezy (1998) finds that, in the laboratory, prior maximums serve as powerful reference points even in the face of the disposition effect. Further, it is easy to imagine the fifty-two week maximum as an attractive reference point since it is a commonly-reported statistic. For example, the stock price sections of most newspapers include the fifty-two week high along with current price levels and trading volumes. Similarly, articles in the financial press often note when a stock is trading at its fifty-two week high. Also, most financial news sources provide price charts over the prior year on which the fifty-two week high is clear. As a result, it seems likely that the typical investor has easy access to historical highs and may use them as a basis for making trading decisions.

In defining whether the stock price in the observation week is above the prior high, we follow Heath et al. (1999). We define the prior high to be the highest closing stock price in the year-long period ending 20 trading days before the last day of the observation week. This definition excludes closing prices in the month immediately prior to the sample week. We do this to avoid the problem that there would be very few observations above a prior maximum if the comparison included weeks immediately prior to the current week. The notion is that investors' reference points adapt over time; the currently-salient reference point is the highest stock price attained some time ago.

[Figure 1]

For example, consider the recent price series for Echo Bay Mines (AMEX:ECO), illustrated in figure 1, and a hypothetical investor deciding whether to sell his position in this stock in late May or early June 2002. This stock closed at \$1.03 in the week ending June 11, 2001 and then dropped before climbing back to close at \$0.91 in the week ending February 4, 2002. It dropped again and then rose to \$0.92 in the week ending March 25, 2002. Using our definitions, the prices in February and March 2002 are below the prior maximum, which was attained in June 2001. In the week of May 20, 2002, the stock climbed to a new high of \$1.09, which is above the prior maximum and climbed further the following week to reach \$1.28 on May 28, before falling back to \$1.20 on June 3 and then falling to \$0.99 the following week.

As we define the prior maximum variable used in this study, the prices on May 20, May 28, and June 3 are above the prior maximum price (i.e., the \$1.03 price reached on June 11, 2001), because the prior maximum is the highest closing price attained in the year-long period ending 20 trading days before the last day of the observation week. This is so even though the price on June 3, 2002 is below the closing price for the immediately previous week. The fact that the stock price has dropped in the last week is likely important and may reduce investors' willingness to trade. This effect is captured separately by including the returns for the prior week in the regression specification.

The S-shaped value function in prospect theory implies that a decision maker is risk-seeking below his reference point and risk-averse above his reference point. If investors set reference points salient for decisions to sell stock they own at the highest price attained by a stock over a prior period of about one year, then the theory predicts that investors are more likely to sell the stock when its price is above the prior maximum (in the example, in late May and early June of 2002) than when its price is below the prior maximum (in the example, the time between June 2001 and mid-May 2002). In this example, sharp price movements are associated with higher volume regardless of whether the stock price is above or below a prior maximum, but volume in late May and early June 2002 for Echo Bay Mines is higher than during run-ups that did not carry the price past the prior maximum in February and March 2002. Our analysis primarily addresses whether this anecdotal evidence is borne out in a representative sample of US equities.

[Figure 2]

Figure 2 presents a basic univariate analysis of the relation between prior price levels and volume in our data (described below) for observations where the stock price in the observation week is in the neighborhood of the prior high. Firm-week observations of volume, expressed as a percentage of shares outstanding, are grouped by percentiles of the distribution of closing prices over the year ending 20 trading days before the last day of the observation week. The figure documents a positive relationship between stock turnover and the price relative to the past distribution of prices, with the effect most pronounced at the 100th percentile (the maximum of the prior distribution). The effect is especially notable when medians are compared.

That reference points might trigger investors to sell is also supported by the notion of resistance levels in the popular press. In particular, one rationale for considering the 52-week high in investment decisions is alleged to be the resistance points which occur around such highs. If investors use previous highs as reference points, that could result in selling pressure around the previous high: investors who delay selling until the stock price increases past the prior maximum then sell heavily may cause selling pressure that dampens further price appreciation. For example, a firm with good news that moves its price above the prior high may languish around the prior high due to increased selling volume, whereas the same stock might more easily move higher if the news did not move the stock past the prior high. In other words, appreciating to the prior maximum may limit a stock's ability to move further upward. Some investment professionals argue that once there is a clear and sustained movement above the prior high, the share becomes a good investment because the resistance is gone and the shares can move higher.

Prospect theory aside, beliefs models may bear on investor behavior around prior highs. Investors may believe that a price, once achieved, is likely to be achieved again. As a result, investors may be hesitant to sell (or anxious to buy) below a prior maximum because they believe share price is likely to revert to its prior level. It is difficult to distinguish empirically between belief models and models based on the value function because investors may appear to be risk-seeking at prices below the prior maximum (and hence, unwilling to liquidate their positions) because they believe the odds of price appreciation are greater. The same issue affects the other research on investor behavior around prior maximums.[1] In fact, even evidence on the disposition effect could reflect the fact that investors believe that they paid a fair price for a stock, so a stock trading below the purchase price is more likely to appreciate.

While it may not be possible to identify which behavioral phenomenon causes increased trading at prices around a prior maximum, our goal is to document that the behavior occurs. Most importantly, we know of no economic reason to expect increased trading around a prior maximum; models of utility-maximizing rational economic agents do not lead to predictions of increased trading around a prior maximum. We are not aware of any evidence that returns are systematically lower (or higher) following a maximum and there are no clear tax or other incentives to trade at that time.

2. Data and Analysis

We base our analysis on a random sample of 1,000 firms drawn from the CRSP universe of common stocks listed on the NYSE, AMEX, or NASDAQ exchanges at some point in the period November 1, 1982 to December 31, 2001 with at least five years of available price, volume and return data. We begin our analysis on November 1, 1982 because that is the first date for which NASDAQ volume is available in CRSP. We limit the sample to 1,000 firms to keep the resulting data set tractable. Because we

[1] As Dhar and Kumar (2001) note, the behavioral finance literature typically does not distinguish between reference points and anchors (i.e., uninformative signals which people use in decision making). Following the prior literature, we refer to the prior maximum as a "reference point" even though we are not able to distinguish between alternative behavioral explanations.

use weekly observations for 1,000 firms over a period of nearly 20 years, there are about 500,000 firm-week observations in total. We consider the three major US exchanges to capture potential differences in investor clienteles, since NASDAQ firms are likely to be owned and traded by a different clientele than NYSE and AMEX firms.

Our primary variable of interest is the percent of abnormal trading volume. We define abnormal volume, ABNVOL, for a given firm-week to be the residual from firm-by-firm regressions of firm volume on market volume using weekly data:

$$\mathrm{VOL}_{it} = \beta_0 + \beta_1 \mathrm{MVOL}_t + \epsilon_{it}$$

where VOL is the average daily number of firm i shares traded as a percentage of firm shares outstanding in week t, and MVOL is the average daily number of market shares traded as a percentage of the number of market shares outstanding in week t.[2] We use the NASDAQ (NYSE) volume market for firms trading on the NASDAQ (NYSE or AMEX).

While we could have focused on a measure of market value of share volume, we chose shares traded to abstract from the effects of share price. Because we are interested in shares that are trading at high prices (relative to past prices), this should bias against finding results. However, it does implicitly assume that investors make decisions based on numbers of shares rather than dollar amounts. This seems consistent with the notion of an investor deciding to liquidate a position rather than to generate a desired amount

[2] Results are not sensitive to the choice of dollar- or equal-weighted measures of market volume.

of cash. Further, results are robust to the inclusion of share price as a control, indicating that the level of share price does not drive the results.

We use average daily volumes over a week since daily volume is likely to be highly correlated and monthly volume may be too aggregated to detect specific effects. Because of concerns about remaining correlation in volume, we adjust for first-order autocorrelation in all of our analyses.

[Table 1]

Table 1 reports descriptive statistics on the sample firms. Volume is stated as a percentage of shares outstanding, so the mean daily volume per week of 0.337% implies annual volume of about 84% of shares outstanding. Volume for our sample firms is somewhat below market volume, which averages 0.518% daily volume per week. By construction, abnormal volume for our sample firms is nearly 0 (the small difference from 0 is due to winsorization after regressing VOL on MVOL). Weekly stock returns excluding dividends for the sample firms average 0.2 %, implying annual returns of about 10%.

As indicated in table 1, the median firm-week is at the 53.3 quantile of prior price distribution. In 38.2% of cases, the observation is above the 75th percentile; in 11.5% of cases, it is above the prior maximum. The fact that the median observation stock price is above the median price of the prior distribution reflects the fact that prices were generally increasing during our sample period, so the typical observation price is higher than the typical price during the previous year.

[Table 2]

To more formally test the relation suggested in figures 1 and 2, table 2 reports the basic regression of abnormal volume on an indicator variable, PRIORMAX, that is 1 when the closing price for the observation firm-week is above the prior high and zero otherwise. We include contemporaneous and prior returns as control variables in the regression because prior research suggests that returns are associated with subsequent volume. For example, Heath et al. (1999) document a relation between prior returns and stock option exercise, which they attribute to a belief in mean reversion of returns in the short run. Similarly, Statman and Thorley (1999) argue that elevated volume reflects overconfidence induced by past investment success.[3] In particular, our concern is that PRIORMAX is correlated with prior return, so a significant coefficient on PRIORMAX might reflect the same effect as the prior return result. Statman and Thorley (1999) also suggest that the relation between volume and returns may be asymmetric, with negative returns reducing volume more than positive returns increase it. As a result, we split returns by sign.[4]

The regression is estimated correcting for first order autocorrelation using the Yule-Walker estimation method [Gallant and Goebel (1976)].[5] Contemporaneous returns

[3] The Statman and Thorley (1999) result is primarily for market volume rather than for individual stocks. Our analysis based on abnormal volume, controlling for the market, so it should not be affected by market volume.

[4] The results are not sensitive to whether return variables are split by sign, nor are they sensitive to the inclusion of measures of longer-term past returns, such as the return over weeks −27 to −52 relative to the observation week.

[5] This method is similar to the Cochrane-Orcutt method [Cochrane and Orcutt (1949)], with the main difference being the retention of the information from the first observation.

are strongly correlated with volume. Consistent with Statman and Thorley (1999), the sign on positive returns is positive and the sign on negative returns (coded as negative values) is negative for the contemporaneous and previous weeks' returns. The likely explanation for the opposite signs on returns is that volume tends to be high when there is news that moves stock prices either positively or negatively. The previous week's return is also significant, consistent with Beaver (1968) who suggests that volume can remain elevated for a week or more following a news release. Also consistent with Statman and Thorley (1999), for returns more than three weeks prior to the sample week, the sign on both positive and negative returns is positive, suggesting that volume tends to be higher for firms that are performing well. This result is interesting because it is difficult to imagine that volume responds to the news released so long in the past. Rather, it seems more consistent with behavioral explanations, such as a belief in mean reversion over short periods or trading by momentum investors who are attracted to stocks that have performed relatively well in the recent past.

The principal variable of interest, PRIORMAX (defined to be 1 when the current price is above the prior high, and 0 otherwise), is positive and significant with a coefficient estimate of 0.079. From table 1, an increase in abnormal volume of that magnitude is enough to move from the median to about the 75th percentile, indicating a substantial increase in volume when the stock price rises above the prior high. The table reports two R^2 statistics, one representing the fit of the model including lagged volume and one the incremental R^2 for the regressions. Despite the fact that the overall magnitude of the effect based on the coefficient estimate is substantial and the t-statistic is large due to the large number of observations, the explanatory power of the regression is relatively low. In part, this is because we controlled for market volume in the first stage regressions. Controlling for market volume biases against finding the predicted results since it eliminates the effect of cases in which market volume is generally high because a disproportionate share of stocks are trading above prior highs. However, analysis of ABNVOL focuses attention on firm-specific effects. Further the regression does not capture firm-specific news that is likely to drive much of firm-specific volume, except as it is reflected in returns variables.

One potential concern with specification (1) of table 2 is that the preceding results might be driven by the effect of earnings and dividend announcements. In particular, omitting dividend and earnings announcements might bias our results if for some reason extreme prices tend to be associated with earnings or dividend announcements. Table 1 reports that firms announced dividends in 3.7% and earnings in about 5.5% of sample weeks. While that seems too infrequent to drive the empirical results, we re-estimate the regression including an indicator variable for earnings and dividend announcements.

Further, volume might be correlated with the level of share price. For example, if investors trade, in part, based on the dollar value of the trade, then low share prices might be associated with high share volume. As well, share price might be correlated with whether a stock is trading at a maximum. While that should bias against our result, stock price could represent an important omitted variable. Therefore, we include share price as a control variable. Finally, the volatility of returns may affect volume for at least two reasons. First, the volatility in increased returns reflects increased uncertainty in the market, which may lead to additional trading. Second, prospect theory suggests that higher volatility may affect decisions to sell. To address these concerns, specification (2) in table 2 reports results controlling for earnings and dividend announcements, share price level and returns volatility. Volume is on average higher around dividend ex-dates and earnings announcement dates. The coefficient on share price is also positive, suggesting that investors are generally more likely to trade when share prices are relatively high. The standard deviation of past returns is negatively correlated with volume, suggesting that return volatility drives out volume. Most importantly, the indicator variable for prior maximum is affected little by inclusion of the additional variables.

It is also possible that the disposition drives abnormal volume since more investors are above their purchase price when above the maximum than at other levels. This seems unlikely, however, since the prior maximum is also likely to be above most investors' purchase prices. However, to examine this further, we use the Ferris et al. (1988) approach to estimate the disposition effect. For a given sample day's price, they form eight equal price bands, four above and four below. They then accumulate volume in each price band over the prior year to create eight variables. Finally, they regress the sample day's volume on the eight prior volume variables. The logic underlying this procedure is that, if most past volume was at prices above (below) the current price, investors should be unwilling (willing) to sell at the current price since, for most, it is below (above) their reference point. We compute similar variables for each firm-week and include them in our regression. Again, results (not tabulated) are unaffected by inclusion of the controls.

[Table 3]

Another potential concern is that other percentiles of the return distribution might have explanatory power. For example, investors might focus on a measure of central tendency like the median. Table 3 compares the coefficient estimate for various other percentiles that might serve as reference points. In particular, we consider the 25th percentile, median, and 75th percentiles. In addition, we construct an additional threshold, the "110th" percentile, defined as the prior high plus 10% of the range of stock prices attained over the prior year.

Table 3 includes three specifications. Specification (1) includes only returns as controls; specifications (2) and (3) include additional controls. Results are similar across the specifications.[6] The PRIORMAX variable has a different interpretation in table 3 than in table 2. The addition of the 110th percentile variable constrains the PRIORMAX coefficient to incorporate the effect on volume of a firm trading at

[6] Results are also robust to the inclusion of variables similar to those in Ferris et al. (1988).

or above its prior maximum and beneath the 110th percentile. The 110th percentile variable captures the effect on volume of a firm trading at or above its 110th percentile and below its 120th percentile.[7] Given the construction, it is not surprising that the coefficient is smaller on PRIORMAX in table 3 when compared with table 2. However, it is striking that the coefficient on PRIORMAX is both larger and more significant than the coefficients on the percentiles below it and larger and more significant than the percentile above it, indicating a more pronounced effect at the maximum than at other percentiles.

While the coefficients on the percentile dummy variables suggest a general positive relation between the level of the observation week price in relation to the past trading range and the observation week trading volume, the coefficient estimate and t-statistic for PRIORMAX are larger than for any other percentile dummy. To test whether the significance of PRIORMAX simply represents the general positive relation between price relative to past levels and volume, regression specification (3) includes the variable RELPRC, which is price for the observation week divided by the median price in the prior distribution.[8] Table 1 reports the descriptive statistics for this variable. By construction, the mean and the median of RELPRC are slightly larger than 1. Controlling for

[7] We exclude firms above the 120th percentile to allow for a fair comparison between the 100th and 110th percentile variables. Results are similar when adding additional increments of percentile variables at and above the 120th percentile.

[8] As an alternative to RELPRC, one could locate the observation week price in the distribution of prior prices, and express it as a fractile. So, for example, an observation at or above the prior high would take a value of 1.00 while an observation at the median would take a value of 0.50. This variable ranges from 0.00 to 1.00. Replacing RELPRC with this variable yields similar results.

the general relationship of price relative to past levels and including additional percentiles (i.e., 25, 50, 75, 110) as control variables, PRIORMAX remains significant and has the largest coefficient of all the percentiles included in the regression.

It does not seem like the high volume associated with the 100th percentile is representative of a more general positive relation between price and trading volume. Some other factor appears to be at work that causes volume to spike at the 100th percentile. While we cannot say for certain that the effect reflects selling induced by a reference point, several observations are worth noting. First, the result is very consistent with the literature on stock options where the direction of trade can be explicitly identified and incentives can be better controlled. Further, it is consistent with laboratory research by Gneezy (1998) and archival studies of individual trader choices including Dhar and Kumar (2001). At a minimum, it seems clear that something occurs at the prior maximum that increases trading volume. Further, the controls for past returns indicate that it is not simply a reflection of the fact that well-performing firms have higher trading volume.

To the extent that traders are less willing to dispose shares at a price below the prior maximum, one would expect pent-up sales demand to accumulate the longer the firm traded below the prior high price. As a result, one might expect the increase in volume when prices cross the prior maximum to be a function of the length of time since the prior maximum. For example, one can imagine investors waiting in the wings to liquidate positions for diversification or liquidity until the price reaches the prior high.

The longer the lag before the new maximum, the greater the accumulated backlog of shares and, hence, the greater the volume when price crosses the prior high.

[Figure 3]

One way to examine this relationship is to recompute the means and medians presented in figure 2 using only those observations for which the stock price attained the prior maximum more than six months before the observation week. Figure 3 is otherwise constructed in the same manner as figure 2. Two differences in these figures are apparent. First, the mean and median volumes are higher in figure 3 than in figure 2 at all percentiles around the prior maximum. Second, the jump in volume at the maximum (i.e., from the 98th to the 100th percentile) is more pronounced in figure 3: In figure 3, the difference in means is 0.055 and in medians is 0.029; in figure 2, the corresponding differences are 0.037 and 0.023, respectively. Thus, in general, the longer the time since the maximum was attained, the greater the volume when that stock price is reached again. This finding is consistent with potential trading activity being pent up between highs and released when the stock price reaches a new high.

A second way to examine this relationship is to include in the regression specification a variable that measures the months since the prior maximum conditional for firm-weeks where the price is at or above the prior high, which we label LHIGH. For firm-weeks where price is below the prior high, LHIGH is set to zero. Further, it seems reasonable to expect that if investors are holding off selling shares until a new maximum is reached, volume will tend to increase when the new level is reached and then trail off the longer the share price remains at a high level. Because the greatest response to a new maximum may well occur shortly after the maximum is reached, we also include the variable ABVMAX, which measures the time (in days) since share price first reached the prior maximum, conditional on the share price being above the prior maximum. For firm-weeks where price is below the prior high, ABVMAX is set to zero.

Table 1 reports descriptive statistics on LHIGH and ABVMAX. The average time since the prior maximum for firms trading above the prior maximum is about 92 calendar days. In addition, the average time a firm at a maximum has been above the previous maximum, given it is currently above the maximum, is about 11 days.

[Table 4]

Table 4 presents regression results including the variables for time since prior maximum and time at current maximum. The coefficient estimate on the LHIGH (the time since the previous high conditioned at being at the max) is positive and strongly significant. If the increased volume associated with the fifty-two week high reflects selling activity around a reference point, the result is consistent with the notion that an inventory of shares which investors wish to trade accumulates while the stock is below the previous high. Similarly, the variable for time spent at the maximum, ABVMAX, is strongly negative, suggesting that the volume effects of exceeding a prior maximum are initially high and dissipate the longer the stock price remains above the prior maximum.

Again, if the prior maximum serves as a reference point, the results are consistent with some investors taking advantage of a recent high to sell shares and the volume dropping the longer the price remains high as those investors' stores of shares are exhausted.

Finally, it is possible that the strength of the relationship differs between NASDAQ and NYSE firms. In particular, the NASDAQ stocks are held more heavily by individual investors. Prior research suggests that less sophisticated investors are likely to be more heavily affected by psychological factors. As such, we might expect the results to be stronger for the NASDAQ firms.

[Table 5]

The results in table 5 suggest that volume for NASDAQ firms is affected more dramatically by prior returns and the prior maximum. The coefficient on the prior maximum is nearly twice that for the NYSE firms. If NASDAQ stocks are generally held by more individual investors and hence tend to have a less sophisticated clientele, the results are consistent with less sophisticated investors relying more heavily on past maximums as reference points. Consistent with this, the returns relation for longer lags is also stronger for the NASDAQ than for the NYSE firms.

3. Other analyses

Also, as noted earlier, one potential concern is that our regression is sensitive to the control for market volume. Replicating our analysis including raw volume leads to very similar results as when using abnormal volume. Similarly, we re-estimate the regression using raw volume as a dependent variable and including market volume as a control in a one-stage regression (effectively constraining the market volume relation to be the same across stocks). While the R^2 is much higher because of the explanatory power of market volume, the results are very consistent. Further, to ensure that extreme volume is not driving the results, we re-estimate abnormal volume based on natural logs, and also estimate the entire regression in ranks, with very similar results.

Another potential concern is that our analysis is detecting inter-firm rather than intra-firm differences. For example, it is possible that some sample firms tend to trade more frequently above prior maximums and also tend to have higher volume for reasons other than their stock price. If so, our interpretation of the link between price level and trading volume would be incorrect. To ensure that our results reflect differences within firms over time rather than across firms, we replicate the analysis using firm fixed effects. Results from this approach are very consistent with those reported earlier, indicating that inference is robust to firm controls.

Finally, it could be the case that our analysis is capturing periods in which volume is elevated and firms are trading at high prices for reasons unrelated to our focus. That seems unlikely here because our sample is randomly selected and we explicitly adjust out the market volume effects. However, to ensure that cross correlation of that type does not drive our empirical results, we replicated our analysis using date fixed effects. Results are very similar to those reported.

4. Conclusions

Our results suggest that psychological factors affect investor trading decisions in equities markets. Across a broad sample of stocks, volume fluctuates depending on the location of the current price in the distribution of prices over the prior year: volume is higher when the stock price is above the 52-week high, suggesting that the prior high is a salient reference point in their decision-making. While our results do not imply that all investors use this cue or even that some investors always use this cue, the 52-week high is a salient reference point for enough investors that this behavioral artifact can be observed in aggregate data.

Our results make several important contributions. First, we build on prior research findings that investors focus on the purchase price as a reference point when making trading decisions. We extend this research by investigating the role of a reference point based on the maximum of a prior distribution. The evidence is consistent with the maximum of a historical distribution serving as a reference point that affects investors' trading behavior.

This study is not the first to investigate the use of a maximum of a prior distribution as a reference point. The prior maximum has been found to affect behavior in the stock option environment (Heath et al. 1999); however, the stock option setting differs from the equity trading setting for at least two reasons. First, in the stock option setting there is not an obvious reference point like purchase price, whereas in equities trading the purchase price is a natural candidate for reference point. Second, the financial sophistication and motivations of option holders of stock options may differ from those of active investors. Our paper documents a similar effect in the equity trading arena as has been found for stock options.

Second, we contribute to the literature on the determinants of market volume. Statman and Thorley (1999) note that determinants of trading volume are generally not well understood, especially with respect to economic models. We document a behavioral determinant of volume by finding that market participants respond by trading when a firm's stock price exceeds the maximum of a prior distribution.

Our results suggest some interesting patterns that might be observed at the maximum of the prior 52-week distribution. In particular, we find abnormal volume to increase at the maximum. It would also be interesting to investigate the types of investors in these transactions. One might expect less (more) sophisticated investors to be the sellers (buyers) in these transactions. Future research might investigate the effects of this phenomenon on the level of stock prices (i.e., does the increase in volume create price pressure). In other words, are the behavioral phenomena documented here large enough to drive price, as the discussion of resistance points suggests? Finally, investigations of other reference points might be considered (e.g., minimum over prior distribution or industry-based reference points).

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Table 1
Descriptive statistics on regression variables

Variable	Number of observations	Mean	Standard Deviation	25^{th} Percentile	Median	75^{th} Percentile
VOL (%)	494,104	0.337	0.501	0.066	0.166	0.382
MVOL (%)	494,104	0.518	0.283	0.311	0.410	0.639
ABNVOL (%)	494,104	-0.019	0.365	-0.149	-0.049	0.033
PRIORMAX	494,104	0.115	0.319	0.000	0.000	0.000
DPCT75	494,104	0.382	0.486	0.000	0.000	1.000
DPCT50	494,104	0.533	0.499	0.000	1.000	1.000
DPCT25	494,104	0.680	0.467	0.000	1.000	1.000
DPCT110	494,104	0.074	0.261	0.000	0.000	0.000
RET0	494,104	0.002	0.068	-0.028	0.000	0.027
RET5	494,104	0.058	0.347	-0.139	0.020	0.197
DIV	494,104	0.037	0.190	0.000	0.000	0.000
EARNANN	494,104	0.055	0.227	0.000	0.000	0.000
SDVOL	492,931	0.458	0.289	0.254	0.384	0.581
PRC	494,104	17.575	16.501	5.500	13.000	24.250
RELPRC	494,104	1.059	0.346	0.871	1.022	1.193
ABVMAX	56,804	10.983	5.783	6.000	11.000	16.000
LHIGH	56,804	3.055	2.805	1.033	1.667	3.967

The unit of observation is a firm-week. For a randomly selected sample of 1,000 firms, all firm-weeks in the period November 1, 1982 to December 31, 2001 with available data are included. VOL is the average daily number of firm shares traded as a percentage of firm shares outstanding in the observation week, and MVOL is the average daily number of market shares traded as a percentage of the number of market shares outstanding in the observation week. ABNVOL is the residual from firm-by-firm OLS regressions of PVOL on MVOL. DPCTi is an indicator variable that takes the value 1 if the closing stock price for the observation week is above the highest price attained in the year-long period ending 20 trading days before the last day of the observation week. PRIORMAX is DPCT100. RET is the raw stock return, excluding dividends, over the observation week. RET5 is return over weeks -5 to -26 relative to the observation week. DIV and EARNANN are dummy variables taking the value 1 if a dividend ex-date or an earnings announcement, respectively, occurs during the observation week. SDVOL is the annuallized standard deviation of stock returns computed from the 26 weekly observations prior to the observation week. PRC is the closing stock price for the observation week. RELPRC is the ratio of the closing price in the observation week to the median value of the distribution of prior prices. ABVMAX is the number of the past trading days for which the closing stock price is above the previous high, given the current price is above the prior high. LHIGH is the time (in months) since the prior high was reached, given the current price is above the prior high. All variables are winsorized at the 1% and 99% levels.

Table 2

Regression of ABNVOL on PRIORMAX, past returns and control variables

Specification	(1)		(2)	
Variable	Coeff.	t	Coeff.	t
Intercept	-0.101	-68.6	-0.105	-46.5
PRIORMAX	0.079	39.7	0.071	35.3
PRET0	1.936	188.4	1.971	189.3
NRET0	-1.284	-103.6	-1.359	-107.6
PRET1	0.610	55.0	0.741	63.1
NRET1	-0.280	-20.8	-0.478	-33.4
PRET2	0.069	6.1	0.207	17.5
NRET2	0.194	14.3	-0.014	-1.0
PRET3	-0.001	-0.1	0.125	10.8
NRET3	0.299	22.1	0.106	7.4
PRET4	0.008	0.8	0.096	9.1
NRET4	0.274	22.0	0.128	9.9
PRET5	0.062	19.8	0.091	27.8
NRET5	0.158	27.1	0.072	11.7
DIV			0.020	10.4
EARNANN			0.084	51.3
SDVOL			-0.132	-30.7
PRC			0.001	18.5
Observations	494,104		492,931	
Regression R^2	0.083		0.091	
Total R^2	0.327		0.332	

The variable NRETi is $\min(0, \text{RET}i)$. The variable PRETi is $\max(0, \text{RET}i)$. See table 1 for other variable definitions.

Table 3

Regression of ABNVOL on PRIORMAX, other thresholds of the past price distribution, past returns and control variables

Specification	(1)		(2)		(3)	
Variable	Coeff.	t	Coeff.	t	Coeff.	t
Intercept	-0.097	-47.3	-0.097	-38.0	-0.251	-48.6
PRIORMAX	0.044	18.4	0.037	15.8	0.035	14.6
DPCT75	0.021	12.3	0.014	8.0	0.010	5.5
DPCT50	0.011	5.8	0.006	3.5	0.001	0.8
DPCT25	-0.012	-6.9	-0.014	-7.5	-0.020	-10.9
DPCT110	0.030	9.8	0.027	9.1	0.026	8.4
PRET0	1.693	154.3	1.742	156.8	1.589	139.2
NRET0	-1.276	-101.0	-1.337	-104.5	-1.394	-106.2
PRET1	0.392	33.4	0.534	43.2	0.289	23.8
NRET1	-0.320	-23.5	-0.501	-34.9	-0.437	-31.0
PRET2	-0.074	-6.3	0.074	6.0	-0.176	-14.5
NRET2	0.136	9.9	-0.055	-3.8	0.022	1.5
PRET3	-0.112	-9.6	0.025	2.0	-0.216	-17.9
NRET3	0.242	17.7	0.065	4.6	0.130	9.2
PRET4	-0.055	-5.2	0.042	3.9	-0.163	-14.8
NRET4	0.219	17.4	0.086	6.6	0.115	8.8
PRET5	0.039	11.7	0.074	21.6	-0.055	-12.7
NRET5	0.115	18.4	0.040	6.2	0.019	2.7
DIV			0.022	10.9		
EARNANN			0.083	50.8		
SDVOL			-0.131	-31.3		
PRC			0.001	20.0		
RELPRC					0.166	32.5
Observations	472,415		471,263		472,415	
Regression R^2	0.064		0.073		0.066	
Total R^2	0.291		0.298		0.293	

See tables 1 and 2 for variable definitions. Firm-weeks with prices at or above the "120th" percentile are excluded from the analysis.

Table 4

Regression of ABNVOL on PRIORMAX, returns and control variables

Variable	Coeff.	t
Intercept	-0.101	-68.3
PRIORMAX	0.091	24.0
ABVMAX	-0.003	-12.0
LHIGH	0.005	9.2
PRET0	1.916	184.9
NRET0	-1.276	-108.8
PRET1	0.605	54.5
NRET1	-0.277	-20.6
PRET2	0.076	6.8
NRET2	0.197	14.5
PRET3	0.021	1.8
NRET3	0.301	22.3
PRET4	0.022	2.1
NRET4	0.279	22.4
PRET5	0.065	20.8
NRET5	0.161	27.6
Observations	494,104	
Regression R^2	0.083	
Total R^2	0.327	

See tables 1 and 2 for variable definitions.

Table 5

Analysis by Exchange

Variable	NASDAQ Coeff.	NASDAQ t	NYSE/AMEX Coeff.	NYSE/AMEX t
Intercept	-0.119	-49.2	-0.089	-56.6
PRIORMAX	0.109	33.5	0.052	24.9
PRET0	2.073	140.5	1.649	124.8
NRET0	-1.293	-72.2	-1.307	-83.4
PRET1	0.652	41.0	0.540	37.9
NRET1	-0.225	-11.5	-0.449	-26.5
PRET2	0.088	5.5	0.055	3.8
NRET2	0.241	12.2	0.037	2.2
PRET3	0.016	1.0	-0.012	-0.8
NRET3	0.363	18.6	0.103	6.1
PRET4	0.025	1.7	-0.002	-0.1
NRET4	0.323	17.9	0.129	8.2
PRET5	0.077	17.3	0.037	9.2
NRET5	0.186	21.9	0.076	10.5
Observations	266,916		227,188	
Regression R^2	0.087		0.082	
Total R^2	0.330		0.324	

See table 1 for variable definitions.

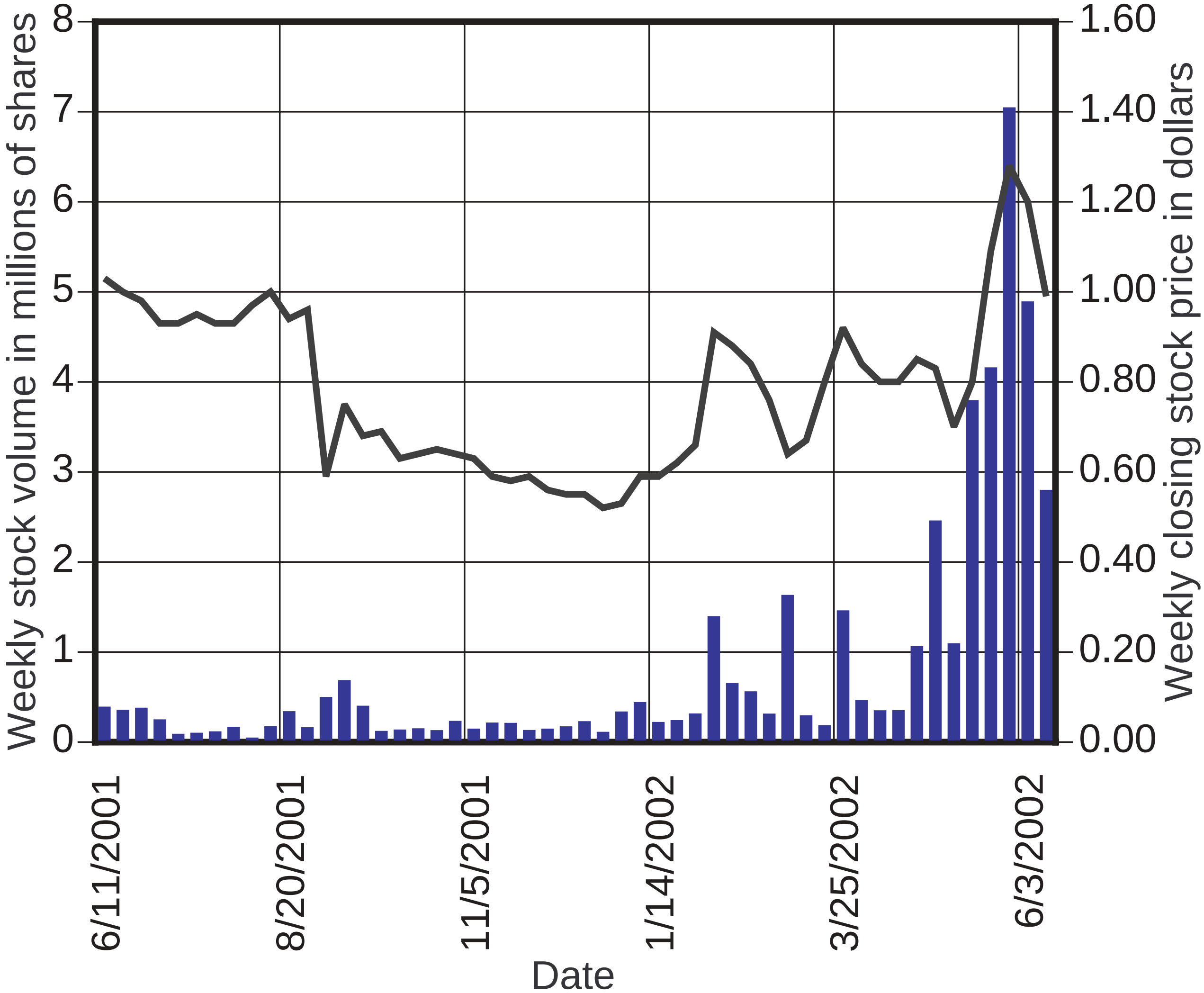

Figure 1

Weekly volume and closing stock price for Echo Bay Mines (AMEX:ECO)
In the figure, the bars represent volume and the line represents price.

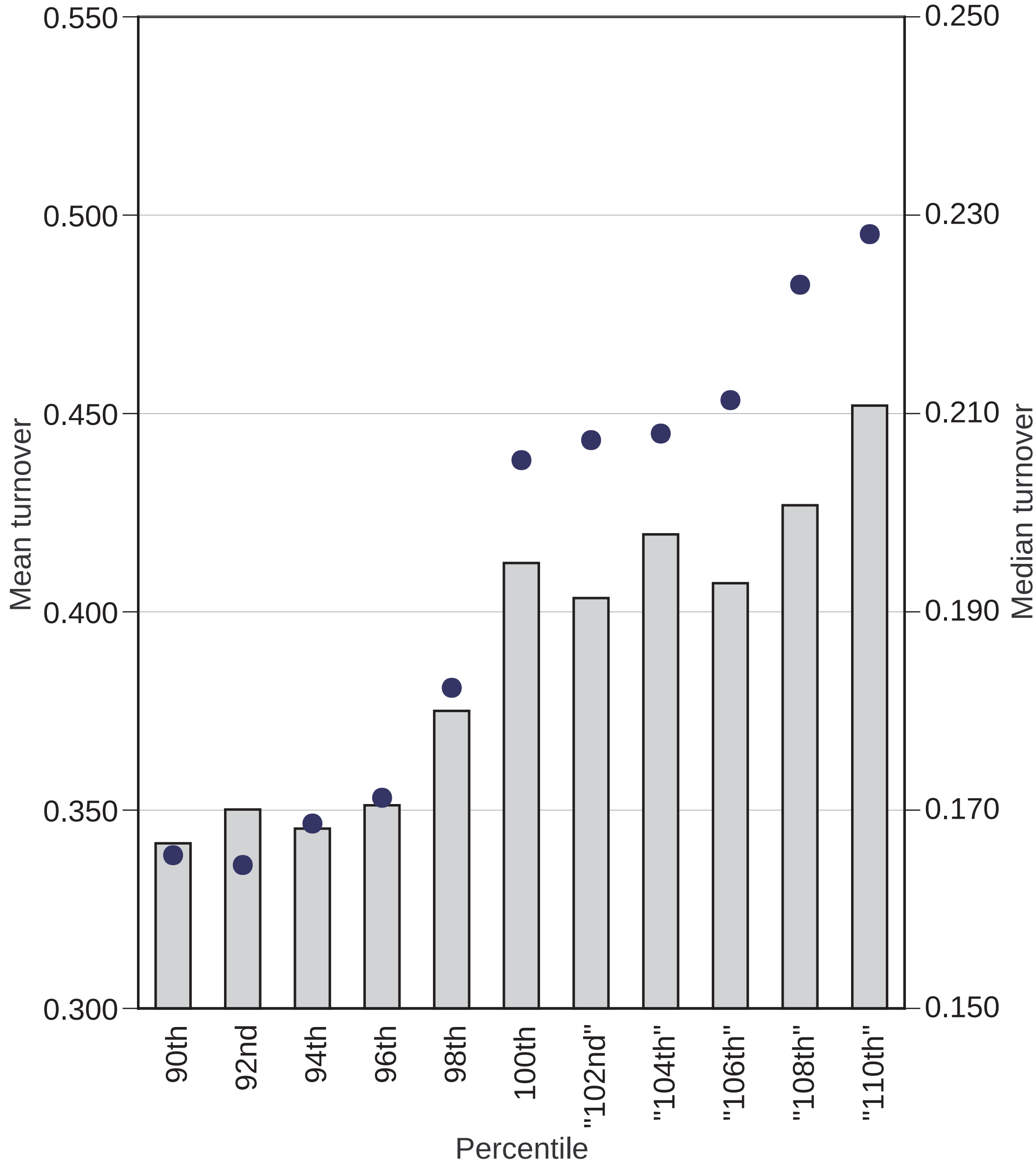

Figure 2
Stock turnover (PVOL) conditioned on the price level relative to the past distribution of prices
Bars plot the mean value (left-scale) and circles plot the median value (right scale) of firm stock volume in the observation week (PVOL) conditional on the closing stock price for the observation week falling within given percentiles of the stock price distribution over the year ending 20 trading days before the last day of the observation week. The "102nd" through "110th" percentiles are computed from price levels equal to the prior maximum (i.e., the 100th percentile) plus 2% through 10%, respectively, of the range of prices over the year ending 20 trading days before the last day of the observation week. Each point on the graph is computed from firm-week observations where the closing price in the observation week falls between the labeled percentile and the adjacent lower labeled percentile.

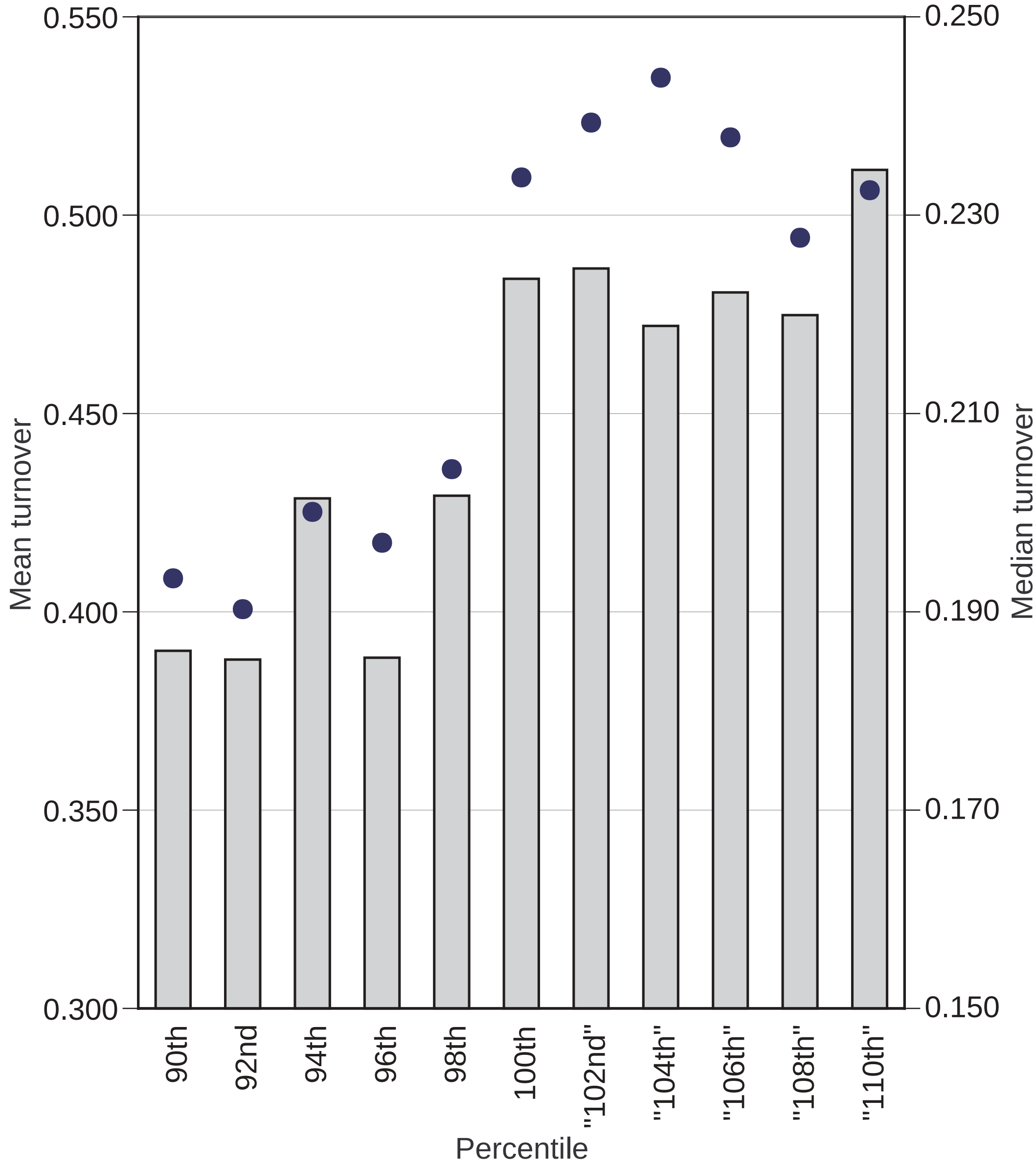

Figure 3
Stock turnover (PVOL) conditioned on the price level relative to the past distribution of prices given the prior maximum obtained more than six months ago
As in figure 2, bars plot the mean value (left-scale) and circles plot the median value (right scale) of firm stock volume (PVOL) conditional on the closing stock price for the observation week falling within given percentiles of the stock price distribution over the year ending 20 trading days before the last day of the observation week. The “102nd” through “110th” percentiles are computed from price levels equal to the prior maximum (i.e., the 100th percentile) plus 2% through 10%, respectively, of the range of prices over the year ending 20 trading days before the last day of the observation week. Each point on the graph is computed from firm-week observations where the closing price in the observation week falls between the labeled percentile and the adjacent lower labeled percentile. Different from figure 2, only firm-week observations for which the prior maximum occurred more that six months before the observation week are included in the calculation of means and medians.