Short-Term Stock Price Reversals May Be Reversed

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Abstract

In present study, I explore intraday behavior of stock prices. In particular, I try to shed light on the dynamics of stock price reversals and namely, on the short-term character the latter may possess. For each of the stocks currently making up the Dow Jones Industrial Index, I calculate intraday upside and downside volatility measures, following Becker et al. (2008) and Klossner et al. (2012), as a proxy for reversed overreactions to good and bad news, respectively. I document that for all the stocks in the sample, mean daily returns following the days when a stock's upside volatility measure was higher or equal to its downside volatility measure are higher than following the days when the opposite relationship held, indicating that stock prices display a short-run 'reversals of reversals' behavior following corrected, or reversed, overreactions to news. Furthermore, I construct seven different portfolios built upon the idea of daily adjusting a long position in the stocks that according to 'reversals of reversals' behavior are expected to yield high daily returns, and a short position in the stocks, whose daily returns are expected to be low. All the portfolios yield significantly positive returns, providing an evidence for the practical applicability of the 'reversals of reversals' pattern in stock prices.

Keywords: Intraday Stock Prices, Intraday Volatility, Overreaction, Stock Price Reversals, Reactions to News

JEL Classifications: G11, G14, G19

1. Introduction

In the last few decades, an increasing number of papers have investigated stock market anomalies, reporting strong evidence that daily stock returns show empirical regularities that are difficult to explain using standard asset pricing theories. The main bottom line of these studies suggests that the use of historical data could be of some help for predicting future returns, with obvious implications for the efficiency of equity markets.

In this context, one of the most widely-discussed phenomena is based on the concept of overreaction. Since the pioneering papers by Shiller (1984) and De Bondt and Thaler

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(1985) a large volume of theoretical and empirical research work has analyzed price overreaction in financial markets reflecting market inefficiency. Typically, the literature closely links price overreaction to forecastability of stock prices and the prospect for investors to earn above-average returns. In order to distinguish stock price overreaction and market inefficiency from predictable changes in expected returns, Lehman (1990) suggests examining returns over short time intervals. In fact, the focus on long-term dynamics in stock returns in the papers by Shiller (1984) and De Bondt and Thaler (1985) is more recently realigned to short-run return behavior, ranging over time periods from a few days up to a month, in the major part of the subsequent literature (e.g., Zarowin, 1989; Atkins and Dyl, 1990; Cox and Peterson, 1994; Park, 1995; Bowman and Iverson, 1998; Nam et al., 2001). The major focus of these studies is on identifying potentially profitable contrarian strategies built on a reverting behavior of stock prices in the short run. For example, Lehmann (1990) and Jegadeesh (1990) show that contrarian strategies that exploit the short-term return reversals in individual stocks generate abnormal returns of about 1.7% per week and 2.5% per month, respectively. Remarkably, Conrad et al. (1994) document that reversal profitability increases with trading activity.

One of the potential means of measuring the degree of intraday stock price overreaction is by employing the daily high and low prices. Since the seminal study by Parkinson (1980), daily highs and lows are widely agreed to contain useful information on return volatility. Parkinson (1980) shows, for example, that the daily price range, given by the difference of the high and the low prices, is a more efficient volatility estimator than the variance estimator based on close-to-close return data. Brandt and Diebold (2006) emphasize that using daily open, close, high, and low prices, instead of ultra-high frequency returns, has the advantage that these data not only are widely available, in many cases over long historical spans, but also yield results being fairly robust against micro-market structure noise arising from bid-ask spread and asynchronous trading. Cheung (2007) argues that the high and the low correspond to the prices at which the excess demand is changing its direction - the information that is not reflected by data on closing prices.

The main goal of the present study is to shed a little more light on the dynamics of stock price reversals and namely, on the short-term character the latter may possess. I employ the intraday upside and downside volatility measures proposed by Becker et al. (2008) and Klossner et al. (2012) as a proxy for intraday overreaction to good and bad news, respectively. These measures are built upon the idea of stock price moves that are corrected, or reversed, on the very same trading day, indicating, thus, stock price overreaction to news during that specific day. The main hypothesis of my research is that these price reversals taking place towards the end of the trading day will, by themselves, be overhit and therefore, reverted during the next trading day. In other words, I expect that if today, a significant stock price move occurs and is reversed, than on the next trading day, the stock price will continue to drift in the direction of the initial today's move, that is, against the direction of today's reversal. I test this hypothesis against the opposite one, suggesting that stock prices may continue to move in the direction of the reversal.

I analyze intraday price data on thirty stocks currently making up the Dow Jones

Industrial Index, and find supporting evidence for my research hypothesis. For each trading day, I compare each stock's measures of upside and downside volatility, and also compare them with the respective measures for the previous trading day, as well as with the same day's average and median measures for the total sample of stocks, and document that daily stock returns tend to be higher following the days with relatively high corrected overreactions to good news, and lower following the days with relatively high corrected overreactions to bad news. Based on this result, I construct a number of daily-adjusted portfolios involving a long position in the stocks on the days when, according to the result, their returns are expected to be high and a short position in the stocks on the days when, according to the result, their returns are expected to be low, and demonstrate that the returns on these portfolios are significantly positive. I conclude that stock prices tend to exhibit a 'reversals of reversals' behavior.

My findings amplify the results documented in the previous literature with respect to the profit potential embedded in the short-term stock price reversals. While previous studies, in general, show that (i) considerable long-term price changes may be, in fact, too strong, creating a possibility to yield consistently significant returns by following the contrarian strategy (e.g., Shiller, 1984; De Bondt and Thaler, 1985), and (ii) short-term stock price reactions to news may be also too strong, leading to subsequent short-term price reversals (e.g., Lehmann, 1990; Jegadeesh, 1990; Conrad et al., 1994), I make an effort to 'move one step forward' and show that intraday (extremely short-term) price *reversals are, by themselves, too strong*. In other words, if within a trading day, as a result of some news, there is a relatively strong stock price move followed by a reversal, then one may generally expect that the total daily stock return does not sufficiently reflect the underlying news, and the effect of this news will continue on the next trading day.

The rest of the paper is structured as follows: In Section 2, I describe the data sample. Section 3 comprises the research hypotheses and the results. Section 4 concludes.

2. Data description

For the purposes of present research, I employ daily opening, high, low, and closing prices of thirty stocks currently making up the Dow Jones Industrial Index over the period comprised from January 2, 2002 to September 30, 2011 (overall, 2456 trading days)[1]. I adjust all the prices to dividend payments and stock splits, and for each stock in the sample and for each trading day in the sampling period, calculate:

1. Stock's open-to-high price difference, as:

$$R_{OH,it} = \frac{P_{H,it}}{P_{O,it}} - 1 \tag{1}$$

where: $R_{OH,it}$ is stock i's open-to-high price difference on day t; $P_{H,it}$ is stock i's highest price on day t; and $P_{O,it}$ is stock i's opening price on day t.

[1] The data were taken from the Yahoo Finance website.

2. Stock's open-to-low price difference, as:

$$R_{OL,it} = \frac{P_{O,it}}{P_{L,it}} - 1 \tag{2}$$

where: $R_{OL,it}$ is stock i's open-to-low price difference on day t; and $P_{L,it}$ is stock i's lowest price on day t.

3. Stock's high-to-close price difference, as:

$$R_{HC,it} = \frac{P_{H,it}}{P_{C,it}} - 1 \tag{3}$$

where: $R_{HC,it}$ is stock i's high-to-close price difference on day t; and $P_{C,\,it}$ is stock i's closing price on day t.

4. Stock's low-to-close price difference, as:

$$R_{LC,it} = \frac{P_{C,it}}{P_{L,it}} - 1 \tag{4}$$

where: $R_{LC,it}$ is stock i's low-to-close price difference on day t.

5. Stock's daily (close-to-close) return, as:

$$R_{D,it} = \frac{P_{C,it}}{P_{C,it-1}} - 1 \tag{5}$$

where: $R_{D,it}$ is stock i's daily return on day t.

Of course, since the following relations between the intraday prices hold:

$$P_{H,it} \geq P_{O,it}\,; \qquad P_{H,it} \geq P_{C,it}\,; \qquad P_{L,it} \leq P_{O,it}\,; \qquad P_{L,it} \leq P_{C,it} \tag{5}$$

the first four price differences are defined so that they are non-negative, representing the absolute values of the respective price changes.

Table 1 comprises the basic descriptive statistics of the intraday price differences and returns for the thirty sample stocks. At this stage, we may note that, as it might be expected for the largest industrial companies of the US, 27 out of 30 stocks have positive mean daily returns, the remaining 3 showing negative, yet close to zero daily returns. Overall, the mean daily returns range from -0.005 to 0.076 percentage points, with standard deviations ranging from 1.183 to 3.568 percentage points. The four intraday mean price differences are highly correlated in the cross-section, that is, all of them are relatively high for certain stocks and relatively low for other ones. One more thing to note is that for 22 out of 30 stocks, the mean open-to-low differences are greater than the mean open-to-high differences, and for 23 out of 30 stocks, the mean low-to-close differences are greater than the mean high-to-close differences. This is an indication for the higher downside intraday price volatility to be defined in the next Subsection.

3. Research hypotheses and Results

3.1 Upside and downside volatility measures

In order to obtain a proxy for intraday stock price overreactions, I use separate measures of intraday upside and downside volatility. These measures capture the deviation of daily high and low prices from the starting and the end points of the intraday price movement. This one-sided concept, which allows distinguishing between upward and downward overreaction, has the advantage to potentially detect asymmetric return behavior.

Following Becker et al. (2008) and Klossner et al. (2012), for each stock *i* and for each trading day *t*, I define daily measures of intraday upside and downside price volatility by:

$$UV_{it} = R_{OH,it} * 100 * R_{HC,it} * 100 \quad (6)$$

$$DV_{it} = R_{OL,it} * 100 * R_{LC,it} * 100 \quad (7)[2]$$

where: UV_{it} represents the upside volatility measure for stock *i* on day *t*; and DV_{it} represents the downside volatility measure for stock *i* on day *t*.

Both UV_{it} and DV_{it} are nonnegative and can be considered as measuring the distance of daily extreme prices from opening and closing prices. Intraday overreactions to good news are characterized by a price increase which is corrected the very same day, thereby causing UV_{it} to be rather large, as the highest price on that day will be significantly above both opening and closing price. In an analogous way, DV_{it} is an indicator of high-frequency overreactions to bad news.

Table 2 presents the descriptive statistics of the intraday volatility measures. For 28 out of 30 stocks, the mean downside measures are larger than the mean upside measures. This result is in line with the findings by Becker et al. (2008) and Klossner et al. (2012), who argue that during the same trading day, stock prices overreact to bad news significantly stronger than they do to good news.

3.2 Upside and downside volatility, and the market efficiency

The concept of stock price reversals is well-documented and widely-discussed in financial literature. Many studies show that stock prices often overreact to news and subsequently revert themselves in order to arrive at some 'fair' reaction. In this study, I make an effort to 'move one step forward' and ask the following question: 'Are the short-run stock price reversals too strong (especially, in the light of the fact that today's investors are well aware of the concept of reversals and, expecting the latter to take place, may substantially increase their magnitude) or may the short-run stock price reversals actually be insufficient? To put it simply, I suggest that if today a significant stock price move

[2] Multiplying twice by 100 is made as a normalization, in order to express the up- and downside volatility measures in percentage points.

occurs and is corrected, or in other words, reversed, then tomorrow there may be either a 'reversal of the reversal', leading to the price drift in the direction of today's initial move, or a 'continuation of reversal', leading to the price drift in the direction of today's reversal. Therefore, I hypothesize that:

Hypothesis 1a: Daily stock price returns should be higher following the days of substantial corrected overreactions to good news.

against: Daily stock price returns should be lower following the days of substantial corrected overreactions to good news.

Hypothesis 1b: Daily stock price returns should be lower following the days of substantial corrected overreactions to bad news.

against: Daily stock price returns should be higher following the days of substantial corrected overreactions to bad news.

As mentioned in the previous Subsection, intraday upside and downside volatility measures may serve as a proxy for corrected overreactions to good and bad news, respectively. Therefore, as a first step in testing the Hypotheses, for each stock in the sample, I compare the mean daily returns following the days when the stock's upside volatility measure was higher or equal to its downside volatility measure, that is, for the days when $UV_{it-1} \geq DV_{it-1}$ holds[3], with the mean daily returns following the days when the stock's downside volatility measure was higher or equal to its upside volatility measure, that is, for the days when $UV_{it-1} < DV_{it-1}$ holds[4].

Table 3 reports the results that strongly support the first versions of the hypotheses. For *all* the sample stocks, mean daily returns are higher if during the previous trading day, corrected overreactions to good news, as expressed by higher UV_{it-1} measures, prevailed. 25 out of 30 respective mean return differences are statistically significant, including 21 at the 5% level, and 14 at the 1% level. Moreover, for *all* the sample stocks, mean daily returns are positive if during the previous trading day, their intraday upside volatility exceeded their intraday downside volatility, and for 28 out of 30 stocks, mean daily returns are negative if during the previous trading day, their intraday downside volatility exceeded their intraday upside volatility. Thus, the results clearly demonstrate that stock prices display a short-term reverting behavior following corrected overreactions to news. Such behavior may be called 'reversals of reversals', and seems to contradict the market efficiency.

3.3 Portfolios based on 'reversals of the reversals' stock price behavior

In the previous Subsection, we have seen that stock *i*'s return on day-*t* tends to be higher if $UV_{it-1} \geq DV_{it-1}$ holds, then if $UV_{it-1} < DV_{it-1}$ holds. This evidence suggests that Hypotheses 1a and 1b, in the first versions, jointly hold. Now, I proceed to separately testing the Hypotheses. I do that by constructing a number of portfolios, approach that in

[3] Indicating the prevalence of corrected overreactions to good news during the previous trading day.

[4] Indicating the prevalence of corrected overreactions to bad news during the previous trading day.

addition to testing the Hypotheses, allows me to consider a number of potentially profitable investment strategies. All the portfolios are built of the sample stocks and upon the idea of holding and daily adjusting a long position in the stocks that according to 'reversals of reversals' pattern are expected to yield high daily returns[5], and a short position in the stocks that according to 'reversals of reversals' pattern are expected to yield low daily returns[6]. The portfolio adjustment transactions are supposed to be performed at the end of each trading day. The total values of the long and the short positions are supposed to be equal, that is, the total market value of each portfolio at the end of each trading day, after the daily adjustment, is supposed to be zero.[7]

a) <u>Portfolios based on upside volatility measures</u>:

Portfolio UP ('Upside volatility - Previous day's upside volatility'): Portfolio implying an equally-weighted long position for the next trading day in the stocks whose today's upside volatility measures are greater then their upside volatility measures for the previous trading day, and an equally-weighted short position for the next trading day in the rest of the sample stocks.

Portfolio UA ('Upside volatility - Average upside volatility'): Portfolio implying an equally-weighted long position for the next trading day in the stocks whose today's upside volatility measures are greater then today's average upside volatility measure for the sample stocks, and an equally-weighted short position for the next trading day in the rest of the sample stocks.

Portfolio UM ('Upside volatility - Median upside volatility'): Portfolio implying an equally-weighted long position for the next trading day in the stocks whose today's upside volatility measures are greater then today's median upside volatility measure for the sample stocks, and an equally-weighted short position for the next trading day in the rest of the sample stocks.

The idea of these three portfolios is based on employing the first version of Hypothesis 1a. That is, an investor is supposed to hold, and continuously adjust, an equally-weighted long position in the stocks whose previous day's upside volatility measures were relatively high, and an equally-weighted short position in the stocks whose previous day's upside volatility measures were relatively low. The portfolios do not suggest any initial investment, since the total values of the long and the short positions are equal.

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[5] Stocks that on previous trading day experienced relatively high corrected overreactions to good news and/or relatively low corrected overreactions to bad news.

[6] Stocks that on previous trading day experienced relatively low corrected overreactions to good news and/or relatively high corrected overreactions to bad news.

[7] In constructing the portfolios, I assume that all the portfolio adjusting transactions are performed at the closing prices based on the intraday up- and downside volatility measures that are readily available. Of course, at the time of the transactions, the closing stock prices, and respectively, the intraday volatility measures, are yet not exactly known. But I suggest that if the portfolio adjusting transactions are performed sufficiently close to the market closing time, then the volatility measures available and the transaction prices should be sufficiently close to those based on the actual closing prices.

b) Portfolios based on downside volatility measures:

Portfolio DP (‘Downside volatility - Previous day’s downside volatility’): Portfolio implying an equally-weighted short position for the next trading day in the stocks whose today’s downside volatility measures are greater then their downside volatility measures for the previous trading day, and an equally-weighted long position for the next trading day in the rest of the sample stocks.

Portfolio DA (‘Downside volatility - Average downside volatility’): Portfolio implying an equally-weighted short position for the next trading day in the stocks whose today’s downside volatility measures are greater then today’s average downside volatility measures for the sample stocks, and an equally-weighted long position for the next trading day in the rest of the sample stocks.

Portfolio DM (‘Downside volatility - Median downside volatility’): Portfolio implying an equally-weighted short position for the next trading day in the stocks whose today’s downside volatility measures are greater then today’s median downside volatility measures for the sample stocks, and an equally-weighted long position for the next trading day in the rest of the sample stocks.

The idea of these three portfolios is based on employing the first version of Hypothesis 1b. That is, an investor is supposed to hold, and continuously adjust, an equally-weighted short position in the stocks whose previous day’s downside volatility measures were relatively high, and an equally-weighted long position in the stocks whose previous day’s downside volatility measures were relatively low. Once again, the portfolios do not suggest any initial investment, since the total values of the long and the short positions are equal.

c) Portfolio based on the comparison of upside and downside volatility measures:

Portfolio U-D (‘Upside volatility – Downside volatility’): Portfolio implying an equally-weighted long position for the next trading day in the stocks whose today’s upside volatility measures are greater or equal to their today’s downside volatility measures, and an equally-weighted short position for the next trading day in the rest of the sample stocks.

The idea of this portfolio is based on jointly employing the first versions of Hypotheses 1a and 1b. That is, an investor is supposed to hold, and continuously adjust, an equally-weighted long position in the stocks whose previous day’s upside volatility measures were higher than the respective downside ones, and an equally-weighted long position in the stocks whose previous day’s upside volatility measures were lower than the respective downside ones. This portfolio too, does not suggest any initial investment, since the total values of the long and the short positions are equal.

According to the definitions, the portfolios in paragraphs (a) and (b) refer to testing Hypotheses 1a and 1b, respectively, while the portfolio in paragraph (c) tests for the joint effect of both tendencies, the issue presented and discussed in Table 3 in the previous Subsection.

Table 4a concentrates the daily performance measures over the sampling period for all the seven portfolios. Strikingly, all the portfolios yield significantly positive mean daily returns. These results, first of all, provide a strong support for both research hypotheses, even when these are separately tested. That is, daily stock returns are significantly higher following the days of the relatively high (with respect to the previous day or to the sample's daily average or median) corrected overreactions to good news and also following the days of the relatively low corrected overreactions to bad news. Moreover, from the practical point of view, at least if the trading commissions are not a problem, the seven portfolios represent potentially profitable investment strategies. The mean returns of about 0.1 percentage point may, at the first glance, seem not quite impressive, but since we are talking about daily returns, the mean annual return of about 34% on Portfolio U-D, for example, looks promising (recall that the portfolios do not request any initial investments and yield *significantly* positive returns).

Finally, as a robustness check, I apply a slightly different approach to calculating the upside and the downside volatility measures, normalizing them by the variance of the respective stocks' returns. That is, I recalculate the intraday volatility measures as follows:

$$UV\_Adj_{it} = \frac{R_{OH,it} * 100 * R_{HC,it} * 100}{\sigma_i^2} \quad (8)$$

$$DV\_Adj_{it} = \frac{R_{OL,it} * 100 * R_{LC,it} * 100}{\sigma_i^2} \quad (9)$$

where: UV_Adj_{it} represents the adjusted upside volatility measure for stock *i* on day *t*; DV_Adj_{it} represents the adjusted downside volatility measure for stock *i* on day *t*; and σ_i^2 is stock *i*'s daily return variance over the sampling period.

Respectively, I reconstruct the seven portfolios, as described above, based on the adjusted intraday volatility measures. Table 4b reports the portfolios' performance measures. First of all, it should be noted that the results for the portfolios UP, DP and U-D remain unchanged, since the normalization of the volatility measures by stock returns' variance does not affect the relationship either between the same stock's upside and downside volatility measures for the same trading day or between the same stock's upside or downside volatility measures for the two consecutive trading days. The results for the portfolios UA, UM, DA and DM slightly differ from those presented in Table 4a, providing even a little stronger evidence of significantly positive daily portfolio returns.

Overall, the results in this Section strongly support the intuition that stock price reversals may be overhit. Investment strategies built upon the expectation of 'reversals of reversals' may, therefore, possess a non-negligible potential.

4. Conclusion

This paper explores intraday behavior of stock prices. In particular, I try to shed light on the dynamics of stock price reversals and namely, on the short-term character the latter may possess. As a proxy for overreactions to good and bad news, I employ intraday upside and downside volatility measures, respectively, which are built upon the idea of stock price moves that are corrected, or reversed, on the very same trading day, indicating, thus, stock price overreaction to news during that specific day. I expect that these price reversals taking place towards the end of the trading day will, by themselves, be overhit and therefore, reversed during the next trading day, that is, if today, a significant stock price move occurs and is reversed, then on the next trading day, the stock price will continue to drift in the direction of the initial today's move and against the direction of today's reversal. I test this hypothesis against the opposite one, suggesting that stock prices may continue to move in the direction of the reversal.

I employ daily opening, high, low, and closing prices of thirty stocks currently making up the Dow Jones Industrial Index, and find supporting evidence for my research hypothesis. First of all, I document that for *all* the stocks in the sample, mean daily returns following the days when a stock's upside volatility measure was higher or equal to its downside volatility measure are higher than following the days when the opposite relationship held. Moreover, for *all* the stocks, mean daily returns are positive if during the previous trading day, their intraday upside volatility exceeded their intraday downside volatility, and for all the stocks but two, mean daily returns are negative if during the previous trading day, their intraday downside volatility exceeded their intraday upside volatility. These findings clearly demonstrate that stock prices display a short-run reverting behavior following corrected overreactions to news. Such 'reversals of reversals' behavior seems to contradict the market efficiency.

Furthermore, I test if on the basis of these findings it is possible to define potentially profitable investment strategies. I compare each stock's volatility measures to their previous trading day's measures, as well as to today's average and median measures for the total sample of stocks, in order to obtain a proxy for substantial intraday corrected overreactions to news. Based on these comparisons, I construct seven different portfolios built upon the idea of daily adjusting a long position in the stocks that according to 'reversals of reversals' behavior are expected to yield high daily returns, and a short position in the stocks, whose daily returns are expected to be low. All the portfolios are found to yield significantly positive returns, providing an evidence for the practical applicability of the 'reversals of reversals' pattern in stock prices.

Overall, my findings amplify the results documented in the previous literature with respect to the profit potential embedded in the short-term stock price reversals. Lehmann (1990), Jegadeesh (1990) and Conrad et al. (1994) analyze stock price reactions to news and conclude that these are usually too strong (overreaction), and therefore, short-term price reversals may be generally expected. In this study, I make an effort to 'move one step forward' and show that intraday (extremely short-term) price reversals are, by themselves, too strong. In other words, if within a trading day, as a result of some news, there is a relatively strong stock price move followed by a reversal, then one may generally expect that the total daily stock return does not sufficiently reflect the underlying news, and the effect of this news will continue on the next trading day. Thus, not only are the stock price reactions to different kinds of news too strong, as shown by the previous literature, but the subsequent reversals (inspired partially by the results shown in the literature?) are probably exaggerated.

To summarize, at least in a perfect stock market with no commissions, the daily-adjusted strategies based on the expectations of the 'reversals of reversals' look promising. This may prove a valuable result for both financial theoreticians in their eternal discussion about stock market efficiency, and practitioners in search of potentially profitable investment strategies. Potential directions for further research may include expending the analysis to other stock exchanges and greater samples, though in the latter case some care has to be taken when defining the benchmarks for high and low volatility measures and also applying similar kind of analysis to longer time intervals.

References

Atkins, A.B. and Dyl, E.A., 1990, 'Price Reversals, Bid-Ask Spreads, and Market Efficiency', *Journal of Financial and Quantitative Analysis*, 25, pp. 535-547.

Becker, M., Friedmann, R. and Klossner, S., 2008, 'Intraday Overreaction of Stock Prices', Working Paper, Saarland University, Saarbrucken.

Bowman, R.G. and Iverson, D., 1998, 'Short-Run Overreaction in the New Zealand Stock Market', *Pacific-Basin Finance Journal*, 6, 5, pp. 475-491.

Brandt, M.W. and Diebold, F.X., 2006, 'A No-Arbitrage Approach to Range-Based Estimation of Return Covariances and Correlations', *Journal of Business*, 79, 1, 61-74.

Cheung, Y.W., 2007, 'An Empirical Model of Daily Highs and Lows', *International Journal of Finance and Economics*, 12, 1, pp. 1-20.

Conrad, J. S., Hameed, A. and Niden, C., 1994, 'Volume and Autocovariances in Short-Horizon Individual Security Returns', *Journal of Finance,* 49, pp. 1305-1329.

Cox, D.R. and Peterson, D.R., 1994, 'Stock Returns Following Large One-Day Declines: Evidence on Short-Term Reversals and Longer-Term Performance', *Journal of Finance*, 49, 4, pp. 255-267.

De Bondt, W. and Thaler, R., 1985, 'Does the Stock Market Overreact?', *Journal of Finance*, 40, 3, pp. 793-805.

Jegadeesh, N., 1990, 'Evidence of Predictable Behavior of Security Returns', *Journal of Finance*, 45, 3, pp. 881-898.

Klossner, S., Becker, M. and Friedmann, R., 2012, 'Modeling and Measuring Intraday Overreaction of Stock Prices', *Journal of Banking and Finance*, 36, 4, pp. 1152-1163.

Lehman, B.N., 1990, 'Fads, Martingales, and Market Efficiency', *Quarterly Journal of Economics*, 105, 1, pp. 1-28.

Nam, K., Pyun, C.S. and Avard, S.L., 2001, 'Asymmetric Reverting Behavior of Short-Horizon Stock Returns: An Evidence of Stock Market Overreaction', *Journal of Banking and Finance*, 25, 4, pp. 807-824.

Park, J., 1995, 'A Market Microstructure Explanation for Predictable Variations in Stock Returns following Large Price Changes', *Journal of Financial and Quantitative Analysis*, 30, 2, pp. 241-256.

Parkinson, M., 1980, 'The Extreme Value Method for Estimating the Variance of the Rate of Return', *Journal of Business*, 53, 1, pp. 61-65.

Shiller, R.J., 1984, 'Stock Prices and Social Dynamics', Brookings Papers on Economic Activity, XII(2), pp. 457-498.

Zarowin, P., 1989, 'Short-Run Market Overreaction: Size and Seasonality Effects', *Journal of Portfolio Management*, 15, 3, pp. 26-29.

Appendix: Tables

The table presents for each of the 30 sample stocks and over the sampling period, the mean intraday price differences, as well as the mean and the standard deviation of daily stock returns, calculated as follows:

$$R_{OH,it} = \frac{P_{H,it}}{P_{O,it}} - 1;\; R_{OL,it} = \frac{P_{O,it}}{P_{L,it}} - 1;\; R_{HC,it} = \frac{P_{H,it}}{P_{C,it}} - 1;\; R_{LC,it} = \frac{P_{C,it}}{P_{L,it}} - 1;\; R_{D,it} = \frac{P_{C,it}}{P_{C,it-1}} - 1$$

where: R and P denote the difference/return and the price, respectively; capital indexes O, C, H, and L stand for Opening, Close, High, and Low, respectively; and small indexes i and t refer to stock and time, respectively.

Table 1: Descriptive statistics of sample stocks' intraday price differences and daily returns

Company (Ticker symbol)	Mean intraday price differences, %				Daily return, %	
	Open-to-high ($R_{OH,it}$)	Open-to-low ($R_{OL,it}$)	High-to-close ($R_{HC,it}$)	Low-to-close ($R_{LC,it}$)	Mean	St. Deviation
Alcoa Inc. (AA)	1.496	1.852	1.695	1.653	-0.004	2.884
American Express (AXP)	1.436	1.470	1.400	1.508	0.054	2.621
Boeing (BA)	1.224	1.304	1.225	1.303	0.047	1.979
Bank of America (BAC)	1.437	1.612	1.582	1.469	0.010	3.568
Caterpillar (CAT)	1.290	1.436	1.317	1.408	0.076	2.189
Cisco Systems (CSCO)	1.427	1.400	1.453	1.374	0.019	2.365
Chevron Corporation (CVX)	1.053	1.092	1.039	1.107	0.058	1.762
E.I. Du Pont de Nemours (DD)	1.149	1.233	1.172	1.209	0.029	1.867
Walt Disney (DIS)	1.237	1.247	1.163	1.320	0.038	2.020
General Electric (GE)	1.118	1.342	1.226	1.234	-0.005	2.120
Home Depot Inc. (HD)	1.312	1.330	1.315	1.326	0.011	2.020
Hewlett-Packard (HPQ)	1.438	1.291	1.303	1.423	0.031	2.225
IBM (IBM)	1.029	0.914	0.943	1.001	0.033	1.597
Intel Corporation (INTC)	1.391	1.427	1.430	1.389	0.017	2.338
Johnson & Johnson (JNJ)	0.782	0.784	0.771	0.794	0.021	1.225
JP Morgan Chase & Co (JPM)	1.484	1.593	1.513	1.566	0.047	2.936
Kraft Foods Inc. (KFT)	0.941	0.937	0.903	0.978	0.020	1.393
Coca-Cola (KO)	0.845	0.842	0.808	0.878	0.033	1.304
McDonald's Corporation (MCD)	1.059	1.016	1.003	1.072	0.071	1.566
3M Company (MMM)	0.941	0.983	0.937	1.986	0.029	1.512
Merck & Company Inc. (MRK)	1.174	1.182	1.151	1.204	0.012	1.919
Microsoft Corporation (MSFT)	1.132	1.109	1.147	1.095	0.015	1.889
Pfizer Inc. (PFE)	1.053	1.156	1.120	1.088	-0.004	1.693
Procter & Gamble (PG)	0.818	0.794	0.744	0.867	0.035	1.183
AT&T Inc. (T)	1.130	1.221	1.172	1.178	0.022	1.753
The Travelers Companies (TRV)	1.218	1.272	1.241	1.250	0.037	2.088
United Technologies Corp. (UTX)	1.023	1.098	1.022	1.099	0.054	1.708
Verizon Communications (VZ)	1.044	1.169	1.065	1.147	0.023	1.681
Wal-Mart Stores Inc. (WMT)	0.936	0.948	0.950	0.934	0.011	1.391
Exxon Mobil Corporation (XOM)	1.031	1.033	0.989	1.075	0.048	1.710

The table presents for each of the 30 sample stocks and over the sampling period, the mean and the standard deviation of the upside (UV_{it}) and the downside (DV_{it}) volatility measures calculated as follows:

$$UV_{it} = R_{OH,it} * 100 * R_{HC,it} * 100\,;\; DV_{it} = R_{OL,it} * 100 * R_{LC,it} * 100$$

where: $R_{OH,it}$ is stock *i*'s open-to-high price difference on day *t*; $R_{OL,it}$ is stock *i*'s open-to-low price difference on day *t*; $R_{HC,it}$ is stock *i*'s high-to-close price difference on day *t*; and $R_{LC,it}$ is stock *i*'s low-to-close price difference on day *t*.

Table 2: Descriptive statistics of upside and downside volatility measures

Company (Ticker symbol)	Upside volatility (UV_{it}), %		Downside volatility (DV_{it}), %	
	Mean	Standard Deviation	Mean	Standard Deviation
Alcoa Inc. (AA)	2.607	7.831	3.546	9.797
American Express (AXP)	2.405	7.245	3.103	9.739
Boeing (BA)	1.438	3.160	1.840	5.242
Bank of America (BAC)	3.351	8.715	4.668	10.457
Caterpillar (CAT)	1.695	4.282	2.197	6.518
Cisco Systems (CSCO)	2.148	5.474	2.015	5.123
Chevron Corporation (CVX)	1.129	3.424	1.379	4.994
E.I. Du Pont de Nemours (DD)	1.396	4.076	1.593	4.166
Walt Disney (DIS)	1.461	3.413	1.906	5.146
General Electric (GE)	1.581	4.702	2.453	10.730
Home Depot Inc. (HD)	1.848	4.479	1.989	5.804
Hewlett-Packard (HPQ)	2.048	6.382	2.169	8.310
IBM (IBM)	1.021	2.545	1.055	3.161
Intel Corporation (INTC)	1.901	3.640	1.905	4.153
Johnson & Johnson (JNJ)	0.658	1.697	0.758	2.540
JP Morgan Chase & Co (JPM)	2.594	7.446	3.260	10.133
Kraft Foods Inc. (KFT)	0.867	2.042	0.999	2.867
Coca-Cola (KO)	0.707	1.929	0.811	2.311
McDonald's Corporation (MCD)	1.108	3.321	1.225	4.152
3M Company (MMM)	0.873	2.187	1.232	10.354
Merck & Company Inc. (MRK)	1.500	4.148	1.742	7.227
Microsoft Corporation (MSFT)	1.316	3.052	1.321	4.403
Pfizer Inc. (PFE)	1.251	4.771	1.475	6.172
Procter & Gamble (PG)	0.637	1.759	2.151	11.673
AT&T Inc. (T)	1.525	4.204	1.692	4.268
The Travelers Companies (TRV)	2.135	8.798	2.007	10.555
United Technologies Corp. (UTX)	1.007	2.654	1.324	4.094
Verizon Communications (VZ)	1.192	3.345	1.524	3.667
Wal-Mart Stores Inc. (WMT)	0.900	2.139	1.028	3.772
Exxon Mobil Corporation (XOM)	1.031	2.672	1.250	5.075

The table presents for each stock i and over the sampling period, the mean daily returns ($R_{D,it}$) following the days when the stock's upside volatility measure was higher or equal to its downside volatility measure ($UV_{it-1} \geq DV_{it-1}$), and following the days when the stock's upside volatility measure was lower than its downside volatility measure ($UV_{it-1} < DV_{it-1}$), and the number of days in each category.

The rightmost column of the table reports the differences between the respective mean daily returns, and their statistical significance.

Table 3: Daily stock returns following the days with prevailing corrected overreactions to good and bad news

Company (Ticker symbol)	Mean daily returns ($R_{D,it}$), %, for the days when:		
	$UV_{it-1} \geq DV_{it-1}$ (No. of days)	$UV_{it-1} < DV_{it-1}$ (No. of days)	Difference (t-statistic)
Alcoa Inc. (AA)	0.085 (1118)	-0.079 (1336)	0.164 (1.40)
American Express (AXP)	0.268 (1162)	-0.139 (1292)	***0.407 (3.85)
Boeing (BA)	0.139 (1137)	-0.034 (1317)	**0.173 (2.15)
Bank of America (BAC)	0.080 (1254)	-0.063 (1200)	0.143 (1.00)
Caterpillar (CAT)	0.161 (1113)	0.005 (1341)	*0.156 (1.75)
Cisco Systems (CSCO)	0.219 (1277)	-0.204 (1177)	***0.423 (4.45)
Chevron Corporation (CVX)	0.162 (1144)	-0.032 (1310)	***0.194 (2.72)
E.I. Du Pont de Nemours (DD)	0.131 (1141)	-0.062 (1313)	**0.193 (2.56)
Walt Disney (DIS)	0.123 (1131)	-0.037 (1323)	*0.160 (1.95)
General Electric (GE)	0.096 (1113)	-0.088 (1341)	**0.184 (2.14)
Home Depot Inc. (HD)	0.113 (1213)	-0.088 (1241)	**0.201 (2.46)
Hewlett-Packard (HPQ)	0.185 (1271)	-0.139 (1183)	***0.324 (3.62)
IBM (IBM)	0.167 (1325)	-0.126 (1129)	***0.303 (4.55)
Intel Corporation (INTC)	0.248 (1202)	-0.210 (1252)	***0.458 (4.88)
Johnson & Johnson (JNJ)	0.078 (1241)	-0.038 (1213)	**0.116 (2.36)
JP Morgan Chase & Co (JPM)	0.126 (1153)	-0.026 (1301)	0.152 (1.28)
Kraft Foods Inc. (KFT)	0.045 (1179)	-0.001 (1275)	0.046 (0.83)
Coca-Cola (KO)	0.155 (1133)	-0.070 (1321)	***0.225 (4.28)
McDonald's Corporation (MCD)	0.158 (1209)	-0.015 (1245)	***0.173 (2.73)
3M Company (MMM)	0.117 (1181)	-0.052 (1273)	***0.169 (2.76)
Merck & Company Inc. (MRK)	0.086 (1188)	-0.056 (1266)	*0.142 (1.84)
Microsoft Corporation (MSFT)	0.139 (1284)	-0.123 (1170)	***0.262 (3.44)
Pfizer Inc. (PFE)	0.186 (1180)	-0.180 (1274)	***0.366 (5.39)
Procter & Gamble (PG)	0.078 (1210)	-0.006 (1244)	*0.084 (1.75)
AT&T Inc. (T)	0.151 (1126)	-0.088 (1328)	***0.239 (3.38)
The Travelers Companies (TRV)	0.138 (1161)	-0.054 (1293)	**0.192 (2.26)
United Technologies Corp. (UTX)	0.112 (1141)	0.002 (1313)	0.110 (1.59)
Verizon Communications (VZ)	0.172 (1075)	-0.095 (1379)	***0.267 (3.92)
Wal-Mart Stores Inc. (WMT)	0.093 (1269)	-0.076 (1185)	***0.169 (3.01)
Exxon Mobil Corporation (XOM)	0.139 (1171)	-0.035 (1283)	**0.174 (2.52)

Asterisks denote two-tailed p-values: *p<0.10; **p<0.05; ***p<0.01.

Table 4a: Historical performance measures of the portfolios based on the 'reversals of reversals' stock price behavior (based on 'unadjusted' intraday volatility measures)

Daily-adjusted portfolios	Daily portfolio performance measures over the sampling period (2456 days)		
	Mean, %	Standard Deviation, %	t-statistic (Mean=0)
Portfolio UP	0.039	0.815	**2.35
Portfolio UA	0.102	1.122	***4.49
Portfolio UM	0.082	0.720	***5.65
Portfolio DP	0.080	0.892	***4.47
Portfolio DA	0.072	1.141	***3.13
Portfolio DM	0.067	0.743	***4.47
Portfolio U-D	0.116	1.069	***5.36

Asterisks denote two-tailed p-values: *p<0.10; **p<0.05; ***p<0.01.

The table presents the means and the standard deviations of daily returns over the sampling period (January 2, 2002 to September 30, 2011) for 7 portfolios implying daily adjustments based on intraday stock volatility measures:

Portfolio UP ('Upside volatility - Previous day's upside volatility'): Portfolio implying an equally-weighted long position for the next trading day in the stocks whose today's upside volatility measures are greater then their upside volatility measures for the previous trading day, and an equally-weighted short position for the next trading day in the rest of the sample stocks.

Portfolio UA ('Upside volatility - Average upside volatility'): Portfolio implying an equally-weighted long position for the next trading day in the stocks whose today's upside volatility measures are greater then today's average upside volatility measure for the sample stocks, and an equally-weighted short position for the next trading day in the rest of the sample stocks.

Portfolio UM ('Upside volatility - Median upside volatility'): Portfolio implying an equally-weighted long position for the next trading day in the stocks whose today's upside volatility measures are greater then today's median upside volatility measure for the sample stocks, and an equally-weighted short position for the next trading day in the rest of the sample stocks.

Portfolio DP ('Downside volatility - Previous day's downside volatility'): Portfolio implying an equally-weighted short position for the next trading day in the stocks whose today's downside volatility measures are greater then their downside volatility measures for the previous trading day, and an equally-weighted long position for the next trading day in the rest of the sample stocks.

Portfolio DA ('Downside volatility - Average downside volatility'): Portfolio implying an equally-weighted short position for the next trading day in the stocks whose today's downside volatility measures are greater then today's average downside volatility measures for the sample stocks, and an equally-weighted long position for the next trading day in the rest of the sample stocks.

Portfolio DM ('Downside volatility - Median downside volatility'): Portfolio implying an equally-weighted short position for the next trading day in the stocks whose today's downside volatility measures are greater then today's median downside volatility measures for the sample stocks, and an equally-weighted long position for the next trading day in the rest of the sample stocks.

Portfolio U-D ('Upside volatility – Downside volatility'): Portfolio implying an equally-weighted long position for the next trading day in the stocks whose today's upside volatility measures are greater or equal to their today's downside volatility measures, and an equally-weighted short position for the next trading day in the rest of the sample stocks.

The intraday volatility measures are calculated as follows:

$$UV_{it} = R_{OH,it} * 100 * R_{HC,it} * 100\,; \quad DV_{it} = R_{OL,it} * 100 * R_{LC,it} * 100$$

where: $R_{OH,it}$ is stock *i*'s open-to-high price difference on day *t*; $R_{OL,it}$ is stock *i*'s open-to-low price difference on day *t*; $R_{HC,it}$ is stock *i*'s high-to-close price difference on day *t*; and $R_{LC,it}$ is stock *i*'s low-to-close price difference on day *t*.

The rightmost column of the table reports t-statistics for the hypothesis that the means return for each of the portfolios equals zero.

Unlike Table 4a, the intraday volatility measures are calculated as follows:

$$UV\_Adj_{it} = \frac{R_{OH,it} * 100 * R_{HC,it} * 100}{\sigma_i^2} \quad DV\_Adj_{it} = \frac{R_{OL,it} * 100 * R_{LC,it} * 100}{\sigma_i^2}$$

where: UV_Adj_{it} represents the adjusted upside volatility measure for stock *i* on day *t*; DV_Adj_{it} represents the adjusted downside volatility measure for stock *i* on day *t*; and σ_i^2 is stock *i*'s daily return variance over the sampling period.

The rightmost column of the table reports t-statistics for the hypothesis that the means return for each of the portfolios equals zero.

Table 4b: Historical performance measures of the portfolios based on the 'reversals of reversals' stock price behavior (based on 'adjusted' intraday volatility measures)

Daily-adjusted portfolios	Daily portfolio performance measures over the sampling period (2456 days)		
	Mean, %	Standard Deviation, %	t-statistic (Mean=0)
Portfolio UP	0.039	0.815	**2.35
Portfolio UA	0.107	0.868	***6.11
Portfolio UM	0.103	0.639	***7.99
Portfolio DP	0.080	0.892	***4.47
Portfolio DA	0.077	0.802	***4.73
Portfolio DM	0.059	0.649	***4.53
Portfolio U-D	0.116	1.069	***5.36

Asterisks denote two-tailed p-values: *p<0.10; **p<0.05; ***p<0.01.