Investor sentiment and the return- implied volatility relation

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June 2012

National Chengchi University

A Thesis for the degree of MBA in Finance

CONTENTS

Abstract

We examine how investor sentiment affects the changes in implied volatility, and discover investor sentiment has impact on the size of the changes in implied volatility through returns, especially when returns are negative. We examine the short-tern relation between the S&P 500 index returns and the changes of VIX from January 1990 to January 2011, and between the NASDAQ-100 index returns and the changes of VXN from February 2001 to January 2011 with proxy for beginning-of-period investor sentiment at both the daily and weekly level. We find that during high sentiment periods, the negative and asymmetric relation of return to changes in implied volatility can be mitigated significantly. When returns are segregated into positive and negative returns, investor sentiment has different impact on the size of changes in implied volatility. In negative returns, investors are more panic than in positive returns, but the panic can be mitigated significantly when investors are in high sentiment. Thus, sentiment can alter the risk attitude of investors and reduce their panic in the future, especially when market has negative performance.

List of Tables

1. Introduction

1.1. Motivation of the study

Traditional theories have point out a positive relation between return-volatility, that is, the more risk you take, the more return you get. But surprisingly many empirical studies have shown a negative return-volatility relation. And some studies show asymmetric relation of them. Why do traditional theories fail to fit the reality world? In order to find the reason out, there are two theories, leverage hypothesis and volatility feedback hypothesis, to explain this negative relation. Leverage hypothesis says negative return increases financial leverage, and stocks become more risk, so the volatility goes up. On the other hand, volatility feedback hypothesis explains the negative return-volatility relation reversely, saying innovations to volatility lead to a decrease in returns.

Besides the two, in recent years, some studies suggest that behavioral explanations may be one of the reasons for negative return-volatility relation, including investors sentiment, irrational, representativeness, affect, loss aversion, extrapolation bias, and so on. However, some of the behavioral explanations are hardly quantified and observed, and some, although have been quantified, have too many proxies to choose. For example, to measure the investor sentiment, one of the behavioral explanations, proxies could be share turnover, numbers of IPOs, first-day return on IPOs, equity share in new issues. Consider there are no perfect or uncontroversial proxies for investor sentiment, Baker and Wurgler (2007) construct an investor sentiment index based on the first principal component of the proxies suggested in past work, and find investor sentiment may have effects on the cross-section of stock prices.

1.2. Objective of the study

This study focus on S&P 500 index returns and changes in VIX (CBOE Volatility Index), and NASDAQ-100 index returns and changes in VXN (CBOE NASDAQ Volatility Index) to exam whether they have positive/negative and asymmetric relation, and add dummy variable from the investor sentiment index that Baker and Wurgler constructed to investigate whether and how the return-implied volatility relation would be effect by the sentiment of investors.

To investigate whether investor sentiment has effect on return- implied volatility relation, we employ both daily and weekly data to see the results of different length of time periods, segment return into positive ones and negative ones to obtain outcomes of opposite market performance, and add the investor sentiment dummy variable to exam sentiment effect on changes in implied volatility.

1.3. Chapter outlines

The remainder of the study is organized as follows. Chapter 2 describes relevant literatures of return-volatility relation, possible hypothesis, and the impact of the investor sentiment. Chapter 3 describes the characteristics of the data and four framework models explaining the relation in this paper. Chapter 4 presents the results of our empirical tests. Chapter 5 reports conclusions.

2. Literature Review

In this chapter, we review the literature on the issue of negative return-volatility relation, possible hypotheses, and the impact of investor sentiment on volatility

2.1. Empirical evidence on negative return-volatility relation

For years, empirical evidence has widely shown a negative return-volatility relation.

In early days, Black (1976) thinks nothing is really constant, the volatility of a stock changes over time, and the option formulas that assume a constant volatility are wrong. In order to correct the option formulas, he tries to find out how the volatility changes with the stock price or in a predictable way. For a long time, he believed that stock returns are related to volatility changes, and the directions are opposite, taking 30's depression as an extremely example. Volatilities seem to increase when stocks go down, and vice versa. And he also has doubt in mind that whether the past volatility has something to do with the size of volatility changes in the future. Therefore, he use the daily data of NYSE stocks from 1964/5/28 to 1975/12/5 to test how the relation between stock returns and volatility changes depends on the stock's volatility, and find negative relation between return and volatility, to say when the stock price goes up, the volatility goes down so much, and the effect is stronger for low volatility stocks than high volatility stocks.

Then there are more studies to investigate the relation between return and realized volatility. Nelson (1991) tests the market risk and expected return relation by a new form of ARCH model. He used daily data of CRSP value-weighted market index from July 1962 to December 1987, and find the estimated risk premium is negatively (though weakly) correlated with conditional variance. Glosten et al.(1993), using a modified GARCH-M model and monthly excess returns of the CRSP value-weighted stock-index from April 1951 to December 1989, conclude that there is a negative relation between conditional expected monthly return and conditional variance of monthly return. Positive unanticipated returns cause a downward revision of conditional volatility, whereas negative unanticipated returns result in an upward revision of conditional volatility. Whitelaw (1994) investigates empirically the comovements of the conditional mean and volatility of stock returns. He test the relation between the excess returns and volatility of the CRSP value-weighted index covered the period May 1953 to April 1989 for monthly, quarterly, and annual holding periods, and find the conditional mean and volatility exhibit an negative and asymmetric relation. And Brandt and Kang (2004) study monthly returns on the value-weighted CRSP index in excess of the one month Treasury bill rate from January 1946 through December 1998. They controlled three information variables, the short rate (yield of a one-month Treasury bill), term premium (the yield spread of a ten-year Treasury bond and a one-year Treasury bill), and default premium (the yield spread of corporate bonds with Moody's Baa and Aaa rating). And document a large and negative contemporaneous correlation between the innovations to the conditional mean and volatility.

After using different models and data periods, and controlling different variables, the above studies all find a negative return-volatility relation. What if the implied volatility instead of realized volatility? Would it lead to a change in the negative relation? Using index data, Giot (2005) investigates the relationships between implied volatility indexes and stock index returns to identify the direction and size between them. He uses returns of the S&P 100 and the NASDAQ-100 stock indexes and their corresponding implied volatility indexes and finds that there is a negative and statistically significant relationship between index return and implied volatility. For S&P 100 the relationship is asymmetric, negative returns are related to larger implied volatility changes, while the asymmetric phenomenon is quite weak in NASDAQ-100 stock indexes. And Hibbert et al. (2008) use daily and intraday data of the S&P 500 and Nasdaq-100 index return and their implied volatility to exam the relation between return and volatility. They find a strong negative relation and that the asymmetry between return and implied volatility are most closely associated with extreme changes in the index returns.

In the situation of individual stock data, Dennis et al. (2006) study the time series of daily stock returns and option-derived implied volatilities innovations for the S&P 100 index and 50 large U.S. firms (50 firms that had the highest total option trading volume) over the period 1988 to 1995. They decompose the volatility into index- and firm level implied volatilities to distinguish between innovations in systematic and idiosyncratic volatility, and to better understand the asymmetric volatility phenomenon. Systematic volatility shocks may attribute to macro events such as interest rate shock or international financial crisis, while idiosyncratic volatility shocks may result from firm-specific events such as product introductions and patent events. They find the relation between index returns and index-level volatility innovations is substantially more negative than the relation between individual stock returns and the respective firm-level volatility innovation. They also find that negative relation is notably stronger between individual stock returns and index-level volatility innovations than between individual stock returns and their respective firm-level volatility innovation. That is to say, individual stock returns are more related to systematic volatility innovations rather than idiosyncratic volatility innovations. Finally, they exam the asymmetric volatility phenomenon and find firm-level conditional volatility is more related to lagged market level return shocks rather than to lagged own-firm return shocks.

2.2. The leverage and volatility feedback hypotheses

There are two popular hypotheses in the literatures to explain the reason for the negative relation between return and volatility, one is the leverage hypothesis, and the other is volatility feedback hypothesis.

2.2.1. The leverage hypothesis

Leverage hypothesis says the changes in volatilities are driven by changes in returns. When the value of the firm drops, the value of equity decreases, and followed by the negative stock return. Since firm value equals debt plus equity, the decrease in equity value would raise the financial leverage and increase the risk of the firm, and thus increase of the volatility of the equity.

For example, consider a firm has a total value of $100 million with $60 in equity and $40 in debts. Suppose there is a bad new and the value of the firm drop to $80 million. Suppose debt still has its original value $40 million because debts generally are bonds with obligation to pay off and sometimes are collateralized. But the value of the equity outstanding now decreased to $40 million. The debt-equity ratio is raised from 2/3(40/60) to 1(40/40), increasing the financial leverage of the firm. As a result of the rise in the debt-equity ratio, the stock is riskier and therefore it would surely drive up the volatility of stocks.

What if the firm has nearly no debt? Black (1976) thinks it can still happen even if a firm has almost no debt, because the firm is likely to have operating leverage due to fixed costs and expenses. A decrease in firm value would raise the operating leverage, and increase the volatility of the firm.

On the other hand, if the equity value goes up, raise the return of stock, and decrease the leverage of the firm, then the volatility of stock would fall. So in the leverage hypothesis, a negative return will be related to a rise in volatility, and a positive return will lead to a fall in volatility.

2.2.2. The volatility feedback hypothesis

The volatility feedback hypothesis is almost the reverse of the leverage hypothesis. It interprets the negative return-volatility relation in an opposite way. Volatility feedback hypothesis states that changes in volatilities lead to changes in returns. That's because the change in volatility leads the change in the risk that investors bear, and thus the expected stock return. For an increase in volatility, investors bear more risk and ask a higher expected return, so the current stock price would fall to adjust to a higher return in the future.

Black (1976) has a brief discussion on this hypothesis. He has an idea that a change in business conditions leads to a change in the volatility of stocks, which leads to a changes in stock prices. A change in business condition may cause by many events, from macro issues, such as market crash, interest rates change, money policies, to firm issues, like new production technology, new investment project, and merger and acquisition program. Business condition changes increase the uncertainty about the payoffs from business investment. If there is more risk to be taken, assuming that the expected payoffs from business investment don't change, in this case, for a higher asked expected return, the stock prices must fall, so that investors will willing continue to hold the existing stocks. A fall in stock prices means an increase in expected return from stocks.

Campbell et al. (1992) develop a modified GARCH-M model to explain the volatility feedback effect over 1926-1988, using the daily and monthly data in U.S. They find that volatility feedback normally has little effect on returns, but it can be important during periods of high volatility. They also emphasized that large pieces of news have a negative volatility effect, while small pieces of news have positive volatility effect because it lowers future expected volatility and increases the stock price. In the extreme case where no news arrivals, the market rises because no news is good news and it reduce volatility. Volatility feedback therefore implies that the movements of stock price will be correlated with future volatility.

2.3. Empirical evidence about the impact of investor sentiment on return-volatility relation

In recent years, more and more literatures focus on the behavioral explanation in the financial area. These literatures study in behavioral finance try to figure out what behavioral bias the investors misconduct and how and in what manner the behavioral biases affect investors when making invest decisions. Since investors are human beings, and the operating functions are extremely complex in our brain, there are many behavioral biases that might have influence on our financial decision-making, such as loss aversion, affect, heuristics, representativeness, anchoring, irrational, overconfidence, emotion, and so on. Some of them give interpretation to market anomalies, and tell us why the reality outcomes sometimes deviate from the theoretical rules. For the negative risk-return relation, behavioral bias of investors may be one of the reasons that cause the result contrary to the traditional theories.

Wang et al. (2006) test whether sentiment is useful for predicting volatility on a daily and weekly basis. Using OEX put–call trading volume ratio, the OEX put–call open interest ratio, the NYSE ARMS index and Surveys of sentiment as sentiment measures, and Granger-causality tests, they find sentiment measures are caused by returns and volatility, except ARMS. In order not to overestimate the true forecasting power of sentiment in predicting volatility, they add lagged volatility or lagged returns in the regression, and discovery ARMS has predictive power for future realized volatility but that this is limited once returns are included. As a result, they conclude that in their study, they only observe very limited evidence that sentiment has forecasting power of volatility, and they don't support noise traders influence returns or volatility.

Hibbert et al. (2008) investigate the S&P 500 and Nasdaq-100 index return-volatility relation, and propose behavioral explanations including representativeness, affect, and extrapolation bias to interpret their empirical results. However, they don't put any behavioral bias proxy into the regression results to get further support of their perspective.

Wondering whether investor sentiment has influences on the mean-variance relation, Yu and Yuan (2011) use the NYSE-Amex returns and investor sentiment index from Baker and Wurgler (2006) to investigate the mean-variance relation between high and low sentiment. They find evidence that sentiment plays a key role in the mean-variance tradeoff. In their study, the stock market return has positive relation to the conditional variance in low-sentiment periods, but in high-sentiment periods, return is unrelated to variance, and sentiment do attenuates the link between the conditional mean and variance of returns. In their opinion, during high sentiment periods, sentiment traders perturb prices away and cause a negative mean–variance tradeoff. They also find that the negative correlation between returns and volatility innovations is much stronger in the low-sentiment periods.

In this study, instead of realized volatility, we use implied volatility since it reflects the predicted future volatility in investors' minds. And we investigate how the relation between implied volatility and return would be effected by investor sentiment.

3. Data Description and Research Methodology

In this chapter we describe the data, sentiment index, and model that are the basis for our empirical analysis of the impact of sentiment on the relation between index returns and implied volatilities.

3.1. Data and variable description

3.1.1. Sample period and index variable

We obtain the daily data for the S&P 500 stock index, the NASDAQ-100 index, the VIX and the VXN from the Chicago Board Options Exchange (CBOE). The daily data for the S&P 500 and VIX (CBOE Volatility Index) covers the twenty-one-years period from January 1990 to January 2011, a total of 5314 trading days. And the period for the NASDAQ-100 index and VXN (CBOE NASDAQ Volatility Index) is from February 2001 to January 2011, a total of 2512 trading days. The data period for NASDAQ-100 and VXN is shorter because the available VXN data start from February 2001.

The S&P 500 index is published since 1957, and has been widely regarded as the best single gauge of the large cap U.S. equities market. And the index includes 500 large-cap leading companies in leading industries of the U.S. economy. Since the stocks included in the S&P 500 are those of large publicly held companies that trade on the largest American stock market exchanges, it captures 75% coverage of U.S. equities. Therefore, S&P 500 includes such a significant portion of the total value of the market that it has a good represent of the U.S. equity market.

For the NASDAQ stock market, the NASDAQ index reflects companies across major industry groups including computer hardware and software, telecommunications, retail/wholesale trade and biotechnology. However, it does not contain securities of financial companies including investment companies. Alike S&P

500, The NASDAQ-100 index includes 100 of the largest domestic and international non-financial securities listed on The NASDAQ Stock Market based on market capitalization.

The Chicago Board Options Exchange’s (CBOE) VIX index is a market implied volatility determined from the bid and ask prices of the S&P 500 index options, and has been considered to be the world's earliest benchmark of market volatility. And VIX is often referred to as the fear index or the fear gauge because it represents one measure of the market's expectation of stock market volatility over the next 30 day period. The original VIX (now the VXO) was constructed using the implied volatilities of OEX (S&P 100) option series so that it represented the implied volatility of a hypothetical at-the-money OEX option with exactly 30 days to expiration. While, in this paper, we use the VIX now has new calculation method. First, the VIX still measures the market's expectation of 30-day volatility, and it based on the S&P 500 index option prices and incorporates information and captures the volatility skew by using a wider range of strike prices, rather than at-the-money series. Second, VIX uses a new formula to calculate expected volatility directly from the prices of a weighted strip of options, while the VXO extracted implied volatility from an option-pricing model. Third, unlike VXO uses S&P 100 Index option price, VIX is based on the options of the S&P 500 Index, which is the primary U.S. stock market benchmark, and provides a more precise and representative of market implied volatility.

The other implied volatility used in this study is VXN which related to NASDAQ-100 index. The VXN was introduced since 2001, and it is based on NASDAQ-100 Index option prices. Also, VXN is a key measure of market expectations of near-term volatility, and it measures the market's expectation of 30-day volatility implicit in the prices of near-term NASDAQ-100 options. The formula and methodology used to derive VXN is the same as to calculate the VIX.

There are advantages of using implied volatility of index, here VIX and VXN. As Hibbert et al. (2008) mentioned, the implied volatility is a market-determined volatility from index options, and it avoids the statistical estimation error of calculating realized volatility. Furthermore, implied volatility is a forward-looking volatility that reflects the reaction to the information of market events and the prediction of investors in the future.

3.1.2. Investor sentiment index

In this paper, we want to know whether investor sentiment has impact on the return-volatility relation. The dummy variable of sentiment index used in this study is based on the data provided by Baker and Wurgler and these data are obtained from their website.[1]

Since there are no definitive or uncontroversial measures of investor sentiment, Baker and Wurgler (2006, 2007) and Baker and Wurgler (2007) form a composite sentiment index based on the first principal component of proxies of investor sentiment. After considered a number of investor sentiment proxies suggested in previous works, they decided to use six of them to form their investor sentiment index. The six proxies they use are the closed-end fund discount, NYSE share turnover, the number and average first-day returns on IPOs, the equity share in new issues, and the dividend premium. To avoid idiosyncratic and non-sentiment-related components, they use principal components analysis to isolate the common component. Also, to remove business cycle variation from the proxies, they regress each of the six proxies on three business cycle proxies they selected to get the residuals of them as cleaner proxies for investor sentiment. Then, they first estimate the first principal component of the six proxies and their lags to get a first-stage index. Next, they compute the

[1] the investor sentiment index data from http://people.stern.nyu.edu/jwurgler/

correlation between the first-stage index and the six proxies and their lags, and then choose six variables that have higher correlation with the first-stage index. And finally, they use the picked six variables, may be the current or lagged value of the proxies, to estimate the first principal component and form their sentiment index.

In this study, we use a dummy variable as high sentiment variable. The dummy equals one if a month as it beginning is a high sentiment month when the sentiment index of Baker and Wurgler is positive. If the sentiment index is negative at the beginning of the month, then the sentiment dummy would equal zero. For example, the January 2009 sentiment index, as a beginning value of February 2009, is negative, so we classify February 2009 as a low sentiment month. And the dummy for the data in February 2009 are zero as its beginning value of the month is negative.

3.2. Methodology

Hibbert et al. (2008) investigate the relation between returns and implied volatility. Using models of their won, a model form Fleming et al. (1995), and two models from Low (2004), they find a strong negative and asymmetric return-implied volatility relation, and try to interpret and link their test results with behavioral explanation. However, they didn't include any behavioral variable into their models to prove the inference in their study. Hence, we modified the models that Hibbert et al. (2008) used to examine the relationship between implied volatility, market returns, and investor sentiment in this study.

We use four regression models to analyze the daily and weekly data of changes in VIX (VXN) and returns of S&P 500 index (NASDAQ-100 index). At first, we test the interaction of investor sentiment and return. We test whether the invest sentiment would have impact on over all return-implied volatility relation. Then we separate returns into positive and negative ones to investigate whether the market performance would alter the impact of interaction of investor sentiment and return. The four models are as below:

$$\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VIX_{t-1} + \alpha_8 \Delta VIX_{t-2} + \alpha_9 \Delta VIX_{t-3} + \alpha_{12} D_{t-1} R_t + \varepsilon_t \quad \text{M1.}$$

$$\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \varepsilon_t \quad \text{M2.}$$

$$\% \Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \varepsilon_t \quad \text{M3.}$$

$$\% \Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \varepsilon_t \quad \text{M4.}$$

Where ΔVIX_t is the change of VIX, given $VIX_t - VIX_{t-1}$, and R_t denotes the S&P 500 index return from $(\text{S\&P index}_t - \text{S\&P index}_{t-1}) / \text{S\&P index}_{t-1}$. $VIX_{t-1}, \Delta VIX_{t-2}$, and ΔVIX_{t-3} are one-, two-, three-period lagged changes in the VIX. R_{t-1}, R_{t-2}, and R_{t-3} are the lagged returns in the S&P 500 index. R_{t+1} is the one-period lead return and R_{t+2} is the two-period lead return in the S&P 500 index. $|R_t|$ is the absolute value and ${R_t}^2$ is the square of R_t. $\% \Delta VIX_t$ is the percentage change in VIX at time t, given $(\% \Delta VIX_t - \% \Delta VIX_{t-1}) / \% \Delta VIX_{t-1}$. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive.

Finally, we test investor sentiment effect by adding D_{t-1} to the models as:

$$\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VIX_{t-1} + \alpha_8 \Delta VIX_{t-2} + \alpha_9 \Delta VIX_{t-3} + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t \quad \text{M5.}$$

$$\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t \quad \text{M6.}$$

$$\% \Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t \quad \text{M7.}$$

$$\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t \qquad \text{M8.}$$

And we also separate returns into positive and negative returns to see the investor sentiment effect in different parts.

The above-mentioned is also implemented into VXN and NASDAQ-100 returns.

3.3. Hypothesis

Our hypothesis is investor sentiment has impact on the return-implied volatility relation. Previous literatures have proven the negative relation between return and implied volatility, and that lagged returns and lagged changes in implied volatility are also factors to determine changes in implied volatility. Here we care about whether investor sentiment would affect the negative relation.

Hypothesis 1: Investor sentiment intensifies the negative relation between return and change in implied volatility.

Hypothesis 2: Investor sentiment mitigates the negative relation between return and change in implied volatility.

Hypothesis 3: When returns are positive, investor sentiment intensifies the negative relation between return and change in implied volatility.

When positive returns occur, investors would decrease the implied volatility. When in high sentiment periods, investors are more optimistic about the future, and the occurrence of positive returns fit their expectation. This raise their confident about the future, making them more certain that market will go up. Thus, they would decrease the implied volatility more than without sentiment.

Hypothesis 4: When returns are negative, investor sentiment mitigates the negative relation between return and change in implied volatility.

When negative returns occur, investors would be panic and are afraid of carry on decline of the market, and this would raise the implied volatility. When in high sentiment periods, investors are more optimistic and have much more confident about the future, so they are not so scared by negative returns. Thus, the addition of implied volatility would be mitigated by investor sentiment.

4. Empirical Results

4.1. Summary statistics of return, volatility and investor sentiment

4.1.1. Daily summary statistics

Table 1 shows the summary statistics of daily index returns, implied volatility and sentiment dummy of S&P 500 index and VIX. There are 5315 observations. The mean and standard deviation of daily S&P 500 return is 0.031% and 1.169, and for daily VIX is 20.381 and 8.2230. The mean of ΔVIX_t and $\%VIX_t$ are 0 and 0.182%, and the standard deviation is 1.509 and 6.103. For daily S&P 500 and VIX data, there are 45.8% days of 5315 days are classify as high sentiment ones.

Table 2 shows the summary statistics of VXN and NASDAQ-100 index return daily data. The mean and standard deviation of daily NASDAQ-100 return is 0.000% and 1.894, and the VXN is 29.673 and 13.623. The mean of ΔVXN_t and $\%VXN_t$ are -0.01 and 0.089%, and the standard deviation is 1.698 and 5.079 respectively. For NASDAQ-100 and VXN's daily data, 46.5% of 2512 days are classified as high-sentiment days.

4.1.2. Weekly summary statistics

In weekly data, Table 3 shows the summary statistics of weekly S&P 500 index return, VIX, and sentiment dummy. The mean and standard deviation of weekly S&P 500 return is 0.155% and 2.552, and for weekly VIX is 20.353 and 8.231. The weekly mean of ΔVIX_t and $\%VIX_t$ are 0.003 and 0.688%, and the standard deviation are 2.317 and 12.08. For daily S&P 500 and VIX data, there are 45.4% weeks of 1063 weeks are classify as high sentiment ones.

Table 4 shows the summary statistics of VXN and NASDAQ-100 index return weekly data. The mean and standard deviation of weekly NASDAQ-100 return is 0.051% and 3.991, and the VXN is 29.710 and 2.711. The mean of ΔVXN_t and

$\%VXN_t$ are -0.066 and 0.395%, and the standard deviation are 3.737 and 11.152 respectively. For NASDAQ-100 and VXN's weekly data, 46.9% of 503 weeks are classified as high-sentiment weeks.

4.2. Empirical result for daily data

4.2.1. Daily results of changes in VIX

Table 5 shows the regression result for daily changes in the VIX. Our main findings suggest that sentiment is a significant factor that mitigated the negative return-implied volatility relation. The negative return-implied volatility relation is mitigated significantly during high sentiment period, and support the hypothesis 2. The coefficients of interaction of investor sentiment and return, α_{12} in our models, are all positive. The coefficients are 18.141, 21.805, 1.440 and 1.429 in model 1, 2, 3, and 4 respectively, and the t-values are 5.89, 7.12, 10.95 and 10.88.

In order to investigate the whether the interaction of investor sentiment and return has different impact on market decline or flourish, we segregate S&P 500 daily returns into positive and negative returns. Panel A and B of Table 6 report the results of the four regression models for daily change in VIX and support hypothesis 4. The results show that investor reduce their risk averse when negative returns occur. The mitigate effect of interaction of investor sentiment and return is stronger when the market decline, for the coefficients in panel B are all higher than in panel A. We can say that when the market falls, investor sentiment reduced their panic. The VIX still raise, but would increase less when in high sentiment period. Investors are more optimistic and have much more confident about the future, so they are not so scared by negative returns and the addition of implied volatility would be smaller.

Table 7 and Table 8 report the sentiment effect of investor sentiment on changes in daily VIX. In overall daily data, investor sentiment has no sentiment effect on return-implied volatility relation, as in Table 7 the coefficients of sentiment dummy aren't significant. While in Table 8 we segregate the returns and regress the sentiment effect again, and find that the investor sentiment has sentiment effect, though not much, when in positive returns. Why investor sentiment make the VIX raise slightly when in positive returns? Yu and Yuan (2011) conjecture that individual traders are the primary candidates for sentiment traders, and they are more active during high-sentiment periods. These individual traders tend to be inexperienced and naive investors, and are more likely to misestimate variance. And De Long et al. (1990) find noise trading is associated with increased price volatility. Brown (1999) also finds that unusual levels of individual investor sentiment are associated with greater volatility. So here in our study, we suppose that in high sentiment period, the sentiment effect of investor sentiment during positive returns is caused by individual traders who are inexperienced and noise trading, making the implied volatility slightly high.

4.2.2. Daily results of changes in VXN

Table 9 shows the regression results of daily changes in VXN. Contract to changes in VIX, the changes in VXN don't be affected by the interaction of investor sentiment and return, for the coefficients of interaction of investor sentiment and return are not significant. While in Table 10, after returns are segmented, the interaction of investor sentiment and return weakly intensified the return-implied volatility changes relation in negative returns, as in panel B the coefficient in model 1 is -10.66, and t-value -1.72. This result is inconsistent with our hypothesis, since we support sentiment would mitigate the relation between return and changes in implied volatility.

Table 11 and Table 12 report the sentiment effect of investor sentiment on changes in daily VXN. In overall daily data, investor sentiment has no sentiment effect on return-implied volatility relation, as in table 11 the coefficients of sentiment dummy aren’t significant. While in Table 12, we find a weakly positive sentiment effect in positive returns and a stronger negative sentiment effect in negative returns. The weakly positive sentiment effect in positive returns only significant in model 4 for the coefficient 0.007, and t-value 2.02. However, in negative return part, panel B of Table 12 shows investor sentiment has a consistent negative sentiment effect on the changes in VXN, and this means that in NASDAQ market, the negative return-implied volatility relation would be mitigated by the sentiment effect of investor sentiment.

4.2.3. Conclusions of daily results

For changes in VIX, high investor sentiment mitigates the negative return-volatility relation by interaction of investor sentiment and return, especially when in negative returns period. This means that sentiment changes the risk attitude of investors, and they are not so risk averse during high sentiment periods. The sentiment effect only exist in positive return, and we suspect that it’s due to the noise traders who are more active in high sentiment periods, especially when the positive returns occur.

For changes in VXN, the interaction of investor sentiment and return don’t has impact on the overall return-implied volatility relation, and only a weakly intensified effect when in negative returns. There is positive sentiment effect in positive returns, the same as VIX daily data. The investor sentiment mitigates the negative return-implied volatility relation through sentiment effect, since the sentiment effect is negative when negative returns occur.

4.3. Empirical result for weekly data

4.3.1. Weekly results of changes in VIX

Table 13 shows the regression result for weekly changes in the VIX. We find that the negative return-implied volatility relation is mitigated significantly during high sentiment period, and support the hypothesis 2. The coefficients of interaction of investor sentiment and return, α_{12}, are positive in model 3 and model 4, the coefficients are 0.873 and 0.942 respectively, and the t-values are 3.51 and 3.77.

Again, we separate returns to investigate whether interaction of investor sentiment and return has different impact on positive returns and negative returns. Table 14 reports the result. Contrary to daily data, we find the mitigation effect only exist in negative returns, as in panel B the coefficients of interaction of investor sentiment and return are significant in model 3 and 4, for t-value 3.28 and 2.68 respectively, while in panel A they are not significant at all. This consistent with our hypothesis 4 that investor sentiment mitigates the negative relation between return and change in implied volatility when returns are negative.

Then we test the sentiment effect of investor sentiment. Table 15 and Table 16 show the results of the sentiment effect regressions. For all weekly data, there is no sentiment effect of investor sentiment, as the sentiment dummies aren't significant at all. But after segmenting the returns, as the result of daily data, we discover there is positive sentiment effect during positive returns. We again suspect this is due to noise trader or sentiment trader who increase the implied volatility slightly when market bloom.

In panel A of Table 15, we also discover that in positive returns period, the interaction of investor sentiment and return intensifies return-implied relation, consistent with our hypothesis 3 that when in high sentiment periods, investors are more optimistic about the future and the occurrence of positive returns fit their expectation. This raise their confident about the future, making them more certain that market will go up. Thus, they would decrease the implied volatility more than without sentiment.

Moreover, in panel B of Table 15, we discover in negative returns period, interaction of investor sentiment and return mitigates return-implied relation, consistent with our hypothesis 4 that when in high sentiment periods, investors are more optimistic and have much more confident about the future, so they are not so panic when undergo negative returns. And this make investors decrease the addition amount of implied volatility during high sentiment period.

4.3.2. Weekly results of changes in VXN

Table 17 reports the regression results of weekly changes in VXN. Sentiment weakly reduce the size of change in VXN in model 3 and model 4, the interaction of investor sentiment and return coefficients are 0.429 and 0.547, and t-value are 2.02 and 2.7 respectively. In table 18, we find the interaction of investor sentiment and return only has a significant impact on the changes in implied volatility when market decline. In panel B when returns are negative, the investor sentiment reduces the negative relation between return and implied volatility in model3 and model 4. Table 19 and Table 20 test the sentiment effect of investor sentiment. We find investor sentiment has a weakly positive sentiment effect in both positive and negative returns, and we suspect it’s due to noise traders who increase the volatility slightly during high sentiment periods.

4.3.3. Conclusions of weekly results

For changes in weekly VIX, investor sentiment mitigates the negative return-implied volatility relation, especially in the negative returns part. Investors are less risk aversion during high sentiment periods. The VIX decrease more when positive return, and increase less when negative returns. Since VIX has been regarded as the fear index, the reduction of VIX indicates that investors are less panic during high sentiment periods.

For changes in weekly VXN, we obtain similar result to weekly VIX data. The investor sentiment mitigates the negative return-implied volatility relation, especially when market decline.

5. Conclusion

The VIX tends to increase during stock market declines and decrease when the market advances. We examine how investor sentiment affects the changes in implied volatility, testing the short-term relation between the S&P 500 index return and the changes of VIX from January 1990 to January 2011, and between the NASDAQ-100 index return and the changes of VXN from February 2001 to January 2011 with proxy for beginning-of-period investor sentiment at both daily and weekly level.

Our main findings suggest that investor sentiment is a significant factor in explaining the negative return-implied volatility relation. We find that during high sentiment periods, the negative and asymmetric relation of return to changes in implied volatility can be mitigated significantly by interaction of investor sentiment and return. That is investor sentiment is associated with fewer implied volatility in index returns, except the daily changes in VXN.

When returns are segregated into positive and negative returns, investor sentiment has different impact on the size of changes in implied volatility. In weekly positive return data, investor sentiment leads to a downward revision in both changes in VIX and VXN. That is when market rise, implied volatility decrease more when investors are in high sentiment.

Furthermore, we find that the investor sentiment has a significant impact on the changes in implied volatility when returns are negative. Our results consistently show that when market decline, changes in implied volatilities are positively correlated with interaction of investor sentiment and return, except daily changes in VXN. Implied volatility tends to increase during stock market declines, while the investor sentiment changes investors' reaction, making them less risk averse, and reduce the size of the addition in VIX and VXN. In other words, in negative returns, investors are more panic than in positive returns, but the panic can be mitigated significantly when investors are in high sentiment. Thus, sentiment can alter the risk attitude of investors and reduce their panic in the future, especially when market has negative performance.

The sentiment effect of investor sentiment is positive when returns are positive. That is, when market rise, the sentiment effect of investor sentiment causes the implied volatility to slightly increase more in high sentiment periods. We suspect that it's due to sentiment traders and noise traders who are inexperienced individual traders and noise trading, making the implied volatility slightly high.

Table 1

Summary statistics of VIX and S&P 500 index return daily data

The S&P 500 index return and VIX sample period is January 1990 to January 2011. The Chicago Board Option Exchange VIX index is a market implied volatility of S&P 500 index options, reflecting market expectations of next 30 days volatility conveyed by S&P 500 stock index option prices. S&P 500 return is the return of the index includes 500 leading companies in leading industries of the U.S. economy. ΔVIX_t is the change in the VIX from the close on day t minus the close on day t-1. $\%\Delta VIX_t$ is the percentage change in VIX at time t. R_t is the return in the S&P 500 index from day t-1 to day t. $|R_t|$ is the absolute value and ${R_t}^2$ is the square of R_t. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_t equals one if the beginning-of-period sentiment index value of the current month t is positive.

	Mean	Median	Std. Deviation	Min.	Max.	Observations
VIX	20.381	18.97	8.230	9.31	80.86	5315
ΔVIX_t	0.000	-0.05	1.509	-17.36	16.54	5314
$\%\Delta VIX_t$(%)	0.182	-0.301	6.103	-29.573	64.215	5314
R_t(%)	0.031	0.053	1.169	-9.035	11.580	5315
$\|R_t\|$(%)	0.788	0.540	0.864	0	11.580	5315
${R_t}^2$(%)	0.014	0.003	0.045	0	1.341	5315
D	0.458	0	0.498	0	1	5315

Table 2

Summary statistics of VXN and NASDAQ-100 index return daily data

The sample period is February 2001 to January 2011. The Chicago Board Option Exchange VXN index is a market implied volatility of NASDAQ-100 index options, reflecting market expectations of next 30 days volatility conveyed by NASDAQ-100 index option prices. NASDAQ-100 return is the return of the index includes 100 of the largest domestic and international non-financial securities listed on The NASDAQ Stock Market based on market capitalization. ΔVXN_t is the change in the VXN from the close on day t minus the close on day t-1. $\%\Delta VXN_t$ is the percentage change in VXN at time t. R_t is the return in the NASDAQ-100 index from day t-1 to day t. $|R_t|$ is the absolute value and ${R_t}^2$ is the square of R_t. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_t equals one if the beginning-of-period sentiment index value of the current month t is positive.

	Mean	Median	Std. Deviation	Min.	Max.	Observations
VXN	29.673	25.19	13.623	12.61	80.64	2512
ΔVXN_t	-0.01	-0.08	1.698	-12.96	12.71	2511
$\%\Delta VXN_t(\%)$	0.089	0.0358	5.079	-26.879	43.742	2511
$R_t(\%)$	0.000	0.094	1.894	-10.519	12.580	2512
$\|R_t\|(\%)$	1.309	0.878	1.369	0	12.580	2512
${R_t}^2(\%)$	0.036	0.008	0.090	0	1.583	2512
D	0.465	0	0.499	0	1	2512

Table 3

Summary statistics of VIX and S&P 500 index return weekly data

The S&P 500 index return and VIX sample period is January 1990 to January 2011. The Chicago Board Option Exchange VIX index is a market implied volatility of S&P 500 index options, reflecting market expectations of next 30 days volatility conveyed by S&P 500 stock index option prices. S&P 500 return is the return of the index includes 500 leading companies in leading industries of the U.S. economy. ΔVIX_t is the change in the VIX from the close on week t minus the close on week t-1. $\%\Delta VIX_t$ is the percentage change in VIX at time t. R_t is the return in the S&P 500 index from week t-1 to week t. $|R_t|$ is the absolute value and ${R_t}^2$ is the square of R_t. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_t equals one if the beginning-of-period sentiment index value of the current month t is positive.

	Mean	Median	Std. Deviation	Min.	Max.	Observations
VIX	20.353	19	8.231	9.31	80.86	1063
ΔVIX_t	0.003	-0.065	2.317	-25.58	21.03	1062
$\%\Delta VIX_t$(%)	0.688	-0.430	12.080	-35.182	77.874	1062
R_t(%)	0.155	0.270	2.552	18.340	19.111	1063
$\|R_t\|$(%)	1.787	1.293	1.828	0.003	19.111	1063
${R_t}^2$(%)	0.065	0.017	0.209	0.000	3.652	1063
D	0.454	0	0.498	0	1	1063

Table 4

Summary statistics of VXN and NASDAQ-100 index return weekly data

The sample period is February 2001 to December 2011. The Chicago Board Option Exchange VXN index is a market implied volatility of NASDAQ-100 index options, reflecting market expectations of next 30 days volatility conveyed by NASDAQ-100 index option prices. NASDAQ-100 return is the return of the index includes 100 of the largest domestic and international non-financial securities listed on The NASDAQ Stock Market based on market capitalization. ΔVXN_t is the change in the VXN from the close on week t minus the close on week t-1. $\%\Delta VXN_t$ is the percentage change in VXN at time t. R_t is the return in the NASDAQ-100 index from week t-1 to week t. $|R_t|$ is the absolute value and ${R_t}^2$ is the square of R_t. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_t equals one if the beginning-of-period sentiment index value of the current month t is positive.

	Mean	Median	Std. Deviation	Min.	Max.	Observations
VXN	29.710	25.17	2.711	12.95	80.64	503
ΔVXN_t	-0.066	-0.21	3.737	-24.59	22.61	502
$\%\Delta VXN_t(\%)$	0.395	-0.920	11.152	-36.020	66.239	502
$R_t(\%)$	0.051	0.187	3.991	-16.473	14.398	503
$\|R_t\|(\%)$	2.859	2.078	2.784	0.003	16.473	503
${R_t}^2(\%)$	0.159	0.043	0.325	0.000	2.714	503
D	0.469	0	0.500	0	1	503

Table 5

Regression result for daily changes in the VIX

M1 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VIX_{t-1} + \alpha_8 \Delta VIX_{t-2} + \alpha_9 \Delta VIX_{t-3} + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M2 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M3 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M4 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

The sample period is January 1990 to January 2011. The Chicago Board Option Exchange VIX index is a market implied volatility of S&P 500 index options, reflecting market expectations of next 30 days volatility conveyed by S&P 500 stock index option prices. S&P 500 return is the return of the index includes 500 leading companies in leading industries of the U.S. economy. ΔVIX_t is the change in the VIX from the close on week t minus the close on week t-1. ΔVIX_{t-1},ΔVIX_{t-2},ΔVIX_{t-3} are one-day, two-day, and three-day lagged changes in the VIX. R_t is the return in the S&P 500 index from day t-1 to day t. $R_{t-1}, R_{t-2},$ and R_{t-3} are the one-day, two-day, and three-day lagged returns in the S&P 500 index, respectively. R_{t+1} is the one-day lead return and R_{t+2} is the two-day lead return in the S&P 500 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiment. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	$\|R_t\|$	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$
M	0.025	-78.458***	1.602	-10.285***	3.195*					-0.087***	-0.256***	-0.045***	18.141***
1	(1.42)	(-33)	(0.89)	(-5.93)	(1.84)					(-6.36)	(-18.55)	(-3.18)	(5.89)
M	-0.077***	-74.713***	9.378***	5.429***		0.000	-27.612***	13.127***					21.805***
2	(-3.23)	(-31.57)	(3.59)	(3.59)		(0)	(-18.35)	(6.39)					(7.12)
M	0.003***	-3.018***											1.440***
3	(3.53)	(-29.66)											(10.95)
M	0.001*	-3.016***							9.161***				1.429***
4	(1.79)	(-29.72)							(5.53)				(10.88)

Table 6

Regression result for daily changes in the VIX for (a) positive and (b) negative returns

M1 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VIX_{t-1} + \alpha_8 \Delta VIX_{t-2} + \alpha_9 \Delta VIX_{t-3} + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M2 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M3 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M4 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

The sample period is January 1990 to January 2011. The Chicago Board Option Exchange VIX index is a market implied volatility of S&P 500 index options, reflecting market expectations of next 30 days volatility conveyed by S&P 500 stock index option prices. S&P 500 return is the return of the index includes 500 leading companies in leading industries of the U.S. economy. ΔVIX_t is the change in the VIX from the close on day t minus the close on day t-1. ΔVIX_{t-1},ΔVIX_{t-2},ΔVIX_{t-3} are one-day, two- day, and three- day lagged changes in the VIX. R_t is the return in the S&P 500 index from day t-1 to day t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-day, two-day, and three-day lagged returns in the S&P 500 index, respectively. R_{t+1} is the one-day lead return and R_{t+2} is the two-day lead return in the S&P 500 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current week t is positive. There are 2823 observations for which R_t is positive and 2491 for which R_t is negative. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$
Panel A: Positive returns												
M1	-0.014	-62.958***	6.295***	-3.677*	8.621***				-0.115***	0.242***	-0.060***	10.366***
	(-0.47)	(-17.37)	(2.73)	(-1.67)	(3.89)				(-6.46)	(-13.68)	(-3.28)	(2.64)
M2	0.023	-60.690***	15.114***	9.160***		-1.404	-22.471***					12.551***
	(0.75)	(-16.43)	(7.9)	(4.6)		(-0.67)	(-10.77)					(3.14)
M3	-0.009***	-1.613***										0.823***
	(-7.04)	(-10.78)										(5.08)
M4	-0.010***	-1.342***						-7.086**				0.895***
	(-7.11)	(-6.7)						(-2.03)				(5.41)

Continued- Regression result for daily changes in the VIX for (a) positive and (b) negative returns

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$
Panel B: negative returns												
M1	-0.165***	-104.808***	-1.838	-15.369***	-1.283				-0.054***	-0.258***	-0.025	33.325***
	(-4.27)	(-23.23)	(-0.65)	(-5.65)	(-0.48)				(-2.6)	(-12.06)	(-1.18)	(6.86)
M2	-0.219***	-106.075***	2.227	0.553		-0.108	-32.114***					38.274***
	(-5.81)	(-23.86)	(0.93)	(0.24)		(-0.05)	(-14.88)					(8.09)
M3	0.003	-3.703***										1.922***
	(1.54)	(-18.75)										(9.12)
M4	0.002	-3.717***						-0.372				1.919***
	(1.27)	(-12.99)						(-0.07)				(8.99)

Table 7

Sentiment effect - Regression result for daily changes in the VIX

M5 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VIX_{t-1} + \alpha_8 \Delta VIX_{t-2} + \alpha_9 \Delta VIX_{t-3} + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M6 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M7 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M8 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

The sample period is January 1990 to January 2011. The VIX index is a market implied volatility of S&P 500 index options, reflecting market expectations of next 30 days volatility conveyed by S&P 500 stock index option prices. S&P 500 return is the return of the index includes 500 leading companies in leading industries of the U.S. economy. ΔVIX_t is the change in the VIX from the close on day t minus the close on day t-1. ΔVIX_{t-1},ΔVIX_{t-2},ΔVIX_{t-3} are one-day, two-day, and three-day lagged changes in the VIX. R_t is the return in the S&P 500 index from day t-1 to day t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-day, two-day, and three-day lagged returns in the S&P 500 index, respectively. R_{t+1} is the one-day lead return and R_{t+2} is the two-day lead return in the S&P 500 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	$\|R_t\|$	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$	D_{t-1}
M5	0.018	-78.426***	1.610	-10.274***	3.207*					-0.087***	-0.256***	-0.045***	18.103***	0.015
	(0.75)	(-32.97)	(0.89)	(-5.92)	(1.85)					(-6.36)	(-18.56)	(-3.19)	(5.87)	(0.43)
M6	-0.066**	-74.776***	9.374***	5.422***		-0.031	-27.628***	13.329***					21.878***	-0.028
	(-2.36)	(-31.58)	(6.18)	(3.58)		(-0.02)	(-18.36)	(6.44)					(7.14)	(-0.8)
M7	0.003***	-3.019***											1.441***	0.000
	(2.61)	(-29.64)											(10.94)	(-0.03)
M8	0.002*	-3.018***							9.231***				1.430***	-0.001
	(1.68)	(-29.71)							(5.55)				(10.89)	(-0.49)

Table 8

Sentiment effect - Regression result for daily changes in the VIX for (a) positive and (b) negative returns

M5 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VIX_{t-1} + \alpha_8 \Delta VIX_{t-2} + \alpha_9 \Delta VIX_{t-3} + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M6 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M7 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M8 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

The sample period is January 1990 to January 2011. The Chicago Board Option Exchange VIX index is a market implied volatility of S&P 500 index options, reflecting market expectations of next 30 days volatility conveyed by S&P 500 stock index option prices. S&P 500 return is the return of the index includes 500 leading companies in leading industries of the U.S. economy. ΔVIX_t is the change in the VIX from the close on day t minus the close on day t-1. ΔVIX_{t-1},ΔVIX_{t-2},ΔVIX_{t-3} are one-day, two- day, and three- day lagged changes in the VIX. R_t is the return in the S&P 500 index from day t-1 to day t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-day, two-day, and three-day lagged returns in the S&P 500 index, respectively. R_{t+1} is the one-day lead return and R_{t+2} is the two-day lead return in the S&P 500 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current week t is positive. There are 2823 observations for which R_t is positive and 2491 for which R_t is negative. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$	D_{t-1}
Panel A: Positive returns													
M5	-0.090**	-57.687***	6.316***	-3.969*	8.551***				-0.114***	-0.240***	-0.059***	0.219	0.170***
	(-2.24)	(-14.18)	(2.74)	(-1.8)	(3.87)				(-6.38)	(-13.58)	(-3.23)	(0.04)	(2.84)
M6	-0.085**	-53.186***	14.973***	8.592***		-.1252	-22.784***					-2.028	0.242***
	(-2.08)	(-12.84)	(7.84)	(4.31)		(-0.6)	(-10.94)					(-0.37)	(3.97)
M7	-0.011***	-1.427***										0.469**	0.006**
	(-6.82)	(-8.47)										(2.14)	(2.39)
M8	-0.012***	-1.253***						-5.321				0.581**	0.005*
	(-6.97)	(-6.1)						(-1.48)				(2.51)	(1.94)

Continued- Sentiment effect regression result for daily changes in the VIX for (a) positive and (b) negative returns

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$	D_{t-1}
Panel B: negative returns													
M5	-0.210***	-107.826***	-1.926	-15.464***	-1.281				-0.055***	-0.259***	-0.025	38.799***	0.095
	(-3.98)	(-21.08)	(-0.68)	(-5.69)	(-0.48)				(-2.64)	(-12.11)	(-1.14)	(5.94)	(1.25)
M6	-0.224***	-106.453***	2.220	0.553		-0.102	-32.106***					38.964***	0.012
	(-4.33)	(-21.13)	(0.93)	(0.24)		(-0.55)	(-14.87)					(6.08)	(0.16)
M7	0.001	-3.812***										2.120***	0.003
	(0.4)	(-17.01)										(7.42)	(1.03)
M8	0.001	-3.790***						0.645				2.128***	0.004
	(0.42)	(-12.87)						(0.12)				(7.24)	(1.03)

Table 9

Regression result for daily changes in the VXN

M1 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VXN_{t-1} + \alpha_8 \Delta VXN_{t-2} + \alpha_9 \Delta VXN_{t-3} + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M2 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M3 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M4 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

The sample period is February 2001 to December 2011. The Chicago Board Option Exchange VXN index is a market implied volatility of NASDAQ-100 index options, reflecting market expectations of next 30 days volatility conveyed by NASDAQ-100 index option prices. NASDAQ-100 return is the return of the index includes 100 of the largest domestic and international non-financial securities listed on The NASDAQ Stock Market based on market capitalization. ΔVXN_t is the change in the VXN from the close on day t minus the close on day t-1. ΔVXN_{t-1},ΔVXN_{t-2},ΔVXN_{t-3} are one-day, two-day, and three-day lagged changes in the VXN. R_t is the return in the NASDAQ-100 index from day t-1 to day t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-day, two-day, and three-day lagged returns in the NASDAQ-100 index, respectively. R_{t+1} is the one-day lead return and R_{t+2} is the two-day lead return in the NASDAQ-100 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	$\|R_t\|$	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$
M1	-0.014	-23.450***	-6.171***	-2.699	5.512***					-0.186***	-0.110***	0.038*	-4.659
	(-0.42)	(-7.53)	(-3.35)	(-1.34)	(3.07)					(-8.42)	(-4.92)	(1.73)	(1.27)
M2	-0.033	-19.991***	-2.037	-0.169		-37.494***	4.234***	2.079					-2.170
	(-0.79)	(-7.27)	(-1.28)	(-0.11)		(-23.57)	(2.66)	(0.94)					(-0.64)
M3	0.001	-0.520***											0.138
	(1.01)	(-5.66)											(1.23)
M4	0.001	-0.523***							0.964				0.136
	(0.61)	(-5.69)							(0.86)				(1.21)

Table 10

Regression result for daily changes in the VXN for (a) positive and (b) negative returns

M1 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VXN_{t-1} + \alpha_8 \Delta VXN_{t-2} + \alpha_9 \Delta VXN_{t-3} + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M2 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M3 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M4 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

The sample period is February 2001 to January 2011. The Chicago Board Option Exchange VXN index is a market implied volatility of NASDAQ-100 index options, reflecting market expectations of next 30 days volatility conveyed by NASDAQ-100 index option prices. NASDAQ 100 return is the return of the index includes 100 of the largest domestic and international non-financial securities listed on The NASDAQ Stock Market based on market capitalization. ΔVXN_t is the change in the VXN from the close on day t minus the close on day t-1. ΔVXN_{t-1},ΔVXN_{t-2},ΔVXN_{t-3} are one-day, two-day, and three-day lagged changes in the VXN. R_t is the return in the NASDAQ-100 index from day t-1 to day t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-day, two-day, and three-day lagged returns in the NASDAQ-100 index, respectively. R_{t+1} is the one-day lead return and R_{t+2} is the two-day lead return in the NASDAQ-100 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. There are 1346 observations for which R_t is positive and 1165 for which R_t is negative. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVXN_{t-1}	ΔVXN_{t-2}	ΔVXN_{t-3}	$D_{t-1}R_t$
Panel A: Positive returns												
M1	0.008	-26.801***	-5.757**	3.056	4.785**				-0.151***	0.004	0.070**	3.008
	(0.14)	(-6.08)	(-2.36)	(1.22)	(2.23)				(5.35)	(0.14)	(2.52)	(0.67)
M2	0.016	-21.695***	-3.469*	3.068		-28.675***	0.353					1.647
	(0.32)	(5.28)	(-1.74)	(1.49)		(-13.65)	(0.16)					(0.38)
M3	0.001	-0.566***										0.270*
	(0.39)	(-4.01)										(1.84)
M4	0.002	-0.797***						4.668				0.184
	(1.2)	(-3.97)						(1.61)				(1.18)

Continued- Regression result for daily changes in the VXN for (a) positive and (b) negative returns

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVXN_{t-1}	ΔVXN_{t-2}	ΔVXN_{t-3}	$D_{t-1}R_t$
Panel B: negative returns												
M1	-0.100	-24.241***	-5.858*	-7.456**	6.389**				-0.188***	-0.218***	-0.003	-10.660*
	(-1.23)	(3.7)	(-1.79)	(-2.33)	(2.14)				(-5.47)	(-6.18)	(-0.09)	(-1.72)
M2	-0.083	-24.393***	-2.319	-3.969		-45.225***	5.990***					-1.963
	(-1.17)	(-4.27)	(-0.91)	(-1.62)		(-18.72)	(2.62)					(-0.35)
M3	0.001	-0.454**										-0.006
	(0.33)	(2.42)										(-0.04)
M4	-0.002	-0.798***						-7.623				-0.081
	(-0.62)	(-2.82)						(-1.62)				(-0.43)

Table 11

Sentiment effect - Regression result for daily changes in the VXN

M5 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VXN_{t-1} + \alpha_8 \Delta VXN_{t-2} + \alpha_9 \Delta VXN_{t-3} + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M6 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M7 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M8 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

The sample period is February 2001 to January 2011. The Chicago Board Option Exchange VXN index is a market implied volatility of NASDAQ-100 index options, reflecting market expectations of next 30 days volatility conveyed by NASDAQ-100 index option prices. NASDAQ-100 return is the return of the index includes 100 of the largest domestic and international non-financial securities listed on The Nasdaq Stock Market based on market capitalization. ΔVXN_t is the change in the VXN from the close on day t minus the close on day t-1. ΔVXN_{t-1},ΔVXN_{t-2},ΔVXN_{t-3} are one-day, two-day, and three-day lagged changes in the VXN. R_t is the return in the NASDAQ-100 index from day t-1 to day t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-day, two-day, and three-day lagged returns in the NASDAQ-100 index, respectively. R_{t+1} is the one-day lead return and R_{t+2} is the two-day lead return in the NASDAQ-100 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	$\|R_t\|$	${R_t}^2$	ΔVXN_{t-1}	ΔVXN_{t-2}	ΔVXN_{t-3}	$D_{t-1}R_t$	D_{t-1}
M5	-0.029	-23.379***	-6.662***	-2.650	5.558***					-0.186***	-0.110***	0.038*	-4.636	0.033
	(-0.65)	(-7.5)	(-3.11)	(-1.32)	(3.1)					(-8.41)	(-4.91)	(-1.73)	(1.28)	(0.5)
M6	-0.017	-20.088***	-2.076	-0.201		-37.549***	4.180***	2.343					-2.115	-0.041
	(-0.36)	(-7.29)	(-1.3)	(-0.13)		(-23.57)	(2.62)	(1.05)					(-0.63)	(-0.67)
M7	0.000	-0.518***											0.137	0.001
	(0.34)	(-5.64)											(1.22)	(0.57)
M8	0.000	-0.521***							0.883				0.135	0.01
	(0.2)	(-5.66)							(0.78)				(1.2)	(0.44)

Table 12

Sentiment effect - Regression result for daily changes in the VXN for (a) positive and (b) negative returns

M5 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VXN_{t-1} + \alpha_8 \Delta VXN_{t-2} + \alpha_9 \Delta VXN_{t-3} + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M6 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M7 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M8 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

The sample period is February 2001 to January 2011. The Chicago Board Option Exchange VXN index is a market implied volatility of NASDAQ-100 index options, reflecting market expectations of next 30 days volatility conveyed by NASDAQ-100 index option prices. NASDAQ 100 return is the return of the index includes 100 of the largest domestic and international non-financial securities listed on The NASDAQ Stock Market based on market capitalization. ΔVXN_t is the change in the VXN from the close on day t minus the close on day t-1. ΔVXN_{t-1},ΔVXN_{t-2},ΔVXN_{t-3} are one-day, two-day, and three-day lagged changes in the VXN. R_t is the return in the NASDAQ-100 index from day t-1 to day t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-day, two-day, and three-day lagged returns in the NASDAQ-100 index, respectively. R_{t+1} is the one-day lead return and R_{t+2} is the two-day lead return in the NASDAQ-100 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. There are 1346 observations for which R_t is positive and 1165 for which R_t is negative. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	R^2	ΔVXN_{t-1}	ΔVXN_{t-2}	ΔVXN_{t-3}	$D_{t-1}R_t$	D_{t-1}
Panel A: Positive returns													
M5	-0.028	-25.124***	-5.694**	2.977	4.812**				-0.150***	0.004	0.069**	0.224	0.072
	(-0.37)	(-4.96)	(-2.33)	(1.19)	(2.24)				(-5.34)	(0.15)	(2.51)	(0.04)	(0.67)
M6	-0.013	-20.306***	-3.428*	3.004		-28.665***	0.327					-0.668	0.060
	(-0.18)	(-4.28)	(-1.71)	(1.45)		(13.64)	(0.15)					(-0.11)	(0.59)
M7	-0.002	-0.449***										0.075	0.005
	(-0.74)	(-2.76)										(0.38)	(1.45)
M8	0.000	-0.715***						6.466**				-0.131	0.007**
	(-0.17)	(-3.49)						(2.14)				(-0.6)	(2.02)

Continued- Sentiment effect regression result for daily changes in the VXN for (a) positive and (b) negative returns

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVXN_{t-1}	ΔVXN_{t-2}	ΔVXN_{t-3}	$D_{t-1}R_t$	D_{t-1}
Panel B: negative returns													
M5	0.107	-13.770**	-5.786*	-7.687**	6.445**				-0.185***	-0.217***	-0.005	-28.124***	-0.434***
	(0.99)	(-1.82)	(-1.77)	(-2.4)	(2.17)				(-5.38)	(-6.17)	(-0.14)	(-3.18)	(-2.76)
M6	0.118	-14.445**	-2.400	-4.184*		-45.195***	5.578**					-18.862**	-0.421***
	(1.21)	(-2.19)	(-0.95)	(-1.71)		(-18.77)	(2.44)					(-2.39)	(-2.99)
M7	0.006*	-0.211										-0.417	-0.010**
	(1.76)	(-0.97)										(-1.6)	(-2.2)
M8	0.003	-0.646**						-11.233**				-0.648**	-0.013***
	(1.01)	(-2.25)						(-2.31)				(-2.32)	(-2.74)

Table 13

Regression result for weekly changes in the VIX

M1 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VIX_{t-1} + \alpha_8 \Delta VIX_{t-2} + \alpha_9 \Delta VIX_{t-3} + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M2 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M3 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M4 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

The sample period is January 1990 to January 2011. The Chicago Board Option Exchange VIX index is a market implied volatility of S&P 500 index options, reflecting market expectations of next 30 days volatility conveyed by S&P 500 stock index option prices. S&P 500 return is the return of the index includes 500 leading companies in leading industries of the U.S. economy. ΔVIX_t is the change in the VIX from the close on week t minus the close on week t-1. ΔVIX_{t-1},ΔVIX_{t-2},ΔVIX_{t-3} are one-week, two-week, and three-week lagged changes in the VIX. R_t is the return in the S&P 500 index from week t-1 to week t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-week, two-week, and three-week lagged returns in the S&P 500 index, respectively. R_{t+1} is the one-week lead return and R_{t+2} is the two-week lead return in the S&P 500 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiment. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	$\|R_t\|$	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$
M1	0.109	-67.979***	-5.715	-2.603	4.842					-0.290***	-0.022	-0.006	-2.423
	(1.61)	(-16.22)	(-1.63)	(-0.74)	(1.43)					(-9.32)	(-0.69)	(-0.2)	(-0.45)
M2	-0.197**	-70.029***	18.398***	-4.345		-10.215***	-4.169	17.126***					4.346
	(-1.97)	(-16.33)	(6.41)	(-1.56)		(-3.65)	(-1.52)	(4.32)					(0.79)
M3	0.011***	-3.067***											0.873***
	(3.62)	(-15.89)											(3.51)
M4	0.009***	-3.078***							3.948***				0.942***
	(2.67)	(-15.99)							(2.63)				(3.77)

Table 14

Regression result for weekly changes in the VIX for (a) positive and (b) negative returns

M1 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VIX_{t-1} + \alpha_8 \Delta VIX_{t-2} + \alpha_9 \Delta VIX_{t-3} + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M2 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M3 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M4 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

The sample period is January 1990 to January 2011. The Chicago Board Option Exchange VIX index is a market implied volatility of S&P 500 index options, reflecting market expectations of next 30 days volatility conveyed by S&P 500 stock index option prices. S&P 500 return is the return of the index includes 500 leading companies in leading industries of the U.S. economy. ΔVIX_t is the change in the VIX from the close on week t minus the close on week t-1. ΔVIX_{t-1},ΔVIX_{t-2},ΔVIX_{t-3} are one-week, two-week, and three-week lagged changes in the VIX. R_t is the return in the S&P 500 index from week t-1 to week t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-week, two-week, and three-week lagged returns in the S&P 500 index, respectively. R_{t+1} is the one-week lead return and R_{t+2} is the two-week lead return in the S&P 500 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current week t is positive. There are 600 observations for which R_t is positive and 462 for which R_t is negative. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$
Panel A: Positive returns												
M1	-0.043	-55.325***	0.725	-1.063	2.439				-0.318***	-0.033	-0.010	0.384
	(-0.35)	(-8.48)	(0.18)	(-0.24)	(0.6)				(-8.83)	(-0.18)	(-0.27)	(0.06)
M2	-0.056	-55.020***	22.472***	-3.682		0.615	0.772					2.621
	(-0.46)	(-8.06)	(6.5)	(-1.03)		(0.16)	(0.21)					(0.36)
M3	-0.016***	-1.592***										0.334
	(-3.25)	(-5.91)										(1.16)
M4	-0.015**	-1.681***						1.143				0.313
	(-2.58)	(-4.46)						(0.34)				(1.06)

Continued- Regression result for weekly changes in the VIX for (a) positive and (b) negative returns

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$
Panel B: negative returns												
M1	-0.363**	-92.103***	-8.360	-0.104	10.849*				-0.252***	0.010	0.011	4.530
	(-2.25)	(-10.76)	(-1.33)	(-0.02)	(1.85)				(-4.62)	(0.19)	(0.2)	(0.51)
M2	-0.377**	-100.146***	10.286**	-7.166		-19.568***	-8.061**					13.086
	(-2.35)	(-11.65)	(2.1)	(-1.64)		(-4.89)	(-1.97)					(1.52)
M3	0.013*	-3.740***										1.392***
	(1.65)	(-9.05)										(3.28)
M4	0.006	-4.250***						-6.383				1.197***
	(0.64)	(-7.71)						(-1.4)				(2.68)

Table 15

Sentiment effect -Regression result for weekly changes in the VIX

M5 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VIX_{t-1} + \alpha_8 \Delta VIX_{t-2} + \alpha_9 \Delta VIX_{t-3} + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M6 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M7 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M8 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

The sample period is January 1990 to January 2011. The Chicago Board Option Exchange VIX index is a market implied volatility of S&P 500 index options, reflecting market expectations of next 30 days volatility conveyed by S&P 500 stock index option prices. S&P 500 return is the return of the index includes 500 leading companies in leading industries of the U.S. economy. ΔVIX_t is the change in the VIX from the close on week t minus the close on week t-1. ΔVIX_{t-1},ΔVIX_{t-2},ΔVIX_{t-3} are one-week, two-week, and three-week lagged changes in the VIX. R_t is the return in the S&P 500 index from week t-1 to week t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-week, two-week, and three-week lagged returns in the S&P 500 index, respectively. R_{t+1} is the one-week lead return and R_{t+2} is the two-week lead return in the S&P 500 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	$\|R_t\|$	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$	D_{t-1}
M5	0.051	-67.684***	-5.603	-2.486	4.984					-0.291***	-0.023	-0.007	-2.757	0.125
	(0.56)	(-16.1)	(-1.6)	(-0.71)	(1.47)					(-9.34)	(-0.72)	(-0.22)	(-0.51)	(0.92)
M6	-0.191*	-70.066***	18.385***	-4.357		-10.229***	-4.179	17.180***					4.392	-0.016
	(-1.66)	(-16.28)	(6.4)	(1.56)		(-3.65)	(-1.52)	(4.3)					(0.79)	(-0.11)
M7	0.012***	-3.068***											0.874***	-0.001
	(2.72)	(-15.85)											(3.5)	(-0.08)
M8	0.010**	-3.083***							3.996***				0.948***	-0.002
	(2.25)	(-15.97)							(2.65)				(3.79)	(-0.34)

Table 16

Sentiment effect - Regression result for weekly changes in the VIX for (a) positive and (b) negative returns

M5 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VIX_{t-1} + \alpha_8 \Delta VIX_{t-2} + \alpha_9 \Delta VIX_{t-3} + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M6 $\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M7 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M8 $\%\Delta VIX_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

The sample period is January 1990 to January 2011. The Chicago Board Option Exchange VIX index is a market implied volatility of S&P 500 index options, reflecting market expectations of next 30 days volatility conveyed by S&P 500 stock index option prices. S&P 500 return is the return of the index includes 500 leading companies in leading industries of the U.S. economy. ΔVIX_t is the change in the VIX from the close on week t minus the close on week t-1. ΔVIX_{t-1},ΔVIX_{t-2},ΔVIX_{t-3} are one-week, two-week, and three-week lagged changes in the VIX. R_t is the return in the S&P 500 index from week t-1 to week t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-week, two-week, and three-week lagged returns in the S&P 500 index, respectively. R_{t+1} is the one-week lead return and R_{t+2} is the two-week lead return in the S&P 500 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. There are 600 observations for which R_t is positive and 462 for which R_t is negative. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$	D_{t-1}
Panel A: Positive returns													
M5	-0.279*	-47.461***	0.987	-0.748	2.507				-0.312***	-0.031	-0.009	-15.614	0.542**
	(-1.77)	(-6.49)	(0.24)	(-0.17)	(0.62)				(-8.49)	(-0.77)	(0.26)	(-1.62)	(2.35)
M6	-0.256**	-45.086***	22.243***	-3.360		0.714	00.546					-17.731*	0.689***
	(-2.17)	(-5.89)	(6.47)	(-0.94)		(0.18)	(0.15)					(-1.74)	(2.81)
M7	-0.020***	-1.458***										0.061	0.009
	(-3.06)	(-4.77)										(0.15)	(0.93)
M8	-0.019***	-1.604***						2.230				-0.035	0.011
	(-2.76)	(-4.18)						(0.63)				(-0.08)	(1.07)

Continued- Sentiment effect regression result for weekly changes in the VIX for (a) positive and (b) negative returns

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVIX_{t-1}	ΔVIX_{t-2}	ΔVIX_{t-3}	$D_{t-1}R_t$	D_{t-1}
Panel B: negative returns													
M5	-0.242	-88.256***	-8.227	-0.482	10.496*				-0.250***	0.009	0.008	-1.687	-0.235
	(-1.06)	(-8.86)	(-1.3)	(-0.08)	(1.78)				(-4.57)	(0.18)	(0.14)	(-0.14)	(-0.76)
M6	-0.135	-92.465***	10.359**	-7.650*		-19.927***	-8.692**					0.448	-0.475
	(-0.6)	(-9.29)	(2.12)	(-1.75)		(-4.97)	(-2.12)					(0.04)	(-1.53)
M7	0.008	-3.885***										1.633***	0.009
	(0.74)	(-8.09)										(2.78)	(0.59)
M8	0.005	-4.265***						-6.184				1.254*	0.002
	(0.45)	(-7.54)						(1.27)				(1.9)	(0.12)

Table 17

Regression result for weekly changes in the VXN

M1 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VXN_{t-1} + \alpha_8 \Delta VXN_{t-2} + \alpha_9 \Delta VXN_{t-3} + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M2 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M3 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M4 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

The sample period is February 2001 to January 2011. The Chicago Board Option Exchange VXN index is a market implied volatility of NASDAQ-100 index options, reflecting market expectations of next 30 days volatility conveyed by NASDAQ-100 index option prices. NASDAQ-100 return is the return of the index includes 100 of the largest domestic and international non-financial securities listed on The NASDAQ Stock Market based on market capitalization. ΔVXN_t is the change in the VXN from the close on week t minus the close on week t-1. ΔVXN_{t-1},ΔVXN_{t-2},ΔVXN_{t-3} are one-week, two-week, and three-week lagged changes in the VXN. R_t is the return in the NASDAQ-100 index from week t-1 to week t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-week, two-week, and three-week lagged returns in the NASDAQ-100 index, respectively. R_{t+1} is the one-week lead return and R_{t+2} is the two-week lead return in the NASDAQ-100 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	$\|R_t\|$	${R_t}^2$	ΔVXN_{t-1}	ΔVXN_{t-2}	ΔVXN_{t-3}	$D_{t-1}R_t$
M1	-0.051	-55.799***	5.291	-13.710***	-0.045					-0.139***	-0.125***	-0.053	-5.743
	(-0.41)	(-10.56)	(1.29)	(-3.34)	(-0.01)					(-3.08)	(-2.77)	(-1.21)	(-0.88)
M2	-0.397**	-56.991***	14.882***	-7.385**		2.614	-1.383	12.556***					-2.721
	(-2.24)	(-10.66)	(4.77)	(-2.36)		(0.84)	(-0.44)	(2.75)					(-0.74)
M3	0.006	-1.964***											0.429***
	(1.46)	(-11.4)											(2.02)
M4	-0.001	-2.049***							4.686***				0.574***
	(-0.3)	(-11.95)							(3.82)				(2.7)

Table 18

Regression result for weekly changes in the VXN for (a) positive and (b) negative returns

M1 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VXN_{t-1} + \alpha_8 \Delta VXN_{t-2} + \alpha_9 \Delta VXN_{t-3} + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M2 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M3 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

M4 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \varepsilon_t$

The sample period is February 2001 to January 2011. The Chicago Board Option Exchange VXN index is a market implied volatility of NASDAQ-100 index options, reflecting market expectations of next 30 days volatility conveyed by NASDAQ-100 index option prices. NASDAQ 100 return is the return of the index includes 100 of the largest domestic and international non-financial securities listed on The NASDAQ Stock Market based on market capitalization. ΔVXN_t is the change in the VXN from the close on week t minus the close on week t-1. ΔVXN_{t-1},ΔVXN_{t-2},ΔVXN_{t-3} are one-week, two-week, and three-week lagged changes in the VXN. R_t is the return in the NASDAQ-100 index from week t-1 to week t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-week, two-week, and three-week lagged returns in the NASDAQ-100 index, respectively. R_{t+1} is the one-week lead return and R_{t+2} is the two-week lead return in the NASDAQ-100 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. There are 266 observations for which R_t is positive and 236 for which R_t is negative. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVXN_{t-1}	ΔVXN_{t-2}	ΔVXN_{t-3}	$D_{t-1}R_t$
Panel A: Positive returns												
M1	-0.238	-40.581***	16.609***	-16.201***	-6.447				-0.168***	-0.098*	-0.029	-12.645
	(-1.09)	(-5.4)	(3.29)	(3.03)	(-1.18)				(-3.21)	(-1.67)	(-0.57)	(-1.61)
M2	-0.304	-38.808***	26.350***	-12.124***		4.005	-1.632					-12.265
	(-1.38)	(-5.1)	(6.49)	(-3.04)		(0.9)	(-0.35)					(-1.52)
M3	-0.023***	-0.845***										-0.157
	(3.48)	(-3.73)										(-0.66)
M4	-0.009	-1.783***						9.948**				-0.346
	(-1.03)	(-3.84)						(2.3)				(-1.39)

Continued- Regression result for weekly changes in the VXN for (a) positive and (b) negative returns

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVXN_{t-1}	ΔVXN_{t-2}	ΔVXN_{t-3}	$D_{t-1}R_t$
Panel B: negative returns												
M1	-0.894***	-95.759***	-5.286	-4.437	7.518				-0.127*	-0.059	-0.085	16.708
	(-3.08)	(-7.9)	(-0.83)	(-0.69)	(1.2)				(-1.73)	(-0.85)	(-1.14)	(1.45)
M2	-0.825**	97.103***	2.760	-4.909		0.516	-3.941					22.801*
	(-2.82)	(-7.78)	(0.59)	(-1.04)		(0.12)	(-0.94)					(1.93)
M3	-0.005	-3.136***										1.385***
	(-0.52)	(-7.54)										(3.58)
M4	0.002	-2.701***						5.300				1.548***
	(0.15)	(-4.57)						(1.04)				(3.7)

Table 19

Sentiment effect - Regression result for weekly changes in the VXN

M5 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VXN_{t-1} + \alpha_8 \Delta VXN_{t-2} + \alpha_9 \Delta VXN_{t-3} + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M6 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} * R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M7 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_t * R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M8 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_t * R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

The sample period is February 2001 to January 2011. The Chicago Board Option Exchange VXN index is a market implied volatility of NASDAQ-100 index options, reflecting market expectations of next 30 days volatility conveyed by NASDAQ-100 index option prices. NASDAQ-100 return is the return of the index includes 100 of the largest domestic and international non-financial securities listed on The Nasdaq Stock Market based on market capitalization. ΔVXN_t is the change in the VXN from the close on week t minus the close on week t-1. ΔVXN_{t-1},ΔVXN_{t-2},ΔVXN_{t-3} are one-week, two-week, and three-week lagged changes in the VXN. R_t is the return in the NASDAQ-100 index from week t-1 to week t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-week, two-week, and three-week lagged returns in the NASDAQ-100 index, respectively. R_{t+1} is the one-week lead return and R_{t+2} is the two-week lead return in the NASDAQ-100 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	$\|R_t\|$	${R_t}^2$	ΔVXN_{t-1}	ΔVXN_{t-2}	ΔVXN_{t-3}	$D_{t-1}R_t$	D_{t-1}
M5	0.006	-56.045***	5.112	-13.916***	-0.266					-0.139***	-0.125***	-0.053	-5.561	-0.120
	(0.03)	(-10.55)	(1.24)	(3.13)	(-0.06)					(-3.08)	(2.76)	(-1.22)	(-0.85)	(-0.48)
M6	-0.295	-57.655***	14.553***	-7.722**		2.286	-1.666	13.302***					-2.165	-0.259
	(-1.45)	(-10.7)	(4.64)	(-2.45)		(0.73)	(-0.53)	(2.88)					(-0.32)	(-1.01)
M7	0.009*	-1.979***											0.437**	-0.008
	(1.71)	(-11.44)											(2.06)	(-0.924)
M8	0.005	-2.083***							5.120***				0.604***	-0.014
	(0.84)	(-12.1)							(4.1)				(2.84)	(-1.55)

Table 20

Sentiment effect - Regression result for weekly changes in the VXN for (a) positive and (b) negative returns

M5 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_4 R_{t-3} + \alpha_7 \Delta VXN_{t-1} + \alpha_8 \Delta VXN_{t-2} + \alpha_9 \Delta VXN_{t-3} + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M6 $\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_2 R_{t-1} + \alpha_3 R_{t-2} + \alpha_5 R_{t+1} + \alpha_6 R_{t+2} + \alpha_{10} |R_t| + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M7 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

M8 $\%\Delta VXN_t = \alpha_0 + \alpha_1 R_t + \alpha_{11} {R_t}^2 + \alpha_{12} D_{t-1} R_t + \alpha_{13} D_{t-1} + \varepsilon_t$

The sample period is February 2001 to January 2011. The Chicago Board Option Exchange VXN index is a market implied volatility of NASDAQ-100 index options, reflecting market expectations of next 30 days volatility conveyed by NASDAQ-100 index option prices. NASDAQ-100 return is the return of the index includes 100 of the largest domestic and international non-financial securities listed on The NASDAQ Stock Market based on market capitalization. ΔVXN_t is the change in the VXN from the close on week t minus the close on week t-1. ΔVXN_{t-1},ΔVXN_{t-2},ΔVXN_{t-3} are one-week, two-week, and three-week lagged changes in the VXN. R_t is the return in the NASDAQ-100 index from week t-1 to week t. R_{t-1}, R_{t-2}, and R_{t-3} are the one-week, two-week, and three-week lagged returns in the NASDAQ-100 index, respectively. R_{t+1} is the one-week lead return and R_{t+2} is the two-week lead return in the NASDAQ-100 index. D is the dummy variable for the high-sentiment periods, which from investor sentiment index in Baker and Wurgler (2007) based on first principal component of six (standardized) sentiments. D_{t-1} equals one if the beginning-of-period sentiment index value of the current month t is positive. There are 266 observations for which R_t is positive and 236 for which R_t is negative. t-statistics are given in brackets; asterisks * show significant at 10% level; ** show significant at 5% level; *** show significant at 1% level.

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVXN_{t-1}	ΔVXN_{t-2}	ΔVXN_{t-3}	$D_{t-1}R_t$	D_{t-1}
Panel A: Positive returns													
M5	-0.599**	-32.814***	17.705***	-16.096***	-5.757				-0.161***	-0.103*	-0.028	-26.028**	0.729*
	(-1.98)	(-3.75)	(3.5)	(-3.03)	(-1.05)				(-3.07)	(-1.76)	(-0.55)	(-2.36)	(1.71)
M6	-0.706**	-29.941***	27.214***	-11.584***		3.315	-1.930					-27.608**	0.817*
	(-2.31)	(-3.36)	(6.69)	(-2.91)		(0.75)	(-0.42)					(2.42)	(1.89)
M7	-0.021**	-0.883***										-0.088	-0.004
	(-2.32)	(-3.34)										(-0.26)	(-0.28)
M8	-0.010	-1.773***						10.154**				-0.403	0.003
	(-1)	(-3.79)						(2.29)				(-1.1)	(0.22)

Continued- Sentiment effect regression result for weekly changes in the VXN for (a) positive and (b) negative returns

	α_0	R_t	R_{t-1}	R_{t-2}	R_{t-3}	R_{t+1}	R_{t+2}	${R_t}^2$	ΔVXN_{t-1}	ΔVXN_{t-2}	ΔVXN_{t-3}	$D_{t-1}R_t$	D_{t-1}
Panel B: negative returns													
M5	-0.926**	-96.623***	-5.293	-4.342	7.576				-0.127*	-0.058	-0.084	17.941	0.060
	(-2.15)	(6.52)	(-0.83)	(-0.67)	(1.21)				(-1.73)	(-0.83)	(-1.13)	(1.07)	(0.1)
M6	-0.804*	-96.536***	2.750	-4.931		0.500	-3.965					21.975	-0.040
	(-1.86)	(-6.42)	(0.59)	(-1.04)		(0.11)	(-0.94)					(1.3)	(-0.07)
M7	-0.026*	-3.693***										2.196***	0.038*
	(-1.78)	(-7.35)										(3.87)	(1.95)
M8	-0.020	-3.058***						10.298*				2.823***	0.053**
	(-1.36)	(4.32)						(1.9)				(2.823)	(2.52)

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