

Title: Time-varying relationship of news sentiment, implied volatility and stock returns
Author: Lee A. Smales, CFA
Affiliation: School of Economics & Finance, Curtin University
Address: Building 402, Kent Street, Perth, WA 6845, Australia
Email: lee.smales@curtin.edu.au

Abstract

I examine the relationship between aggregate news sentiment, S&P500 index returns, and changes in the implied volatility index (VIX). I find a significant negative contemporaneous relationship between changes in VIX and both news sentiment and stock returns. This relationship is asymmetric whereby changes in VIX are larger following negative news and / or stock market declines. VAR analysis of the dynamics and cross-dependencies between variables reveals a strong positive relationship between previous and current period changes in implied volatility and stock returns, while current period and lagged news sentiment has a significant positive (negative) relationship with stock returns (changes in VIX). I develop a simple trading strategy whereby high (low) levels of implied volatility signal attractive opportunities to take short (long) positions in the underlying index, while extremely negative (positive) news sentiment signals opportunities to enter short (long) index positions. The investor fear gauge (VIX) appears to perform better than news sentiment measures in forecasting future returns.

Keywords

News sentiment, Stock market, Implied volatility, Trading strategy

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1. Introduction

Keynes (1936) suggests that the “animal spirits” of investors have a strong influence on financial markets. In recent years, the attention of academics, media, and market professionals has been captured by the Chicago Board Option Exchange’s market volatility index (the VIX); a measure of the implied volatility of S&P500 index options. Often referred to as the “investor fear gauge”, the VIX expresses a consensus view about expected future stock market volatility; the higher the VIX, the greater the fear. A second measure, based on the sentiment of news articles, has become popular with evidence of a particularly strong relationship between pessimistic news and subsequent negative market returns (Tetlock [2007]). Both the investor fear gauge and news-based sentiment are trying to capture aspects of the same concept – “market sentiment”. The main motivation of this study is to understand whether the measures are inter-related, and whether either measure is successful in explaining market returns and capturing this elusive concept, and whether this changes over time. I find evidence that both measures are related and have a statistically significant relationship with market returns, although VIX appears to be a more useful gauge, at least on an aggregate level, at forecasting future returns. I also find that the identified relationship changes over time with sentiment having a stronger association with returns during periods of crisis.

Prior work has considered the relationship between the implied volatility index and stock market returns. Bollen and Whaley [2004] and Whaley [2009] argue that the indicator reflects the price of portfolio insurance and therefore the demand for put options is the key driver in volatility measures such as VIX. Fleming et al. [1995] find that VIX is a good but biased predictor of future stock market volatility. Fleming et al. [1995], Whaley [2000] and Giot [2005] find a significant negative and asymmetric contemporaneous relationship between stock returns and changes in implied volatility; VIX increases more as the S&P500 index falls than it decreases when the S&P500 index rises. Siriopoulos and Fassas [2009] find the same relationships hold for a range of international implied volatility indices and the corresponding underlying equity index. Smales [2016a, 2016b] shows that there is also a similar relationship between VIX and returns in the bond and currency markets. Low [2004] finds the relationship is non-linear and exhibits a “house-money effect”. The leverage hypothesis has been favoured as the explanation for this risk-return relationship – Black [1976] postulates that negative shocks to returns increase financial leverage, thus making stocks riskier and subsequently driving up volatility. Similarly, Whaley

[2000] states that if expected market volatility increases then investors demand higher rates of return on stocks and so stock prices fall.

A related field of work has considered the impact of news arrival on stock returns and volatility, and identified that the arrival of firm-specific news can drive movements in stock prices and volatility. Earlier research focused on specific and easily identifiable news events such as scheduled dividend announcements earnings results. For example, Patell and Wolfson [1984], and Woodruff and Senchak [1988] find that much of the market adjustment occurs in the first 30 minutes following the announcement of earnings and dividends. More recently, the quantifying of news language (e.g. Tetlock [2007]) has enabled the identification of market reactions across a wider range of events. In particular, the relevance and sentiment of news has been tested in a variety of market settings. Tetlock et al. [2008] find that a quantitative measure of language can predict firms' earnings and stock returns, Dzielinski [2011] finds that positive (negative) news results in above (below) average returns. The availability of news analytics tools, with pre-processed sentiment indicators, has enabled the extension of this analysis to high-frequency data: Leinweber and Sisk [2011] note that news-driven event trading requires gathering information from the right sources, while Groß-Klußmann and Hautsch [2011] and Smales [2014] find that high-relevance news induces an increase in market activity and volatility with negative news sentiment having a greater impact than positive news. Prior work has yet to investigate whether aggregated firm-specific news has an empirical relationship with the implied volatility index, and the returns of the underlying stock index.

This paper intersects these two developing avenues of research and focuses on two closely related questions which investigate the empirical link between the release of firm-specific news, implied volatility indices and stock index returns. More precisely, I seek to examine three research questions:

1. Are measures of market sentiment related?
2. Do measures of market sentiment (investor fear gauge and news-based sentiment) explain contemporaneous stock market returns?
3. Does this relationship change over time? In particular, is it influenced by financial crisis?

The first question is important; if the measures are not related we could suspect that at least one branch of the developing literature on market sentiment is following the wrong path. The

second question seeks to confirm existing results, but also is implicit in seeking to determine whether one measure has a stronger or more consistent relationship than the other. The final question considers the time-varying nature of the relationship and adds to our understanding on how periods of financial crisis influence stock market dynamics. It is difficult, if not impossible, to show causality in a contemporaneous relationship and I do not try to do it here. Instead, my objective is to provide a greater understanding of the statistical relation between the current conditions of the market and the perception of risk by sophisticated market participants.

Aggregating news sentiment for the constituents of the S&P 500 Index, over an eleven-year time period, I examine the relationship between news sentiment, S&P 500 Index returns, and changes in the index of implied volatility (VIX). Examining the contemporaneous relationship first, I find a significant negative relationship between news sentiment and changes in VIX, with positive (negative) news related to a decrease (increase) in VIX; the relationship is much stronger during the financial crisis period of 2008-2009. I find evidence of an asymmetric effect where the magnitude of the change in VIX is larger during intervals of negative news. Additionally, I confirm findings from the earlier literature such that there is evidence of an inverse and asymmetric relationship between movements in VIX and S&P 500 Index returns.

Analysis of dynamics and cross-dependencies between variables in a VAR framework reveals a strong positive relationship between previous and current period changes in implied volatility and stock returns, while current period and lagged news sentiment has a significant positive (negative) relationship with stock returns (changes in VIX). A simple trading strategy emerges such that extremely high (low) levels of implied volatility signal attractive opportunities to take short (long) positions in the underlying index, while extremely negative (positive) news sentiment signals opportunities to enter short (long) index positions. Combining the entry points signalled by levels of VIX, with those flagged by news sentiment, produces a low frequency trading strategy that results in consistently profitable trades. While there is evidence that both sentiment measures are associated with stock market returns, the investor fear gauge (VIX) appears to be more useful in forecasting returns at an aggregate level.

The remainder of this paper is organized as follows: Section 2 discusses the nature of the data used in this paper; VIX, S&P 500 index returns and aggregated news. Section 3 investigates the contemporaneous relationship between unscheduled aggregate news releases and changes in implied volatility and stock market returns. Section 4 considers the inter-temporal relationship

between news releases, VIX and future stock market returns, and assesses the profitability of simple trading strategies. Section 5 concludes the paper.

2. Data

2.1 *News Sentiment*

In order to facilitate the processing of new information, several news vendors offer software capturing particular characteristics of news in real-time. These tools electronically analyse available textual information using linguistic pattern recognition algorithms. Words, word patterns, the novelty of a news item, its type and other characteristics are translated into indicators of the relevance and novelty as well as the sentiment of the item. Pre-processed news data is gathered from a news analytics tool called Ravenpack, which utilises news items posted on the Dow Jones newswire and in the Wall Street Journal. News arrival is recorded with GMT time stamps with up to a millisecond precision. Prior work (e.g. Smales [2014]) demonstrates that news that is highly relevant and novel induces a greater impact on asset prices. I therefore include only news items that are published for the first time (Ravenpack Story_Event_Index equal to 1) and classified as highly relevant (Ravenpack classifies HIGH RELEVANCE as a score in the interval [90-100]). This leaves 2,138,342 news headlines for S&P 500 Index stocks over the period 04 Jan 2000 to 31 Dec 2010. Figure 1 shows the distribution of news items per trading day over the sample period, where on average there are approximately 777 news items reported in each trading day. The number of news items released each day gradually increased over the period 2000 – 2007 but has remained steady since; whilst there is no pronounced yearly pattern of news arrival there are noticeable spikes which have occurred around specific events such as the terrorist attacks on 11 Sep 2001, and the demise of Lehman Brothers in 2008.

<Insert Figure 1>

Ravenpack provides several *Sentiment* indicators with *Multi-Classifier for Equities* (MCQ) providing the focus in this paper. MCQ is a multi-classifier score that represents the news sentiment on the tone applicable only towards the most relevant companies mentioned in a story. The score is derived from a combination of analytics values produced by classifiers which focus on short commentary and editorials (BMQ), earnings evaluations (BEE), corporate actions (BCA) and changes in analyst recommendations (ANL_CHG). BEE uses Ravenpack's Traditional Tagging methodology and is based on a Rule Base that maps key words, phrases, combinations and other word-level definitions to pre-defined sentiment values. An Expert Consensus Methodology

underpins BMQ and BCA scores and entails training classification algorithms on the results of financial experts manually tagging stories. An MCQ score is present when the relevance score for a company is 90 or higher and either there is an ANL-CHG score or all of BMQ, BEE and BCA scores are positive, neutral or negative. The logic of this classifier is to detect consistent sentiment classifications, and discard combinations where the classifiers have contradictory scores. Ravenpack assigns this classifier a score of 0 to negative sentiment, 50 to neutral and 100 to positive; the analysis scales the scores to the more intuitive levels of -1, 0, +1.

The firm-specific MCQ score is utilized to create an aggregate measure of news sentiment by averaging the firm-specific MCQ for the given interval, t , for all 500 companies that make up the S&P 500 Index in each period. To cater for intervals which naturally have a higher (or lower) degree of news releases, such as the quarterly earnings season or periods around public holidays¹, I use an average, or standardised, MCQ score (the MCQ score divided by the number of news releases on that day) throughout the empirical analysis. Table 1 shows that the average daily news sentiment score is close to neutral (0.007), although this varies significantly during the sample period with a low of -0.054 in 2007, and a high of 0.50 in 2001.

<Insert Table 1>

2.2 *Implied Volatility Index (VIX)*

VIX² is an index computed on a real time-basis throughout each trading day, estimating the level of implied volatility by averaging the weighted prices of SPX puts and calls over a wide range of strike prices³, and thus representing expected market volatility over the next 30 calendar days. The VIX is quoted in percentage points and translate, roughly, to the expected movement in the S&P 500 Index over the next 30-day period, which is then annualized. For example, if the VIX is 20, this represents an expected annualized change of 20% over the next 30 days; thus one can infer that the index options markets expect the S&P 500 to move up or down 5.77% ($20\% / \sqrt{12}$) over the next 30-day period. The S&P 500 Index option market is the most active index option market in the US, and is seemingly dominated by portfolio insurers who routinely buy out of the money and at the money index puts for insurance purposes. CBOE reports that total volume of puts was 62% greater than that of calls in 2010 (108.5m v 66.8m), hence it is likely that

¹ I repeat the analysis using aggregate MCQ for each interval and achieve qualitatively similar results.

² CBOE and TRTH ticker symbol VIX.

³ For a full explanation of the methodology see <http://www.cboe.com/micro/vix/vixwhite.pdf>

it is put buyers who help to drive changes in implied volatility (VIX) and provides the index with the colloquial name of the “fear gauge”.

Data for VIX is collected from Thomson Reuters Tick History, provided by SIRCA⁴, for the period January 2000 – December 2010 to coincide with the availability of data for news sentiment. Table 1 provides summary statistics for VIX, and shows that the mean level over the whole sample period is 23.20 although this ranges from a 2005 mean of 12.80 to a 2008 mean of 32.74 (and a closing high of 80.86 on 20 Nov 2008). The average daily change in VIX is -0.004, with both the largest daily decrease of 11.11 points, and largest daily increase of 13.99 points occurring in 2008. The standard deviation of changes in VIX is 1.56, although there is substantial fluctuation in this measure of the volatility of volatility.

2.3 S&P 500 Index Returns

The S&P 500 Index⁵ (SPX) is a free-float capitalization weighted index based⁶ on the common stock prices of 500 leading companies, and encapsulates 75% of the market value of U.S. equities. The index is closely followed by market participants, and is seen by the media as a “bell-weather” for the state of the U.S. economy. I collect daily and intraday data for the S&P 500 Index from TRTH, provided by SIRCA, for the period January 2000 – December 2010. Table 1 reports the mean level for the index during this period as 1183. During the sample period there appears to be two clear cycles of equity prices; a 2000 peak followed by a 2003 low, and a 2007 all-time high (1,565 reached on 09 Oct 2007) proceeded by a local minimum in 2009 (the 752 daily low of this cycle was reached on 20 Nov 2008). The average mean daily return for the index is close to zero, where S&P 500 Index Returns are calculated as:

$$RSPX_t = \ln\left(\frac{SPX_t}{SPX_{t-1}}\right) \quad (1)$$

Table 2 provides information on the autocorrelation, and cross-correlation, of the collected data. Panel A indicates a high degree of persistence in news sentiment for at least one week, while changes in VIX and stock index returns have a much smaller degree of autocorrelation. Panel B demonstrates a highly significant and negative contemporaneous

⁴ Securities Industry Research Centre of Asia-Pacific

⁵ Ticker symbol SPX

⁶ For full methodology see:

<http://www.standardandpoors.com/indices/sp-500/en/us/?indexId=spusa-500-usdof--p-us-l-->

correlation between changes in VIX and SPX returns, and a similar relationship between news sentiment and changes in implied volatility levels – positive (negative) news occurs in the same period that VIX falls (rises). In addition there is a well-defined positive relationship between news sentiment and stock market returns. During the financial crisis period of 2007-2009 the correlations between the factors become somewhat stronger – particularly for the relationship between news sentiment and the other two variables.

<Insert Table 2>

3. The contemporaneous relationship between news, implied volatility and stock returns

In this section, I investigate the contemporaneous relationship between aggregated news releases, changes in the implied volatility index, and returns on the associated stock market index. More specifically, I aim to ascertain the relationship between aggregated news sentiment and changes in VIX and the S&P 500 index at daily and intra-daily intervals. It is important to note that in utilising contemporaneous specifications I do not wish to imply causality, but instead seek to examine the reliability of statistical relations. Whaley [2009] notes that VIX levels change over time, while Giot [2005] notes an important difference in the implied volatility index response to stock returns across sub-periods; therefore this I also seek to observe how the relationships vary over an extended period of time, with a particular focus on the period containing the global financial crisis (GFC) of 2008-2009⁷.

3.1 Relationship between aggregate news sentiment and implied volatility

Prior work has identified a relationship between the release of firm-specific news and the return volatility of individual stocks. For instance, Groß-Klußmann and Hautsch [2011] and Smales [2014] find that the release of highly relevant news induces an increase in return volatility, with negative news having a greater impact than positive news.

<Insert Figure 2>

The significant and negative correlation presented in Table 2 Panel B, together with a cursory view of Fig 2, suggests that a similar contemporaneous relationship may also hold between the release of news and changes in VIX. In particular, positive (negative) news is related

⁷The crisis period is defined as 01 January 2008 – 30 June 2009 as this coincides with the recession in the U.S. as determined by NBER.

to a decrease (increase) in the implied volatility index. I quantitatively evaluate this relationship using an ordinary least square (OLS) specification. In the first instance, I examine the direct relationship between changes in VIX and the release of news:

$$\Delta VIX_t = \beta_0 + \beta_1 News_t + \varepsilon_t \quad (2)$$

Where ΔVIX_t is the change in VIX during the interval t , $News_t$ is the aggregated sentiment of news items released during interval t , and ε_t is the error term for interval t . Newey West standard errors are used to correct for heteroskedasticity. I note that the time series of volatility measures tend to be persistent, although the daily changes in the time series are less so, and consider the inclusion of a lagged dependent variable to take account of this. Re-running the analysis including a lagged variable has an inconsequential effect on the estimated coefficient, therefore only the results from the parsimonious model are reported in this paper⁸.

I then specifically test for the asymmetric news reaction by disaggregating news releases into a positive and negative component:

$$\Delta VIX_t = \beta_0 + \beta_1 |News_t^-| + \beta_2 News_t^+ + \varepsilon_t \quad (3)$$

Where ΔVIX_t is the change in VIX during the interval t , $News_t^+$ is the aggregated sentiment of news items released during interval t conditional on positive news (i.e. $News_t > 0$) and 0 otherwise. $News_t^-$ is the aggregated sentiment of news items released during interval t conditional on negative news (i.e. $News_t < 0$) and 0 otherwise. Since $News_t^-$ only takes a negative (or zero) value, the absolute value is used in order to aid interpretation of the estimated coefficient⁹.

<Insert Table 3>

Table 3¹⁰ reports the estimated results for the overall relationship between changes in VIX and the sentiment of news release, using a daily time interval. The estimated relation for the whole sample is:

$$\Delta VIX_t = 0.020 - 3.404 News_t$$

⁸ Results for the specification that includes the lagged dependent variable are available from the author upon request.

⁹ If this was not used, the reader would need to interpret a negative estimated coefficient to have a positive impact on changes in VIX (i.e. a negative coefficient multiplied by a negative observation for news).

¹⁰ The results presented in Table 3 and 4 use average news sentiment during period t , analysis using the sum of news sentiment produces qualitatively similar results.

The intercept is significantly below zero, suggesting that VIX will decline in the absence of news releases with aggregate sentiment. The coefficient for news sentiment is significant at the 1% level, where the sign of the coefficient confirms the initial hypothesis that news sentiment has a negative relationship with changes in implied volatility, i.e. positive (negative) news is related to a decline (increase) in VIX. Examining the relationship for each annual sub-period reveals that it evolves over time; news sentiment has an insignificant relation with changes in VIX during periods of low implied volatility (2003-2005) and a much stronger connection during periods of high implied volatility. In particular, the period surrounding the global financial crisis (GFC) of 2007-2009 produces highly significant coefficients and evidence of a stronger association (high R²). Results for the hourly and 5-minute interval reveal that the relationship between news sentiment and changes in implied volatility becomes weaker as the time interval is reduced; the association is significant only for the period 2006-2009 when considering hourly intervals, and is not significant in any individual year when considering 5-minute intervals. This in contrast to the findings by Groß-Klußmann and Hautsch [2011] and Smales [2014] who note almost instantaneous reactions of individual stock prices to firm-specific news, and suggests that the assimilation of aggregated news takes some time to process.

<Insert Table 4 >

Table 4 reports the estimated results for the relationship between changes in VIX and news sentiment disaggregated into positive and negative news, over daily time intervals. The estimated relation for the whole sample is:

$$\Delta VIX_t = -0.128 + 5.615|News_t^-| - 1.099News_t^+ + \varepsilon_t$$

The intercept is significantly below zero when considering the overall sample, suggesting that VIX will decline in the absence of news releases with aggregate positive or negative sentiment. This is apparently driven by the 2007-09 period (coinciding with the GFC) when the intercept is negative and significant. I interpret this as “no news is good news” during periods of generally high investor fear.

The coefficients for positive and negative news sentiment are significant and confirm ex-ante expectations. In particular, positive news relates to a decline in VIX and negative news is associated with an increase in implied volatility. In addition, there is evidence of an asymmetric relationship whereby the change in VIX is larger in periods of negative news (i.e. 2007 – 2009). Considering the annual sub-periods reveals that the relationship is relatively constant over time,

although the magnitude of the coefficients does vary somewhat. In 2002, and 2008, (periods of stock market declines and sharply increasing VIX) positive news has the more significant association; one possible explanation been that during periods that witness a high degree of negative news, as commonly occurs when markets are falling and volatility is increasing, any additional negative news will have less impact than positive news that is seized on by the market to initiate a ‘relief rally’.

Analysis of intra-daily intervals reveals that the relationship between negative news and changes in VIX is positive and significant for both hourly and 5-minute intervals. When considering the annual sub-periods this association is significant only for the period around the GFC for the hourly interval, and only in 2008 for the 5-minute interval. The relation between positive news and changes in VIX is inverse, as expected, but not significant overall, or in any sub-period. Again, there is evidence of an asymmetric relationship with the magnitude of the coefficient for negative news been larger than that for positive news.

3.2 Relationship between implied volatility index and stock market returns

The VIX has become known as the “investor fear gauge” since it spikes during periods of market turmoil; such fears also tend to manifest in stock prices. If expected volatility increases (decreases), investors will demand higher (lower) rates of return on stocks, so stock prices fall (rise). Figure 3 shows the daily closing levels of VIX and the S&P 500 Index over the period January 2000 – December 2010. Figure 4 demonstrates that spikes in the VIX are coincident with spikes in the opposite direction for the S&P 500 Index. For example, on 22 March 2001 there was a 5.89% fall in the S&P 500 Index, with a jump in the VIX of 5.7 points (16.9%). Similarly, at the start of September 2008 there was a sharp spike in VIX along with declines in the S&P Index.

<Insert Figure 3>

<Insert Figure 4>

An ordinary least squares (OLS) specification is used to formerly assess the contemporaneous relationship between VIX and S&P 500 Index returns. Prior research (e.g. Fleming et al. [1995] and Whaley [2000]) has noted an asymmetric relationship in the sense that VIX will rise by more following a stock market decline than it will fall following a stock market

rally. To incorporate this effect I include an additional term, $RSPX$, the return of the S&P 500 Index conditional on the market declining. The full specification is then:

$$\Delta VIX_t = \beta_0 + \beta_1 RSPX_t + \beta_2 |RSPX_t^-| + \varepsilon_t \quad (4)$$

Where ΔVIX_t is the change in VIX during the interval t , $RSPX_t$ is the return in the S&P500 Index over the interval t , and $RSPX_t^-$ is the return on the S&P 500 Index in interval t conditional on the market going down and 0 otherwise. As with the negative news variable in equation (3), the absolute value of $RSPX$ is used in order to aid with interpretation of the estimated coefficient.

<Insert Table 5>

Table 5 – Panel A shows that the estimated relation between the change in VIX and S&P 500 Index returns, for the whole sample of 2,760 daily observations, is:

$$\Delta VIX_t = -0.124 - 92.57 RSPX_t + 0.298 |RSPX_t^-|$$

The estimated intercept in the regression is -0.124 and this is significantly different from zero and this suggests that if the S&P 500 Index does not change over the day, then VIX will decline; this is consistent with VIX acting as a measure of market volatility. Both of the estimated coefficients relating to SPX are significantly different from zero at the 1% level. However, the magnitude of the coefficients varies over the sample period; β_1 has a high (in terms of absolute value) of -130.59 in 2007 and a low of -52.24 in 2004, while β_2 has a high of 75.02 (2009) and a low of 2.592 (2000). β_2 is also insignificant in a number of years during the sample period. The overall strength of association between the variables (R^2) is 0.651, but is lower in 2000 (0.433) and higher in 2007 (0.756). The apparent break-down in the relationship in 2000 occurred as the dot-com bubble peaked and investors became nervous despite the fact the S&P500 Index continued to rally.

The estimated slope coefficient for S&P 500 returns is negative and significant, reflecting the inverse relationship between stock market returns and changes in investor fear. There is evidence of asymmetry resulting from market declines (consistent with Giot [2005] and Whaley [2009]), as the estimated coefficient for $|RSPX|$ is well-defined and positive, and implies that negative market returns result in additional increases in levels of investor fear. Whaley (2009) argues that the asymmetric effect is a result of the demand for portfolio insurance, that is investors purchasing index puts to protect against further market declines. As a result VIX better

reflects investors' fear of downside risk, rather than gauging investor enthusiasm in a market rally.

Whilst the focus of the discussion has been on the contemporaneous relationship based on daily observations, Table 5 Panel B & Panel C shows the results for the higher-frequency hourly and 5-minute observations. The general findings are the same, but the magnitude of the coefficients becomes lower, and the strength of the relationship (R^2) declines, as the data frequency increases.

3.3 *Inter-relationship between news sentiment, changes in implied volatility and stock returns*

Having identified the existence of an association between news sentiment and changes in implied volatility, and changes in implied volatility and stock market returns, I attempt to close the circle by examining the three-way relationship between news sentiment, implied volatility and stock returns. An OLS specification is used to identify the relationship, with each specification presenting the opportunity to examine the association given a

$$RSPX_t = \beta_0 + \beta_1 \Delta VIX_t + \beta_2 News_t + \varepsilon_t \quad (5.a)$$

$$RSPX_t = \beta_0 + \beta_1 \Delta VIX_t + \beta_2 \Delta VIX_t^+ + \beta_3 News_t + \varepsilon_t \quad (5.b)$$

$$RSPX_t = \beta_0 + \beta_1 \Delta VIX_t + \beta_2 \Delta VIX_t^+ + \beta_3 |News_t^-| + \beta_4 News_t^+ + \varepsilon_t \quad (5.c)$$

Where $RSPX_t$ is the return in the S&P500 Index over the interval t , ΔVIX_t is the change in VIX during the interval t , ΔVIX_t^+ is the change in VIX during interval t conditional on the index increasing and 0 otherwise. As before, $News_t$ is the aggregated sentiment of news items released during interval t , $News_t^+$ is the aggregated sentiment of news items released during interval t conditional on positive news (i.e. $News_t > 0$) and 0 otherwise. $|News_t^-|$ is the absolute value of the aggregated sentiment of news items released during interval t conditional on negative news (i.e. $News_t < 0$) and 0 otherwise, and ε_t is the error term for interval t .

<Insert Table 6>

Table 6 presents the results for the estimated coefficients. Consideration of the whole sample period confirms the highly significant and negative relationship between changes in VIX and stock market returns. In addition there is a significantly positive relationship between stock returns and news sentiment. Therefore, days with positive stock returns are associated with

positive news sentiment and declines in VIX. The addition of the term for conditional positive changes in VIX is found to be insignificant and has little impact on the other coefficients in the regression. The third specification confirms the asymmetric impact of negative news sentiment over the whole sample period, such that negative news has an influence on stock returns that is 2.7 times greater than that for positive news.

The previous 2 sections have identified a difference in the identified relations during the crisis periods (2008-2009) as compared with prior to that crisis. Therefore, the analysis is repeated with the sample sub-divided into pre-crisis and crisis periods in order to examine any change in the associated relationships. The general finding for the sub-periods is qualitatively similar to the result for the overall sample, however the explanatory power (R^2) is stronger during the crisis, and there is also additional evidence of a changing relationship during the crisis period. Notably, news sentiment has a much more substantial contemporaneous relation to market returns during the crisis period (an eleven-fold increase in the coefficient).

Additionally, the asymmetric effect of positive and negative news seems to switch during the crisis. Prior to the crisis, positive news has a positive and insignificant relationship with returns, while during the crisis this relationship becomes highly significant and the magnitude of the coefficient is 2.4 times larger than that for negative news; this may imply that the market seizes on any good news during a period of excessively negative news. The change in the news sentiment – return relationship may be explained by the literature on investor attention ([Barber and Odean, 2008], [Huo et al., 2009] and [Andrei and Hasler, 2014]). During the crisis period there is a greater amount of news published, this news is generally more negative and read with great interest by investors. The result is that news has a greater influence on market returns (and volatility) during such crisis periods.

The analysis is repeated in order to provide estimates for the relationship during hourly, and 5-minute, intervals¹¹. The results for hourly intervals are similar to the daily interval although the strength of the relationship is much stronger during the crisis with R^2 doubling from 0.35 to 0.70. In contrast to the daily interval, both the change in the implied volatility index does have an asymmetric relationship with returns both prior to and during the crisis period. The results also confirm the switch in the asymmetric effect of news sentiment during pre- and crisis

¹¹ Only the results for the daily interval are reported in Table 6. Results for the higher-frequency intervals are available from the author upon request.

periods. Analysis of the 5-minute interval results again shows that the relationship is much stronger during the crisis period (R^2 is 0.41 versus 0.01 prior). News sentiment is significant only in the crisis period, and again the asymmetric effect is confirmed with negative news proving to be a highly significant factor during the crisis period.

In summary, news sentiment has a significant negative relationship with changes in VIX, with positive news related to a decline in VIX, and negative news related to an increase – this relationship becomes much stronger during periods of high implied volatility, and consistently negative news, such as the GFC of 2008-2009. A decline (increase) in the implied volatility index occurs in periods of positive (negative) news and there is evidence of asymmetry where the magnitude of the change in VIX is larger during intervals of negative news. Consistent with Giot [2005] and Whaley [2009], there is evidence of an inverse and asymmetric relationship between movements in VIX and S&P 500 Index returns. Examining the three factors together confirms the earlier results, highlights the existence of a stronger relationship between news sentiment and returns during crisis periods, and suggests that the asymmetry of the relationship between returns and changes in VIX may not hold once controlling for news sentiment.

4. News release and VIX indices as indicators of returns on the S&P 500 index

4.1 VAR Model

The analysis of the previous section provide strong evidence of a contemporaneous relationship between the release of relevant aggregated firm-specific news, changes in implied volatility and returns on the S&P 500 stock index. Panel B of Table 1 indicates a degree of persistence in the individual processes for news releases and changes in VIX, together with a significant degree of cross-correlation between the variables. Therefore, to correctly model the dynamics of this interaction it is appropriate to explicitly consider the dependencies and interdependencies in a Vector Auto-Regression (VAR) framework. The model specification is as follows:

$$y_t = \alpha + A_1 y_{t-1} + A_2 y_{t-2} + \sum_{i=0}^2 \beta_{t-i} News_{t-i} + \varepsilon_t \quad (6)$$

Where α is a (2 x 1) vector of constants, A_i is a (k x k) co-efficient matrix, $News_{t-i}$ is an exogenous variable representing the release of news in current and prior intervals (measured as average MCQ for the given interval). ε_t is a (2 x 1) vector of error terms that are not serially

correlated and are also uncorrelated with the past values of the endogenous variables. A lag length of 2 is found to optimise the Akaike Information Criteria (AIC).

<Insert Table 7>

Table 7 reports the estimates of the VAR model for the Daily time interval¹². The results can be summarized as follows: First, as expected from the analysis of the underlying autocorrelations there is significant positive own dynamics for stock returns, and significant negative own dynamics for changes in VIX. Second, there is a strong positive relationship between previous period changes in VIX and current period stock returns. Third, previous period rises (declines) in the stock market indicate current period decreases (increases) in the implied volatility index. Finally, there is confirmation of the results in the prior section whereby current period news releases have a significant relationship with both stock returns and changes in VIX; positive (negative) news in the current period indicates a rise (fall) in current period S&P 500 returns, and a fall (rise) in the implied volatility index. Interestingly, this relationship is also found to hold for one-period lags of news arrival, although the coefficients are found to be much smaller.

4.2 *A Trading Strategy*

The empirical results from VAR analysis, together with the results of an analysis of contemporaneous relationships found in Section 3, suggest that it is worthwhile investigating news releases and VIX as indicators of future stock market returns; if they are found to be reliable indicators then it may be possible to construct a profitable trading strategy.

4.2.1 *Stock returns at extreme levels of investor fear*

Section 3.2 provides clear evidence of the inverse relationship between implied volatility and stock market returns. It is possible that levels of VIX may indicate market conditions that may result in profitable entry in trading strategies, possible as a result of over-bought or over-sold market conditions. This can be examined by considering the relationship between the level of VIX and the forward looking changes in the underlying stock index. More specifically, I consider the relationship between the level of the implied volatility index (VIX_t) at a given time, t , and the forward looking 1-, 5-, 20-, 60- and 250-day returns on the S&P 500 index.

¹² The results for the shorter time intervals are qualitatively similar.

I create a classification of VIX levels based on 5 rolling, equally spaced, quintiles of the implied volatility index at any given time. At time t , the quintiles are computed for the set of VIX values which includes the past history of the VIX index from the start of the sample up to time $t-1$. VIX_t is compared to the quintiles and ranked accordingly. If VIX_t is extremely high (low) then it will be ranked close to 5 (1). This provides a quantitative measure of the trading environment in terms of the fear level relative to the investors' information set. Given the rank, R_t , is observed at time t it is possible to compute the forward looking returns for the S&P 500 index which correspond to the forward looking returns for a long position in the S&P 500 index for a predetermined time horizon of 1-, 5-, 20-, 60- and 250- days following the observed VIX. This trading rule is implemented for all available observations in the S&P 500 dataset.

<Insert Table 8>

The outcome of this trading strategy¹³ is reported in Table 8. Columns 3 to 10 shows the average and coefficients of variation of the 1-, 5-, 20-, 60- and 250-day forward looking returns for category R (Column 1). Column 2 shows the number of trades (observations) within each category. As the level of implied volatility (VIX) increases there is a monotonic increase in the realized volatility of returns – this is consistent with Fleming et al (1995) who note that VIX performs well as a volatility forecast – and there is also a decline in average returns. For high levels of VIX, $R \geq 4$, forward looking returns are always negative, whatever the time horizon. Correspondingly, lower levels of VIX, $R \leq 3$, produce forward looking returns that are always positive on average. The results in this section suggest that extremely high (low) levels of implied volatility signal attractive entry points for traders to take short (long) positions in the underlying index. The profitability of this trading strategy is consistent with the FEARS strategy suggested by Da et al. (2015). They suggest that increases in investor fear corresponds with low market returns on the day of the increase (as I find in this paper) but predicts high returns (a reversal) over the following period.

4.2.2 *Stock market returns following news releases*

Prior literature, including Tetlock [2007], Dzielinski [2011], and Smales [2014, 2016a], has examined the relationship between stock market returns and news releases. Corresponding with Section 4.1 results, the consensus view is that positive (negative) news results in above (below) average returns. It is possible that periods of extremely negative (positive) news may signal

¹³ Analysis using hourly and 5-minute data produces qualitatively similar results.

opportunities to enter short (long) index positions in order to benefit from future stock market movements.

In a similar vein to the previous section I create a classification of news sentiment levels based on 5 rolling, equally spaced, quintiles of the news sentiment level at any given time, with a 1-year history. $News_t$ is compared to the quintiles and ranked accordingly. If $News_t$ is extremely negative (positive) then it will be ranked close to 1 (5), providing a relative measure of the excessiveness of the news sentiment factor. Given that rank, R_t , is observed at time t it is possible to compute the forward looking returns for the S&P 500 index which thus correspond to the forward looking returns for a long position in the S&P 500 index for a predetermined time horizon of 1-, 5-, 20-, 60- and 250-days triggered by the observed news sentiment. This trading rule is implemented for all available observations in the S&P 500 dataset.

<Insert Table 9>

The outcome of this trading strategy¹⁴ is reported in Table 9. Columns 3 to 10 shows the average and coefficients of variation of the 1-, 5-, 20-, 60- and 250-day forward looking returns for category R (Column 1). Column 2 shows the number of trades (observations) within each category. While there is no discernible pattern for the coefficient of variation, the average return appears to increase (go from negative to positive) as news sentiment becomes less negative. For extremely more negative news sentiment, $R \leq 2$, forward looking returns are always negative, whatever the time horizon. Correspondingly, positive levels of news sentiment, $R \geq 3$, produce forward looking returns that are positive on average for 20-days. For horizons greater than 20-days, returns are negative on average. Consistent with prior work, the stock market reaction following extremely negative news is of greater magnitude than the reaction following positive news (at least for the first 20-days). For example, the occurrences in category $R = 1$ (extremely negative news) provide an average return of -0.68% over the next 20 days, while occurrences of extremely positive news ($R = 5$) produce an average return of just 0.26% over the next 20 days. The results in this section suggest that extremely negative (positive) news sentiment signal attractive entry points for traders to enter short (long) positions in the underlying index.

4.2.3 *Combining VIX and news sentiment indicators*

The prior two sections have highlighted the possibility of using extreme levels of investor fear and news sentiment to signal entry points for trading in the S&P 500 Index. However, it may

¹⁴ Analysis using hourly and 5-minute data produces qualitatively similar results.

be possible to improve the reliability of the trade signals by combining the two indicators; index buy signals would occur when there is extremely positive news during periods of low implied volatility, whereas sell signals occur when there is extremely negative news during periods of high investor sentiment.

<Insert Table 10>

Table 10 shows the outcome of 4 possible trading strategies – formed using the rolling quintiles from the prior sections. Strategy A combines the highest levels of investor fear (VIX rank 5) with the most negative news (news sentiment rank 1) and suggests a sell signal is appropriate. At the other end of the spectrum, Strategy D suggests a buy signal through the combination of low levels of VIX (rank 1) with the most positive news (rank 5). Strategy's B and C lie in-between, combining high (low) VIX with positive (negative) news.

Trading opportunities are signalled at a much lower frequency using the combined strategies (Strategy C has the most frequent signals with 210, while Strategy D only has 39 trade initiation signals) but result in profitable trades for long positions in Strategy C and D, and short positions in Strategy A and B, for investment horizons out to 250-days. Since strategies A and B (C and D) both result in positive (negative) returns, irrespective of news sentiment, it appears that the level of investor fear is more important than news in determining market returns.

The evidence provided by the combined trading strategies is consistent with the explanation of Simon and Wiggings [2001] who note that investors tend to have large cash positions in excessively bearish markets (consistent with the environment that would trigger Strategy A) and therefore news can generate large cash inflows into the market, driving returns. On the other-hand, in an excessively bullish market investors are more fully invested and therefore positive news will not bring as much buying power.

4.3 *Out of sample testing of trading strategy*

I seek to validate the trading strategies presented in the prior section by using an out of sample test. I obtain relevant data on stock market returns, changes in VIX, and news sentiment to the end of December 2012¹⁵ which provides a two-year period for the test. Quintiles are again computed using a rolling window, with the low/high levels of VIX and news sentiment for 2011 (2012) based on the data for 2010 (2011). Six strategies are developed on the basis of the strongest

¹⁵ The out of sample test period is constrained by my access to news sentiment information. I believe that the two-year sample period provides sufficient evidence regarding the success of the strategy, particularly when a bootstrapping process is utilized.

results reported in section 4.2. First, I consider strategies based on the lowest ($R = 1$) and highest ($R = 5$) levels of investor fear. Next, I consider the most negative and most positive news sentiment. Finally, I consider two combined strategies; one with low investor fear and positive news sentiment, the other with high VIX and negative positive sentiment. A bootstrapping methodology is employed with 10,000 resamples. Results are reported in Table 11.

<Insert Table 11>

The strategies developed using levels of investor fear are consistently profitable. Going long (short) when VIX is low (high) produce statistically significant returns. The results for news sentiment are mixed. Positive returns follow positive news sentiment but the returns are generally lower than for the VIX strategies. The results for negative news are not conclusive at all, suggesting this is a weak strategy. Finally, the combined strategies are both profitable, with the short position established following high levels of investor fear, coupled with negative news producing the highest returns for periods out to 60-days (equivalent to 3-months). Whilst I have not specifically introduced transaction costs into the analysis of the trading strategies, I note such strategies may be implemented using S&P 500 Index Futures (or E-Mini Futures). S&P 500 futures contracts have very low transaction costs, involving small bid-ask spreads, high levels of liquidity, and low margin requirements.

In summary, VAR analysis finds a strong positive relationship between previous and current period changes in implied volatility and stock returns, while current period and lagged news sentiment has a significant positive (negative) relationship with stock returns (changes in VIX). Such results may be useful for investors looking to find appropriate trade entry points, with extremely low (high) levels of implied volatility signalling attractive opportunities to take long (short) positions in the underlying index. Further, extremely negative (positive) news sentiment signals opportunities to enter short (long) index positions. Combining the entry points signalled by levels of VIX, with those flagged by news sentiment, produces a low frequency trading strategy that results in consistently profitable trades with an average 1-month (3-month) return of up to 5.71% (10.90%). There is some evidence to suggest that the level of investor fear (VIX) is more powerful in forecasting future stock market returns.

5. Conclusion

Investor sentiment indicators such as VIX are frequently mentioned by the media, and utilised by market professionals, to gauge market conditions. At the same time, market participants utilize pre-processed news sentiment indicators, to summarize large amounts of real-time data and to inform trading strategies. This paper examines the relationship between the two types of sentiment indicators and stock market returns.

Investigation of the contemporaneous relationship demonstrates that a significant negative relationship exists between changes in VIX and aggregated news sentiment; the association is stronger during periods of high-volatility, such as during the financial crisis of 2008-2009. There is evidence of asymmetry where the magnitude of the change in VIX is larger during intervals of negative news, although this asymmetry apparently reverses when there is an excessive amount of bad news, possibly because the market 'prices in' the bad news during such periods and is more attentive to positive news. Alternatively, it may be that option traders react aggressively to negative news in low-volatility periods by strongly bidding up implied volatility, but are reluctant to do so in high-volatility trading environments. The previously documented negative and asymmetric relationship between changes in VIX and S&P 500 returns is also confirmed. Investigation of the three factors highlights the existence of a stronger relationship between news sentiment and returns during crisis periods, and suggests that the asymmetry of the relationship between stock returns and changes in VIX holds even when news sentiment is controlled for.

Analysis of market dynamics and cross-dependencies between variables in a VAR model finds a strong positive relationship between previous and current period changes in implied volatility and stock returns, while current period and lagged news sentiment has a significant positive (negative) relationship with stock returns (changes in VIX). Investors may be able to employ the findings to find appropriate trade entry points, with extremely high (low) levels of implied volatility signalling attractive opportunities to take short (long) positions in the underlying index. Further, extremely negative (positive) news sentiment signals opportunities to enter short (long) index positions. Combining the entry points signalled by levels of VIX, with those flagged by news sentiment, produces a low frequency trading strategy that results in consistently profitable trades with an average 1-month (3-month) return of up to 2.88% (16.72%) in out of sample testing. Empirical evidence suggests that the level of investor fear is more important in forecasting stock market returns.

A possible extension of this topic could be the application to individual stocks, or other asset classes such as exchange-traded foreign exchange or government bond futures, although calculation of meaningful implied volatility measures is computationally difficult since large cross-sectional option price datasets are required and the problem of stale-quotes can be difficult to overcome. In addition, it may be interesting to examine whether this framework is applicable in an international context, particularly to those markets, such as Australia, Germany and UK, which already publish implied volatility indices.

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Web-sourced Material:

VIX Methodology - <http://www.cboe.com/micro/vix/vixwhite.pdf>

Market statistics - <http://www.cboe.com/data/marketstats-2010.pdf>

S&P 500 Index - <http://www.standardandpoors.com/indices/sp-500/en/us/?indexId=spusa-500-usduf--p-us->