Positive Feedback Trading in the Options Market

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The cross-correlation between the S&P options and the underlying S&P futures contract is investigated. I use the volatility spread, the difference between implied volatilities of puts and calls, to measure price pressures in the options market. This paper finds that option-implied volatilities are predictable in a statistical sense. Positive one-month and three-month returns on S&P futures are associated with a reduction in the volatility spread measured at the end of the period. This suggests that as the underlying market rises, call prices rise and put prices fall. This type of trading behavior is consistent with a momentum-trading behavior in the options markets

Introduction

Option prices are derived from the underlying asset price and the expected future dispersion in the asset price. Full information about the expected asset price volatility, along with a known asset price, fully determines the price of the contingent claim. Option prices, therefore, should have no information content beyond what the underlying asset prices provide. The true conditional volatility is unobservable. The realized option value and the known asset price, however, can be used to estimate the implied volatility of the option, which reflects the market's forecast of the future volatility of the asset. In efficient markets, implied volatility solely depends of the current asset and option values and thus should have no bearing on past or future asset prices. This study finds evidence of a relationship between returns on the underlying asset during a period and the implied volatility in the option price at the end of the period. This suggests that implied volatilities are at least statistically predictable.

This observation is conceivable if asset prices are correlated over time and across markets. This means that price movements in the underlying asset market at one point in time cause price pressures in the options market at a later time, which suggests that a rise in the asset price triggers trading in the options market. This kind of trading behavior is known as *momentum trading* and is described in the literature extensively by several authors, including DeLong, Shleifer, Summers and Waldmann (1990). DeLong *et al.* introduce *positive feedback (momentum)* traders,

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who buy when prices rise and sell when prices fall and who may have a variety of incentives for this behavior. These incentives include trend chasing, inability to meet margin calls, or portfolio insurance. Informed traders anticipating the behavior of momentum investors alter their trading behavior to profit from the followers' expected reaction. Therefore, informed traders buy more than what the fundamental value would suggest, which reinforces the trading by positive feedback traders and drives the price above its fundamental value. The result of such trading behavior is a positive short-term autocorrelation and long-term mean reversion as prices return to their fundamental values. Hong and Stein (1999) recognize momentum traders as those who condition their trades only on past price changes. This simple trading rule, along with a gradual release of information to news watchers (or informed traders), allows for both short-term under-reaction and long-term over-reaction.

There is an abundance of empirical studies on autocorrelation and cross-correlation patterns of various sorts in equity markets. Jedadeesh and Titman (1993) find evidence of a pattern of short-term momentum followed by a longer-term reversal in stock prices. DeBondt and Thaler (1985 and 1987) find convincing evidence of a long-term over-reaction in stock markets. Lo and MacKinlay (1990) report cross-correlation patterns between large and small firm portfolio returns. This latter study leads a series of other studies that conclude that trading activity in one market segment leads to trading in other market segments with a delay. Chordia and Swaminathan (2000), for example, report evidence of leadership based on turnover volume. As stocks with high trading intensity move, others follow with a delay of up to several weeks.

The notion of interaction between informed and positive feedback traders raises the question of whether these traders use the options and the underlying asset markets. And, if so, which market does each type of trader use? Recent inquiries on the links between the stock and options markets focus on the short-term information transfer between the two markets. These studies investigate the time series relationships between prices of the underlying securities and the options prices, implied prices, or trading volume. The literature is divided on which of the two markets leads. Stephan and Whaley (1990) support the notion that the stock market leads the options market. Manaster and Rendleman (1982), Anthony (1988), and Easley, O'Hara, and Srinivas (1998) find that the options market leads the underlying asset market. The latter study uses a modified measure of trading volume called *positive option volume*, comprising long call and short put trades. Negative option volume contains long put and short call trades. All of these studies probe the short-term relationship between the two markets (intra-day and the next day), as they focus on quick information transfers across markets. Even though the autocorrelation and cross-correlation studies in equity markets cover longer periods of time, the long-term lead-lag relationships in the options and the underlying asset markets have not been investigated.

This study fills the literature gap by investigating the longer-term cross-correlation patterns between the options and the stock markets and tests the momentum-trading hypothesis. I show that trading activity in the S&P futures market leads to price pressures in the options market, which indicates that momentum traders use options to chase movements in the underlying assets. I also show that the information carryover to the options markets eventually reverses the trend as asset values revert to their fundamental values. These results are consistent with the results of Day and Lewis (1992), who find that implied volatilities have some incremental information regarding the weekly S&P 100 index returns.

In recent years evidence has appeared that indicates the implied volatilities on put options are on average, higher than implied volatilities of call options. Harvey and Whaley (1992) find such evidence in options on the S&P 100 index, and Yadav and Pope (1994) report similar results for options on stock index futures in the U.K. Although the underlying causes of this difference in implied volatilities are not readily apparent, Harvey and Whaley suggest a portfolio insurance story. Because buying index puts is a convenient and inexpensive form of portfolio insurance, the resulting price pressure may cause puts to be expensive relative to calls. According to this theory, the implied volatility of put options persistently dominates the implied volatility of call options.

In order to investigate autocorrelation and cross-correlation patterns in the two markets this study examines the lead-lag relationship between prices of the underlying security and the implied volatilities of the options. Following Harvey and Whaley, I use the implied volatility difference as an indicator of pressure in the options market. This paper departs from Harvey-Whaley and examines the multivariate time series characteristics of the implied volatilities of puts and calls. The results show evidence to support the notion of positive feedback trading in the S&P 500 options market. I find that developments in the underlying security market (the S&P 500 futures) cause price pressures in the derivative security market for up to three months.

Hypotheses

If positive feedback traders of the type described by DeLong *et al.* use the options markets for their speculative trading, then movements in the options market follow price changes in the underlying asset market. If, on the other hand, informed traders use the options market transactions, then the options market would lead the underlying security market.

To measure price pressures in the options market I use observed implied volatilities in the call and put options prices. When there is positive news, speculative traders buy calls and/or sell puts, which causes a positive pressure in the options market by bidding up the call prices and putting downward pressure on put prices. These forces cause the implied volatility on calls to rise and implied volatility of puts to decline. I use the volatility spread (put volatility minus call volatility) to measure this pressure. A positive pressure will cause the volatility spread to narrow, and a negative pressure will widen it. My primary hypothesis is whether the volatility spread is time varying and related to the movements in the underlying market.

Define the volatility spread as $\sigma_{d,t} = \sigma_{p,t} - \sigma_{c,t}$, where σ_{pt} and σ_{ct} are the average implied volatility for put and call contracts at time t, respectively. Averages are calculated across all option contracts for which valid prices are available at time t. The model that I test is the following VAR model, similar to that which several cross-correlation studies use:

$$(1)\ \sigma_{d,t} = \alpha_1 + \sum_{i=1}^{n} \gamma_i R_{\tau,t-i} + \theta_1 \sigma_{d,t-1} + \xi_t$$

$$(2)\ R_{\tau,t} = \alpha_2 + \sum_{j=0}^{m} \beta_i \sigma_{d,t-j} + \theta_2 R_{\tau,t-1} + \nu_t \quad \text{for } t = 1, \ldots T$$

where:

$\sigma_{d,t}$ = The volatility spread in the last trading day of the month;
$R_{\tau,t-i}$ = The returns on the S&P 500 index futures in the preceding period;
$R_{\tau,t}$ = The return in the subsequent period;
$\sigma_{d,t-j}$ = The lagged values of the volatility spread.

If momentum traders use the options market, they buy calls and sell puts when the underlying market rises. When the assets market falls, they sell calls and buy puts. The resulting price pressure would induce a negative relationship between lagged returns in the underlying asset market ($R_{\tau,t-i}$) and the volatility spread ($\sigma_{d,t}$) in the options market at time t. Negative γ_i, thus, supports the notion of momentum trading in the options markets.

In equation (2), β_i represents the measured effect of the volatility spread on subsequent observed returns in the asset market. If there is any information transfer from the options to the stock market, then β_i will be significant. If momentum traders choose the stock market instead, an increase in volatility spread (as informed traders buy puts and/or sell calls), will be followed by selling pressure in the stock market. This would produce significant negative β_i coefficients.

In both equations the lagged values of the dependent variable are included to remove potential biases caused by autocorrelation patterns, as several studies report evidence to support autocorrelation patterns in equity markets (e.g., Jegadeesh and Titman).

If momentum trading is strong enough to reverse the process, then short-term momentum will be followed by a longer-term reversion in the stock market, and speculative activity by momentum traders becomes a stabilizing force. Jegadeesh and Titman find some evidence to support this notion in equity markets. If this is the case, then a positive correlation between the volatility spread and subsequent asset market returns is expected. In other words, a low (high) volatility spread, indicating a positive (negative) pressure in the options, will be followed by a subsequent negative (positive) return in the stock market in the subsequent periods.

Because it is not clear what time horizons the constant τ in equations (1) and (2) should take, I run tests using different values for these time horizons. Accordingly, in the empirical results that follow, spot market returns used in regressions (1) and (2) span from one month to one year. This time frame is consistent with the results found by Jegadeesh (1990) in equity markets.

Data and Methodology

The options used in this study are the options on the S&P 500 futures contract that trade on the Chicago Mercantile Exchange (CME). The data on options and futures prices were provided by the CME. I use Black's (1976) model to calculate implied volatilities. The Eurodollar deposit rates provided by the Division of International Finance of the Federal Reserve System are used as the risk free rate in the calculation of implied volatilities. In cases where a Eurodollar rate that corresponds exactly with an option's maturity was not available, I linearly interpolated the two nearby Eurodollar rates to estimate the appropriate risk-free rate.

The options database used in this study covers calendar years 1985-1994. The volatility spread is calculated at the end of each month using the month-end closing prices. The volatility spread at the end of period t is calculated as the difference between the simple average implied volatility of calls and the corresponding average for puts, each averaged across all contracts for which valid closing prices are available. Regression coefficients are estimated using ordinary least squares (OLS), and Newey-West (1987) standard errors are used to adjust for heteroskedasticity and autocorrelation caused by overlapping observations.

Harvey and Whaley raise two potentially important issues regarding the calculation of implied volatilities from observed option prices. Both of these issues arise from the use of closing option prices. First, there is a 15-minute time difference between the closing time of the options market (3:15 PM CST) and the closing time of the underlying futures market (3:00 PM CST). This study minimizes the impact of this 15-minute time and information difference by using monthly observations. The other problem is the bid-ask bounce, as the last transaction price of the day may be a bid or an ask price. To calculate the implied volatility, following Harvey and Whaley, I use multiple option transactions and include the closing prices of all option contracts traded on the last day of each month.

Empirical Results

Figures 1 through 3 show the behavior of implied volatility for calls, puts, and the volatility spread during the sample period. The graphs indicate that the implied volatility of puts is larger than the implied volatility of calls, and the volatility spread is always greater than zero. This is consistent with the findings of Harvey and

Whaley and Yadav and Pope. The two most pronounced spikes in the volatility spread occur in October-November 1987 and in November 1990. The first spike occurs after the 1987 crash, at which time both put and call implied volatilities spike, and the surge of put options is slightly larger than that of calls. The second spike occurs during the Gulf War at which time both volatilities increase moderately. Due to the dominance of put volatility, the resulting spike in volatility spread is more pronounced. Both spikes occur during times of high uncertainty in financial markets, so it is not surprising to see puts become more expensive relative to calls.

Table 1 presents the basic statistics for the sample. σ_a is the simple average of implied volatility for all calls and puts. σ_d is the volatility spread or the difference between (the average) implied volatilities of puts and calls. The average volatility spread over the 10-year period is about 0.10, consistent with the casual observation I made in the graphs. This result, which confirms the findings of Harvey and Whaley, is interesting, as the volatility of puts and calls on the same underlying asset with similar expiration date should be about the same. Harvey and Whaley propose a portfolios insurance theory to explain why put implied volatility is higher than call implied volatility. Because put options provide an inexpensive means of hedging a long portfolio of assets, they receive a premium relative to the calls. Regardless of why the volatility spread is consistently positive, it is obvious the implied volatilities reflect price pressures in the options market. R_1, through R_{12}, are the subsequent returns on the S&P futures contracts over the following month and up to a year. SD represents the simple standard deviation of the variable and ρ is the first-order autocorrelation of the variable. The average implied volatility of puts and calls (σ_a) and long-term returns are autocorrelated. These are expected, as there is a large degree of overlap between adjacent observations.

Table 2 presents the results of regression equation (1), using one- to 12-month S&P futures returns as explanatory variables. The lagged values of the volatility spread also are included in alternate equations. The estimated coefficients for these terms are always positive, significant, and consistent for various return horizons. This indicates a strong positive autocorrelation in volatility spreads, which is expected as they represent market forecasts of infinite horizon volatilities. The volatility spreads also are autocorrelated, which confirms Harvey and Whaley's findings.

Figure 1—Time Series Plot of Put Options Implied Volatility

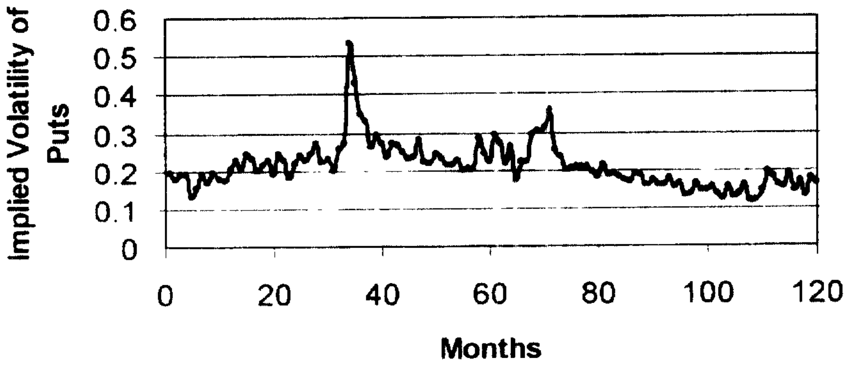

Figure 2—Time Series Plot of Call Options Implied Volatility

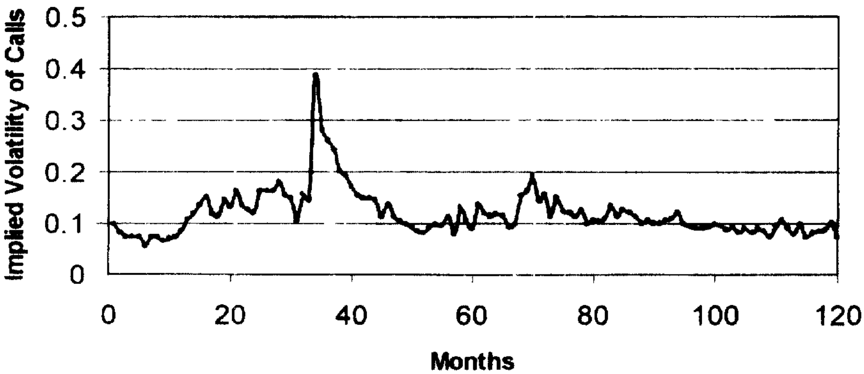

Figure 3—Time Series Plot of Volatility Spread

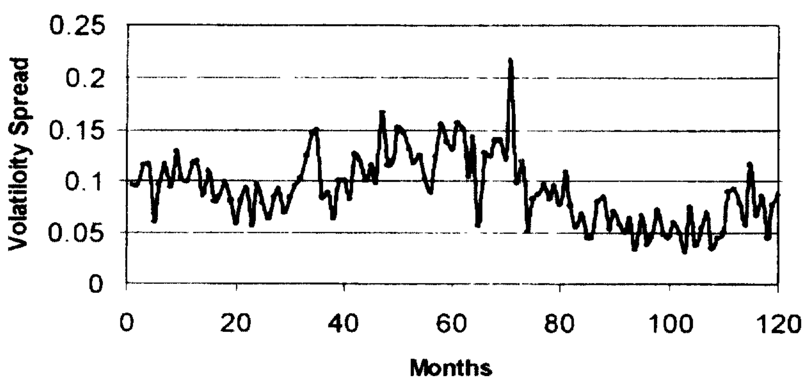

Table 1—Basic Statistics for S&P 500 Option Implied Volatilities and Returns on the Underlying Futures Contract in the Sample Period

Variable	N	Mean	Median	SD	Skewness	ρ	Max	Min
σ_a	120	0.1694	0.1566	0.0615	2.5711	0.7894	0.4918	0.0956
σ_d	120	0.1024	0.0949	0.0505	2.0125	0.5708	0.3390	0.0343
R_1	120	0.0090	0.0110	0.0438	-1.0615	-0.0078	0.1318	-0.2176
R_3	120	0.0279	0.0296	0.0739	-1.2719	0.6147	0.2045	-0.3017
R_6	120	0.0569	0 0489	0.0990	-0 2257	0 7689	0.3121	-0.2061
R_{12}	120	0.1195	0 1127	0.1292	-0.1466	0.8387	0 3913	-0.2070

σ_a and σ_d are the mean volatility of all puts and calls and the volatility spread, respectively. R_1 through R_{12} are the returns on the underlying futures contract over a one-month to twelve-month period SD is the standard deviation and ρ is the first-order autocorrelation of the series

The returns on the underlying asset seem to be correlated with the volatility spreads at the end of the period for up to six months. Once the autocorrelation term is introduced, the coefficient remains significant only for the one-month and three-month returns. In both cases the coefficient is negative, which supports the momentum-trading story. Volatility spreads drop when return on the S&P futures in the preceding period is positive, which implies that an upward movement in the asset market causes the put prices to drop and call prices to rise. This result is consistent with the prediction that positive feedback traders trade in the options market after the futures prices have risen. On the other hand, puts tend to become relatively more expensive and calls less expensive after the underlying market has fallen. These results suggest that momentum trading in the options market continues for up to three months.

Table 3 reports the regression estimates for equation (2) using one- to 12-month returns as dependent variable. I use contemporaneous and lagged values (up to five periods) of the volatility spread as independent variables. In alternate equations, I also include lagged values of the dependent variables to capture the autocorrelation of returns in the futures market. These autocorrelation terms are all insignificant and do not suggest any serial correlation patterns. The β_is are only sporadically different from zero. The coefficients for the first and second order lags are significant for some of the return horizons. These coefficients are almost always positive, which suggests some degree of reversal.

As discussed previously, there are two large spikes in the volatility spread (Figure 3). It is possible that the results obtained in Table 3 are driven or biased by a few extreme observations such as these two spikes. To address this issue in Table 4, I modify the regression equation (2) to include a dummy variable that takes a value of 1 when the volatility spread is greater than 0.2 and zero otherwise. There are six such observations, two in 1987 (October and November), and four in 1990 (February, August, September, and November). This model also includes the contemporaneous and two lagged values of the volatility spread, the first-order autocorrelation term. The estimated coefficients for the dummy variable are always significant and positive, which suggests a clear shift in the intercept during these extreme events.

Table 2—OLS Estimates of the Regressions of Volatility Spread on Lagged Spot Market Returns

$$\sigma_{d,t} = \alpha_i + \sum_{i=1}^{3} \gamma_i R_{\tau,t-i} + \theta_i \sigma_{d,t-1} + \xi_t .$$

Length of Lag	Intercept	R_{t-1}	R_{t-2}	R_{t-3}	$\sigma_{d,t-1}$
1 Month	0.111	-0.401	-0.331	-0.133	
	(9.50)	(-3 11)	(-4 13)	(-1.36)	
	0 052	-0.387	-0.118	0 042	0 537
	(3.62)	(-3 28)	(-1.49)	(0 46)	(5.49)
3 Months	0.113	-0 302	-0.098	0.021	
	(7 94)	(-2.80)	(-1.31)	(0.42)	
	0.061	-0.175	-0.031	0.015	0 465
	(3 23)	(-1.98)	(-0.68)	(0.46)	(4 17)
6 Months	0 113	-0.200	-0 005	0.007	
	(7 02)	(-2 35)	(-0.08)	(0.11)	
	0.055	-0.097	-0 023	0.443	0.512
	(3 05)	(-1 66)	(0.07)	(0.12)	(4.56)
12 Months	0.11	-0.092	0 034	-0.013	
	(4.18)	(-1 5)	(0.5)	(-0.17)	
	0.048	-0.036	0.020	-0.012	0 562
	(2.35)	(-1 02)	(0 51)	(0.32)	(5 43)

The numbers in parentheses are t-statistics and are calculated by using the Newey-West standard errors

I interpret these results as an improvement in model specification because they effectively remove some outlying observations from the sample. The lagged S&P returns also are positive and significant, which suggests a continuation pattern in three- to 12-month S&P futures returns. The volatility spread seems to be positively correlated to the subsequent returns on the underlying asset in the next three to six months, which supports a momentum reversal. DeLong *et al.* predict that positive feedback trading has a stabilizing effect. Several recent studies have reported a negative reverse causation in the equity markets. For example, Chordia and Swaminathan (2000) report that while return on high volume stocks is positively correlated with returns on low volume stocks in the subsequent period, the reverse causation is usually negative.

Summary

This paper investigates the information transfer between the S&P futures options market and the underlying S&P 500 futures market over time horizons of up to one year. I search for evidence of positive feedback trading by examining the lead-lag relationships between the returns on the S&P 500 futures and the volatility spread in the options market This paper also investigates the possibility of momentum reversal to determine if the activities of positive feedback traders in the options market drive the prices beyond their fundamental value and cause a reversal in the underlying asset market.

Table 3—OLS Estimates of the Time Series Regressions of S&P 500 Returns on Lagged Volatility Spreads

$$R_{\tau,t} = \alpha_2 + \sum_{j=0}^{5} \beta_j \sigma_{d,t-j} + \theta_2 R_{\tau,t-1} + \nu_t$$

Dependent Variable	Intercept	$\sigma_{d,t}$	$\sigma_{d,t-1}$	$\sigma_{d,t-2}$	$\sigma_{d,t-3}$	$\sigma_{d,t-4}$	$\sigma_{d,t-5}$	R_{t-1}
R_1	-0.004	-0.097	0.049	0.173				
	(-0.73)	(-1.13)	(0.581)	(2.63)				
	-0.002	-0.139	0.061	0.193				-0.082
	(-0.28)	(-1.87)	(0.78)	(2.75)				(-0.65)
R_3	-0.007	0.081	0.272	0.225	-0.053	-0.192	0.009	
	(-0.46)	(0.95)	(3.49)	(1.99)	(-0.52)	(-2.37)	(0.07)	
	0.007	0.018	0.200	0.205				-0.126
	(0.04)	(0.11)	(1.46)	(1.56)				(0.75)
R_6	0.008	0.281	0.186	0.201	-0.034	-0.217	0.064	
	(0.27)	(1.96)	(1.65)	(1.99)	(-0.28)	(-2.98)	(0.56)	
	0.040	0.193	0.096	0.120				-0.222
	(1.03)	(1.02)	(0.71)	(1.25)				(-1.75)
R_{12}	0.055	0.193	0.357	0.222	0.017	-0.025	-0.134	
	(0.99)	(1.13)	(2.06)	(2.00)	(0.12)	(-0.23)	(-0.5)	
	0.124	0.060	0.251	0.211				-0.33
	(1.9)	(0.27)	(1.51)	(1.91)				(-1.56)

The numbers in parentheses are t-statistics and are calculated using the Newey-West standard errors

The results indicate that returns in the underlying market lead the movements in the options market for up to three months. Prior one-month and three-month returns on S&P futures contracts have explanatory power over volatility spreads observed at the end of the period. This means that buying in the asset market over a one- to three-month period is associated with upward pressure on calls and downward pressure on puts. This positive pressure, triggered by long call and short put trades, increases the implied volatility for calls and lowers the implied volatility for puts, thus reducing the volatility spread at the end of the period. Inversely, the downward movement in the stock market creates a negative pressure (resulting from short call and long put trades), increasing the volatility spread. I find this result consistent with the prediction of De Long, Shleifer, Summers, and Waldmann (1990).

The stabilizing effect of feedback trading also is tested, i.e., whether the activities in the options market are strong enough to cause a reversal in the underlying market. The results, after controlling for extreme price changes in the S&P market, support the existence of such a feedback effect. The end of period observed volatility spreads positively affect the subsequent returns in the S&P futures market. This means that an increase (decrease) in call (put) prices is followed by a decline in the S&P returns in the subsequent periods. This result supports the reversion hypothesis and the empirical evidence reported for equity markets by Jegadeesh and Titman (1993) and Chordia and Swaminathan (2000). Given the predictive ability of the volatility spread for spot market returns, this spread may be viewed as the barometer

Table 4—OLS Estimates of Time Series Regression of S&P 500 Returns on Lagged Volatility Spread with a Spike Dummy

$$R_{i,t} = \alpha_2 + \sum_{i=0}^{2} \beta_i \sigma_{d,t-i} + \theta_2 R_{i,t-1} + D + \nu_t .$$

Dependent Variable	Intercept	σ_{dt}	σ_{dt-1}	σ_{dt-2}	R_{t-1}	Spike Dummy
R_1	-0.009	-0.108	0.060	0.107	-0.037	0.114
	(-1.49)	(1.54)	(0.60)	(1.85)	(-0.31)	(8.71)
R_3	-0.022	0.483	0.048	-0.118	0.665	0.105
	(-2.26)	(3.12)	(0.43)	(-2.09)	(7.83)	(10.57)
R_6	-0.015	0.433	-0.053	-0.582	0.735	0.142
	(-1.08)	(3.09)	(-0.51)	(-[illegible].00)	(12.02)	(13.95)
R_{12}	-0.007	0.373	0.175	-0.147	0.833	0.128
	(-0.42)	(1.72)	(0.742)	(-1.64)	(16.78)	(7.8)

The numbers in parentheses are t-statistics and are calculated using the Newey-West standard errors

of investment sentiment. Derman, Kani, and Zou (1996) suggest using the volatility spread as a simple way of capturing the market sentiment.

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