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Unraveling the Enigmatic Interplay: Options Market Activity, Investor Mood Spectrums, and Stock Return Volatility Intricacies

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ABSTRACT

This study examines S&P 500 firms from 2008 to 2018 and uncovers a complex, non-linear relationship between the options market call-put ratio and investor sentiment that challenges assumptions of linearity. The link between options trading and underlying volatility appears disrupted during moderate pessimism but reemerges forcefully amid extreme negative sentiment. This suggests limits to arbitrage and information opacity enable sentiment transmission into prices. Notably, firm size moderates this relation, with larger firms partially insulated from sentiment-driven volatility extremes. Our findings challenge paradigms of simplistic sentiment-volatility connections, indicating the strength of such links depends on the sentiment regime, firm characteristics, and investor composition. Options market signals require carefully disentangling the prevalent investor mood and firm-specific informational frictions to interpret properly. Finally, this study enhances understanding of the intricate dynamics through which investor sentiment manifests in volatility dynamics.

Keywords: Investor sentiment, Open interest, Price volatility, Information transparency

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1. Introduction

A long-standing debate in financial economics considers whether asset prices reflect fundamental value or are also driven by noise and sentiment unrelated to fundamentals. On one side, the Efficient Market Hypothesis (EMH) argues prices fully incorporate available information, leaving little room for noise (Fama, 1970). However, an opposing view emerged in behavioral finance holding that irrational noise traders who make decisions biased by emotions can move prices away from intrinsic value (Black, 1986; De Long, Shleifer, Summers, & Waldmann, 1990). We review these conflicting perspectives and describes a study examining how investor sentiment impacts trading behavior and stock price volatility.

According to Noise Trader Theory, market participants influenced by noise and sentiment may generate deviations between prices and fundamental value (Black, 1986). Supporting this view, Kahneman and Tversky (1979) demonstrate individual investors frequently make irrational choices biased by cognitive limitations and emotions. Moreover, limits to arbitrage can allow mispricing to persist if arbitrageurs lack sufficient capital or exhibit irrational biases themselves (Shleifer & Vishny, 1997). Consequently, an extensive literature argues investor sentiment significantly impacts financial markets (De Long et al., 1990; Lee, Shleifer, & Thaler, 1991).

While theoretical and empirical research demonstrates investor sentiment affects trading behavior, open questions remain regarding the mechanism and boundary conditions of this influence. Specifically, the relation between sentiment and measures of trading activity such as volume and open interest is not fully characterized. Furthermore, moderators like firm size may impact whether sentiment translates into stock price changes. This study pursues two primary objectives – (1) establish correlations between investor sentiment and trading activity including volume and open interest and (2) test firm size as a moderator of the sentiment-price volatility relation. Derived from noise trader theory and behavioral finance, the overarching hypothesis is that sentiment has a larger impact on trading and prices for smaller, difficult to value firms relative to larger firms.

To test these hypotheses, investor sentiment data from Baker and Wurgler (2006) is gathered along with market trading activity variables including call-put ratios. Sentiment is then related to concurrent and lagged trading activity to demonstrate correlation over time. Next, these sentiment measures are interacted with firm size to show larger mitigating effects for larger firms.

Demonstrating the effect of sentiment on market trading behavior and stock volatility will advance the theoretical debate regarding efficient markets. Moreover, establishing firm size as a moderator provides ideas for future research into boundary conditions and has practical implications for investors concerned about protecting against sentiment-driven mispricing.

The remainder of the paper is organized as follows. Section 2 provides a review of relevant literature on investor sentiment and market efficiency and conducts the research hypotheses. Section 3 presents the data, variable measures, and empirical methodology. Section 4 discusses the results, and Section 5 presents the conclusions.

2. Literature Review and Hypothesis Development

2.1 Investor Sentiment and Market Behavior

Extensive prior research demonstrates the ability of investor sentiment to influence financial markets (Black, 1986; De Long et al., 1990; Lee et al., 1991). Specifically, sentiment refers to investors' optimistic or pessimistic views regarding future asset price performance (Baker &

Wurgler, 2007; Brown & Cliff, 2004). As sentiment fluctuates, it impacts trading behavior and can push prices temporarily away from intrinsic value (De Long et al., 1990). Consequently, predictability in asset returns emerges, reflecting mispricing caused by waves of irrational sentiment (Baker & Wurgler, 2007).

Many methods exist to proxy for investor sentiment using market data. For example, closed-end fund discounts widen when sentiment turns negative (Swaminathan, 1996), trading volume rises with optimistic sentiment (Baker & Stein, 2004), and options positioning shifts based on future return expectations (Dennis & Mayhew, 2002). One such market-based sentiment measure relies on the ratio between the number of purchased call and put options, known as the put-call ratio (PCR). When the ratio decreases as more calls are purchased relative to puts, it indicates rising optimism. Simon and Wiggins (2001) documents a negative relation between put-call ratio and future returns on S&P 500 index, supporting PCR as a reliable contrarian sentiment indicator. Prior research demonstrates PCR contains information on broad shifts in investor sentiment (Bandopadhyaya & Jones, 2008).

2.2 Trading Behavior and Return Volatility

Changes in market trading activity impact asset price volatility. Past studies establish a positive association between volume and return volatility (Copeland, 1976; Morse, 1980). Moreover, open interest serves as a proxy for trader positions and opinions (H. Bessembinder, Chan, & Seguin, 1996) and market depth (Hendrik Bessembinder & Seguin, 1993). Increases in open interest can dampen volatility by providing liquidity (Fung & Patterson, 1999), while declines potentially foreshadow the end of a price trend as positions unwind (Floros, 2007).

2.3 Sentiment, Behavior, and Returns

The above strands of literature intersect in examining how investor sentiment may impact trading decisions and asset price changes over time. Prospect theory argues individuals frequently violate expected utility assumptions, making choices influenced by emotion-driven biases (Kahneman & Tversky, 1979). Thus, waves of sentiment can push prices away from fair value (De Long et al., 1990). This motivates the following hypotheses:

Hypothesis 1: Investor sentiment positively correlates with the call-put ratio.

Hypothesis 2: The relation between open interest and return volatility depends on the prevailing investor sentiment.

Moreover, prior theory and evidence suggest the impact of sentiment varies across assets. Stocks difficult to value and more prone to information asymmetry exhibit greater sentiment sensitivity (Baker & Wurgler, 2007). This implies:

Hypothesis 3: Smaller, higher-growth firms demonstrate a stronger relation between sentiment, trading behavior, and return volatility.

3. Data and Research Methodology

3.1 Research Data

This study utilizes a comprehensive sample of 245 constituent firms of the Standard & Poor's 500 index (S&P 500) over the ten years from 2008-2018, compiled from the Datastream database. The total dataset encompasses 655,165 daily observations across these firms. Investor sentiment data originates from the monthly index constructed by Baker and Wurgler (2006), obtained from Professors Wurgler and Zhou's data website.

The empirical analysis unfolds in three stages. First, we estimate OLS regression models relating sentiment to trading activity, including volume and open interest. Separate models test

positive and negative sentiment periods based on the sign of the sentiment index (Equations 1-3). Next, we divide the full sentiment index into decile groups and include interaction terms between open interest and these sentiment partitions to allow differential impacts on return volatility (Equation 4, Table 1). Finally, we construct comparable samples of S&P 500 and Dow Jones Industrial Average (DJIA) firms over the sample timeframe. The goal is to examine whether firm size moderates the influence of sentiment as trading behavior translates into stock price changes. This final test provides new evidence for Baker and Wurgler (2007) hypothesis that sentiment sensitivity decreases with easier intrinsic value assessment.

3.2 Variable Measures

We define and measure the key variables employed in our study, focusing on both dependent and independent variables. These variables are critical components of our research.

3.2.1 The absolute value of the constituent stock's two-day return (ABSR)

$\boldsymbol{A}BSR_{i,t}$ corresponds to the absolute value of the percentage change in the stock price of firm *i* over a two-day period in month *t*. It is calculated as:

$$ABSR_{i,t} = \left| \frac{Closing\ \ price_{i,t} - Closing\ \ price_{i,t-1}}{Closing\ \ price_{i,t-1}} \right| \times 100, \quad (1)$$

where $Closing\ \ price_t$ is the closing stock price of firm *i* on day *t*. $Closing\ \ price_{t-1}$ is the closing stock price of firm *i* on the previous trading day, *t-1*. The absolute value function |.| ensures that $ABSR_{i,t}$ captures the magnitude of the two-day return, regardless of whether it is positive or negative.

This measure is used as a proxy for intra-month stock price volatility or variability. A higher value of $ABSR_{i,t}$ indicates greater volatility in the stock price over the two-day period within month *t*.

3.2.2 Call-to-Put ration for open interest (CPOI)

$\boldsymbol{C}POI_{i,t}$ represents the ratio of the total open interest (number of outstanding contracts) for call options relative to the total open interest for put options for stock *i* in month *t*. It is calculated as:

$$CPOI_{i,t} = \frac{Call\ \ open\ \ interst_{i,t}}{Put\ \ open\ \ interst_{i.t}}, \quad (2)$$

where $Call\ \ open\ \ interst_t$ is the total number of call option contracts outstanding for stock *i* at the end of month *t*. $Put\ \ open\ \ interst_t$ is the total number of put option contracts outstanding for stock *i* at the end of month *t*

A higher value of $CPOI_{i,t}$ indicates that market participants have larger open interest positions in call options compared to put options for that stock in month *t*. This is considered to reflect relatively more optimistic sentiment or positioning among options traders. Conversely, a lower $CPOI_{i,t}$ means put open interest exceeds call open interest, suggesting relatively more pessimistic or bearish sentiment.

Therefore, $CPOI_{i,t}$ serves as a measure of the relative optimism or pessimism of options traders for stock i based on their outstanding positions, as stated in the original description.

3.2.3 Investor sentiment index (SENT)

$SENT_{i,t}$ refers to the Baker and Wurgler (2006) investor sentiment index value in month *t*. This is a composite index that measures overall investor sentiment or mood in the stock market based on several underlying proxies such as trading volume, IPO activity, closed-end fund discounts, etc. A higher value of SENT indicates a period of relatively high or optimistic investor sentiment, while a lower value suggests relatively low or pessimistic investor sentiment in that month.

$SENT_{i,t}^{\ 2}$ is simply the square of the sentiment index value in month *t*. It is included to allow for potential non-linear effects of investor sentiment in the empirical models. For example, if the relationship between sentiment and the dependent variable (e.g. options trading activity) is convex, then the squared sentiment term $SENT_{i,t}^{\ 2}$ will capture this non-linearity.

The sentiment index and its square are included as explanatory variables to examine how different levels and potential non-linear patterns of overall investor sentiment impact various metrics related to trading behavior and volatility in the options market.

3.2.4 Call-to-Put ratio for transaction volume in the options markets (CPVM)

The Call-to-Put ratio for transaction volume ($CPVM_{i,t}$) represents the ratio of the total trading volume in call options to the total trading volume in put options for stock *i* during month *t*. It is calculated as:

$$CPVM_{i,t} = \frac{Call\ \ transaction\ \ volume_{i,t}}{Put\ \ transaction\ \ volume_{i,t}}, \tag{3}$$

where $Call\ \ transaction\ \ volume_{i,t}$ is the total number of call option contracts traded for stock *i* in month *t*. $Put\ \ transaction\ \ volume_{i,t}$ is the total number of put option contracts traded for stock *i* in month *t*

A higher value of $CPVM_{i,t}$ indicates that the trading volume was higher for call options compared to put options for that stock and month. This tilt towards relatively more call option volume can suggest a more bullish or optimistic sentiment among traders. Conversely, a lower $CPVM_{i,t}$ means put option trading volume exceeded call option volume, which may reflect more bearish or pessimistic sentiment.

Therefore, similar to the call-put open interest ratio, $CPVM_{i,t}$ serves as a measure of relative optimism or pessimism among options traders, but based on the actual trading volumes rather than open interest levels. Higher call volume versus put volume is interpreted as more optimistic positioning.

3.2.5 Diversity index in transaction volume of the options markets (BIVM)

We use the Blau's index (Blau, 1977) diversity measure for options transaction volume, denoted as BIVM, and it can be defined as:

$$BIVM_{i,t} = 1 - \left[\left(\frac{Call\ \ transaction\ \ volume}{Total\ \ transaction\ \ volume}\right)^2 + \left(\frac{Put\ \ transaction\ \ volume}{Total\ \ transaction\ \ volume}\right)^2\right], \tag{4}$$

where $Call\ \ transaction\ \ volume$ is the total number of call option contracts traded for stock *i* in month *t*. $Put\ \ transaction\ \ volume$ is the total number of put option contracts traded for stock *i* in month *t*. $Total\ transaction\ volume$ is the sum of $Call\ transaction\ volume$ and $Put\ \ transaction\ \ volume$.

The index ranges from 0 to 0.5, with higher values indicating more even balance in volumes between calls and puts. A value closer to 0.5 means the volumes were relatively equal. Lower values mean the volumes were more concentrated in either calls or puts, with 0 indicating all volume was in just one option type.

Consequently, BIVM measures the diversity or dispersion in trading activity across call and put options. Higher diversity suggests more balanced trading interest, while lower diversity implies traders heavily favored one option type over the other in their transactions. This variable allows examining how the distribution of trading volumes, not just relative Call/Put ratios, relates to investor sentiment or other variables of interest.

3.2.6 Diversity index in open interest (BIOI)

This study utilizes the Blau's index (Blau, 1977) diversity measure for options open interest, denoted as BIOI, which can be defined as:

$$BIOI_{i,t} = 1 - \left[\left(\frac{Call\ \ open\ \ interst}{Total\ \ open\ \ interst}\right)^2 + \left(\frac{Put\ \ open\ \ interst}{Total\ \ open\ \ interst}\right)^2\right], \tag{5}$$

where $Call\ \ open\ \ interst$ is the total number of outstanding call option contracts for stock *i* at the end of month *t*. $Put\ \ open\ \ interst$ is the total number of outstanding put option contracts for stock i at the end of month t. $Total\ open\ interst$ is the sum of $Call\ open\ interst$ and $Put\ \ open\ \ interst$.

Similar to Blau's index (Blau, 1977) for transaction volumes, BIOI captures the degree of balance or dispersion in the open interest levels between call and put options for stock *i* in month *t*. The index ranges from 0 to 0.5, with higher values indicating a more even balance in open interest between calls and puts. A value closer to 0.5 means the open interests were relatively equal. Lower values mean the open interest was more concentrated in either calls or puts, with 0 indicating all open interest was in just one option type.

Therefore, BIOI measures the diversity or dispersion in outstanding option contract positions across calls and puts. Higher diversity suggests more balanced positioning, while lower diversity implies traders heavily favored holding positions in one option type over the other. This variable allows examining how the distribution of open interest across calls and puts, not just relative ratios, relates to investor sentiment or other variables of interest in the options market.

3.2.7 The transaction volume increase rate in the options markets (VMIR)

The transaction volume increase rate in the options markets, denoted as $VMIR_{i,t}$, can be defined as:

$$VMIR_{i,t} = \frac{Transaction\ \ volume_t - Transaction\ \ volume_{t-1}}{Transaction\ \ volume_{t-1}}, \tag{6}$$

where $Transaction\ \ volume_t$ is the combined trading volume of call and put options for stock *i* in month *t*. $Transaction\ \ volume_{t-1}$ is the combined trading volume of call and put options for stock *i* in the previous month *t-1*. $VMIR_{i,t}$ measures the monthly percentage change or growth rate in the overall options trading volume for a given stock *i*.

A positive value indicates the total volume increased from the previous month, while a negative value means the volume decreased compared to the prior month. This metric allows examining

how changes in overall trading activity levels in the options market relate to other variables like investor sentiment or subsequent stock return volatility.

Rapid increases in VMIR could potentially signal shifting investor expectations or sentiment that is driving higher options volume. Conversely, declines may coincide with periods of lower investor interest or conviction about the future direction of the underlying stock. By including VMIR as an explanatory variable, the models can assess whether monthly fluctuations in overall trading volumes across calls and puts provide incremental predictive power for the dependent variables of interest.

3.2.8 Open interest increase rate (OIIR)

The open interest increase rate, denoted as $OIIR_{i,t}$, can be defined as:

$$OIIR_{i,t} = \frac{Open\ \ interst_t - Open\ \ interst_{t-1}}{Open\ \ interst_{t-1}}, \tag{7}$$

Where $Open\ \ interst_t$ is the combined total of outstanding call and put option contracts for stock *i* at the end of month *t*. $Open\ \ interst_{t-1}$ is the combined open interest of calls and puts for stock *i* at the end of the previous month *t-1*. $OIIR_{i,t}$ represents the monthly percentage change or growth rate in the aggregate open interest across all call and put options on a given stock *i*.

A positive value of OIIR indicates that the total open interest increased from the prior month, suggesting more new positions are being opened than closed out. A negative value means the total open interest decreased compared to the previous month, implying more options positions are being closed than opened. This variable captures how quickly or slowly the overall outstanding interest in options contracts is expanding or contracting over time.

Changes in OIIR could reflect shifting sentiment, expectations or positioning among options traders. Rapidly rising open interest may suggest increasing speculative interest or hedging demand, while declining open interest could mean waning conviction. By including OIIR in the empirical models, the analysis can evaluate whether monthly fluctuations in the growth of total open interest across all options has explanatory power for other market variables of interest.

3.3 Empirical Model

The following empirical models explore the relationship between investor sentiment and various measures of options trading activity and stock return volatility. The models incorporate the Baker and Wurgler (2006) investor sentiment index and different indicators derived from call-and-put option contracts' open interest and trading volume. The aim is to examine how sentiment influences options market dynamics and stock return volatility.

The first empirical model examines the relationship between investor sentiment and the call-to-put ratio for open interest (CPOI), which captures relative optimism through the positioning of options traders. It is specified as:

$$CPOI_{i,t} = \beta_0 + \beta_1 SENT_{i,t} + \beta_2 {SENT_{i,t}}^2 + \beta_3 CPVM_{i,t} + \beta_4 CPOI_{i,t-1} + \varepsilon_{i,t}, \tag{8}$$

where $CPOI_{i,t}$ represents the call-to-put ratio for open interest for stock *i* in month *t*, capturing relative optimism through the positioning of options traders. $SENT_{i,t}$ refers to Baker

and Wurgler (2006) investor sentiment index and $SENT_{i,t}{}^2$ is its square. $CPVM_{i,t}$ represents the Call-to-Put ration for transaction volume.

The second model uses the Blau (1977) index to measure dispersion across call and put open interest (BIOI) and transaction volume (BIVM):

$$BIOI_{i,t} = \beta_0 + \beta_1 SENT_{i,t} + \beta_2 SENT_{i,t}{}^2 + \beta_3 \mathrm{BI}VM_{i,t} + \beta_4 \mathrm{BIOI}_{i,t-1} + \varepsilon_{i,t}, \quad (9)$$

where $BIOI_{i,t}$ stands for Blau (1977) index measuring dispersion across call and put open interest ($\text{Blau's index} = 1 - \sum_{k=1}^{k} P_i^2$) for stock *i* in month *t*. $BIVM_{i,t}$ stands for Blau's index (Blau, 1977) diversity index in transaction volume($\text{Blau's index} = 1 - \sum_{k=1}^{k} P_i^2$), denotes the average degree of transaction volume for calls and puts. The definitions of $SENT_{i,t}$ and $SENT_{i,t}{}^2$ are the same as equation (8).

The third model looks at the monthly growth rate in total options open interest (OIIR):

$$OIIR_{i,t} = \beta_0 + \beta_1 SENT_{i,t} + \beta_2 SENT_{i,t}{}^2 + \beta_3 VMIR_{i,t} + \beta_4 OIIR_{i,t-1} + \varepsilon_{i,t}, \quad (10)$$

where $OIIR_{i,t}$ corresponds to the monthly growth rate in total open interest across call and put contracts for stock *i* in month *t*. $VMIR_{i,t}$ is the transaction volume increase rate. The definitions of $SENT_{i,t}$ and $SENT_{i,t}{}^2$ are also the same as equation (8).

Next, we estimate stock return volatility regressions with sentiment interactions:

$$ABSR_{i,t} = \alpha_1 + \beta_1 OIIR_{i,t} + \beta_2 BIOI_{i,t} + \beta_3 VMIR_{i,t} + \beta_4 BIVM_{i,t} + \varepsilon_{i,t}, \quad (11)$$

where $ABSR_{i,t}$ corresponds to the absolute two-day return for stock *i* in month *t*, proxying for intra-month price volatility. Investor sentiment deciles classification results and variable definitions on the following table:

Table 1. Variable definitions and summary statistics

Presents definitions and descriptive statistics for the key variables used in the regression models including sentiment indices, trading activity measures, and returns.

Variable	Definition	Measurements
$ABSR_{i,t}$	Absolute value of the constituent stock's two-day return	$\left\lvert \frac{Closing\ \ price_t - Closing\ \ price_{t-1}}{Closing\ \ price_{t-1}} \right\rvert \times 100$
$CPOI_{i,t}$	Call-to-Put ratio for open interest	$\frac{Call\ \ open\ \ interst_t}{Put\ \ open\ \ interst_t}$
$CPVM_{i,t}$	Call-to-Put ratio for transaction volume in the options markets	$\frac{Call\ \ transaction\ \ volume_t}{Put\ \ transaction\ \ volume_t}$
$BIOI_{i,t}$	Blau's index (Blau, 1977) diversity index in open interest	$1 - \left[\left(\frac{Call\ \ open\ \ interst}{Total\ \ open\ \ interst}\right)^2 + \left(\frac{Put\ \ open\ \ interst}{Total\ \ open\ \ interst}\right)^2\right]$

$BIVM_{i,t}$	Blau's index (Blau, 1977) diversity index in transaction volume of the options markets	$1-\left[\left(\frac{Call\ \ transaction\ \ volume}{Total\ \ transaction\ \ volume}\right)^2+\left(\frac{Put\ \ transaction\ \ volume}{Total\ \ transaction\ \ volume}\right)^2\right]$
$OIIR_{i,t}$	Open interest increase rate	$\frac{Open\ \ interst_t-Open\ \ interst_{t-1}}{Open\ \ interst_{t-1}}$
$VMIR_{i,t}$	Transaction volume increase rate in the options markets	$\frac{Transaction\ \ volume_t-Transaction\ \ volume_{t-1}}{Transaction\ \ volume_{t-1}}$
$SENT_{i,t}$	Investor sentiment index	Baker and Wurgler (2006)

Table 2. Investor sentiment partition by deciles

Summarizes the distribution of monthly sentiment index values across deciles, which are utilized to allow for non-linear effects in return volatility tests.

Group	Lower limit	Upper limit	Range
1(Low)	-0.8939	-0.6484	0.2455
2	-0.6484	-0.2761	0.3723
3	-0.2761	-0.2070	0.0691
4	-0.2070	-0.1343	0.0727
5	-0.1343	-0.0856	0.0487
6	-0.0856	-0.0533	0.0323
7	-0.0533	0.0079	0.0612
8	0.0079	0.0698	0.0619
9	0.0698	0.1298	0.0600
10(High)	0.1298	0.3842	0.2544

4. Empirical Results

4.1 Empirical Results

Tables 3 and 4 present findings regarding the impact of investor sentiment on options trading activity. We focus our discussion on the economic and statistical significance of the negative sentiment results in Table 4 given the more pronounced effects.

4.1.1 Positive sentiment

Interestingly, the positive sentiment period does not exhibit statistically significant relations between market sentiment and trading behavior including the call-put ratio (CPOI). One potential explanation lies in the relative restrictiveness of the sample's sentiment distribution. As Table 1 shows, the highest sentiment observation corresponds to a z-score of only 0.38, indicating fairly muted peaks in optimism. With such limited upside variation, the trading measures may lack sensitivity to small positive shifts. However, Table 5 verifies that even conditioning on an equal negative sentiment range, no significant CPOI effect appears. This implicates more complex explanations than just limited sentiment variability. Additionally, we examine whether sentiment affects other trading activities and find that sentiment is hard to affect an investor's trading activity when the range of sentiment is limited.

Table 3. Impact of positive sentiment on trading behavior – S&P 500

The sample period corresponds to months classified as exhibiting positive investor sentiment. Positive Sentiment presents SENT is more than zero. CPOI denotes the call-put open interest ratio. BIOI stands Blau (1977) index of open interest dispersion across calls and puts. OIIR presents growth rate of aggregated open interest. SENT is Baker and Wurgler (2006) investor sentiment index. CPVM denotes call-put trading volume ratio. BIVM stands Blau (1977) index for volume. VMIR presents growth rate of total trading volume. LAG- is the lagged independent variable. Superscripts *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Variables	CPOI	BIOI	OIIR
SENT	0.007 (0.627)	-0.001 (0.300)	0.348 (0.525)
SENT2	-0.048 (0.240)	0.003 (0.114)	-0.393 (0.802)
CPVM	0.002*** (<0.001)		
LAG-CPOI	0.969*** (<0.001)		
BIVM		0.008*** (<0.001)	
LAG-BIOI		0.974*** (<0.001)	
VMIR			0.002*** (<0.001)
LAG-OIIR			-0.063*** (<0.001)
Constant	0.035*** (<0.001)	0.009*** (<0.001)	0.168*** (<0.001)
N	193,276	197,326	197,103
Adjusted R^2	0.962	0.963	0.020

4.1.2 Negative sentiment

Table 4 shows intriguing non-linear dynamics between sentiment and trading activity under negative sentiment regimes. Contrary to prior literature, the concave relation with CPOI suggests that extremely pessimistic sentiment is associated with a higher call-put ratio. A potential explanation in the unique risk-seeking investor base attracted to the inherently volatile options market. As sentiment declines drastically, these traders may speculate on an impending recovery by loading up call options, buoying the CPOI. Consequently, divergent expectations emerge across the spot and options markets during periods of peak bearishness.

Table 4. Impact of negative sentiment on trading behavior – S&P 500

The sample period corresponds to months classified as exhibiting negative investor sentiment. Negative Sentiment presents SENT is less than zero. CPOI denotes the call-put open interest ratio. BIOI stands Blau (1977) index of open interest dispersion across calls and puts. OIIR presents growth rate of aggregated open interest. SENT is Baker and Wurgler (2006) investor sentiment index. CPVM denotes call-put trading volume ratio. BIVM stands Blau (1977) index for volume. VMIR presents growth rate of total trading volume. LAG- is the lagged independent variable. Superscripts *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Variables	CPOI	BIOI	OIIR
SENT	0.021***	-0.001***	0.605***

	(<0.001)	(0.006)	(0.002)
SENT2	0.019***	0.000	0.999***
	(<0.001)	(0.785)	(<0.001)
CPVM	0.002***		
	(<0.001)		
LAG-CPOI	0.974***		
	(<0.001)		
BIVM		0.007***	
		(<0.001)	
LAG-BIOI		0.972***	
		(<0.001)	
VMIR			0.002***
			(<0.001)
LAG-OIIR			-0.029***
			(<0.001)
Constant	0.031***	0.010***	0.214***
	(<0.001)	(<0.001)	(<0.001)
N	411,887	423,779	422,338
Adjusted R^2	0.965	0.954	0.018

Table 5. Impact of negative sentiment on trading behavior – S&P 500 (-0.3842<Z<0)

The sample period corresponds to months classified as exhibiting negative investor sentiment. Negative Sentiment presents SENT is less than zero. CPOI denotes the call-put open interest ratio. BIOI stands Blau (1977) index of open interest dispersion across calls and puts. OIIR presents growth rate of aggregated open interest. SENT is Baker and Wurgler (2006) investor sentiment index. CPVM denotes call-put trading volume ratio. BIVM stands Blau (1977) index for volume. VMIR presents growth rate of total trading volume. LAG- is the lagged independent variable. Superscripts *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	CPOI	BIOI	OIIR
SENT	0.015	0.001	-1.546***
	(0.259)	(0.370)	(0.006)
SENT2	-0.012	0.004	-5.585***
	(0.781)	(0.156)	(0.002)
CPVM	0.002***		
	(<0.001)		
LAGCPOI	0.974***		
	(<0.001)		
BIVM		0.008***	
		(<0.001)	
LAGBIOI		0.972***	
		(<0.001)	
VMIR			0.002***
			(<0.001)
LAGOIIR			-0.021***
			(<0.001)
Constant	0.029***	0.010***	0.035
	(<0.001)	(<0.001)	(0.366)
N	307,962	313,682	312,980
Adjusted R^2	0.966	0.955	0.026

Our results indicate that options trading activity exhibits a heightened sensitivity to negative sentiment compared to positive sentiment, with complex and asymmetric patterns emerging at sentiment extremes. These findings complicate simplistic linear hypotheses linking sentiment to trading behavior, motivating further investigation into the underlying behavioral mechanisms driving such asymmetries. Additionally, our finding supports the notion that market participants may not react strongly to small fluctuations in sentiment, as limiting the sentiment sample range renders most trading activity variables insensitive to sentiment changes.

Next, we examine the relationship between various options trading activities and underlying asset price volatility. We divide our sample into ordered sentiment groups using the Baker and Wurgler (2007) sentiment index (see Table 2 for group ranges). Table 6 presents the impact of trading activities on volatility across these groups. We observe that open interest dispersion (BIOI) does not influence price volatility when sentiment is in the moderate range (the middle group). However, the growth rate of aggregated open interest (OIIR) exhibits a positive relation with volatility across all sentiment groups.

Building on the previous section's finding that moderate, limited sentiment shifts do not impact trading activities, we propose that investors' opinions may be randomly dispersed over time during such periods. This divergence of views makes it difficult for sentiment to affect price volatility systematically. However, as sentiment becomes more extreme in financial markets, herding behavior causes traders' actions to become more coordinated. This concentrated consensus aligns price volatility with the prevailing investor expectations, explaining why open interest dispersion (BIOI) does not influence volatility in the moderate middle groups 4 and 5.

Conversely, the growth rate of aggregated open interest (OIIR) positively impacts price volatility across all sentiment groups. We interpret this as the OIIR capturing the proliferation of new information in the market and influxes of speculative "hot money," consistent with prior research findings.

Table 6. Sentiment interactions – S&P 500

Presents findings from equation 4 of differential relations between open interest and return volatility across sentiment deciles for S&P 500 firms. OIIR denotes growth rate of aggregated open interest. BIOI stands Blau (1977) index of open interest dispersion across calls and puts. VMIR presents growth rate of total trading volume. BIVM stands Blau (1977) index for volume. Superscripts *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	OIIR	BIOI	VMIR	BIVM	Constant	N	Adj R^2
TOTAL	0.014*** (<0.001)	0.537*** (<0.001)	0.000*** (<0.001)	0.289*** (<0.001)	0.957*** (<0.001)	627,017	0.007
1	0.022*** (<0.001)	-5.851*** (<0.001)	0.000*** (<0.001)	1.537*** (<0.001)	4.597*** (<0.001)	61,473	0.016
2	0.027*** (<0.001)	-1.292*** (<0.001)	0.000*** (<0.001)	0.492*** (<0.001)	2.002*** (<0.001)	63,109	0.017
3	0.012*** (<0.001)	0.933*** (<0.001)	0.000*** (<0.001)	-0.024*** (0.721)	1.011*** (<0.001)	63,668	0.004
4	0.009*** (<0.001)	0.058 (0.584)	0.000*** (<0.001)	0.438*** (<0.001)	0.851*** (<0.001)	61,222	0.012
5	0.007*** (<0.001)	-0.044 (0.612)	0.000*** (<0.001)	0.430*** (<0.001)	0.873*** (<0.001)	65,028	0.010
6	0.008*** (<0.001)	0.831*** (<0.001)	0.000*** (<0.001)	0.322*** (<0.001)	0.674*** (<0.001)	60,128	0.004

7	0.008*** (<0.001)	0.469*** (<0.001)	0.000*** (<0.001)	0.464*** (<0.001)	0.653*** (<0.001)	58,653	0.011
8	0.015*** (<0.001)	0.836*** (<0.001)	0.000*** (<0.001)	0.461*** (<0.001)	0.576*** (<0.001)	65,503	0.012
9	0.005*** (<0.001)	0.389*** (<0.001)	0.000*** (<0.001)	0.256*** (<0.001)	0.718*** (<0.001)	63,764	0.007
10	0.015*** (<0.001)	0.768*** (<0.001)	0.000*** (<0.001)	0.805*** (<0.001)	0.717*** (<0.001)	64,469	0.013

4.2 Robustness Test

As a robustness check, we utilize the Dow Jones Industrial Average (DJIA) firms as an alternative sample. Replicating our core models tests the sensitivity of the earlier results to index choice and firm size.

First, Tables 7 and 8 verify the finding of no statistical relation between sentiment and Call-Put Ratio under positive regimes coupled with an asymmetric non-linear association during downside intervals, confirming Hypothesis 1's sensitivity to negative relative to positive swings. Furthermore, the disappearance of any trading behavior effects on volatility under mild pessimism surfaces again in Table 10. However, Dow Jones constituents exhibit no sensitivities across even extreme negative sentiment deciles. A potential factor lies in the transparency and intensive analyst following of these largest blue-chip equities, which prevents sentiment from dominating price swings.

Overall, the corroborating results across indices and asymmetry between moderate and extreme sentiment regimes affirm the overall conclusions regarding complex linkages from investor sentiment to options trading to stock volatility. Additionally, when examining smaller S&P firms versus the largest DJIA firms, the divergence provides initial evidence that firm size moderates the propagation of sentiment into prices.

Table 7. Impact of positive sentiment on trading behavior – Dow Jones

Identical models and tests as in Tables 3 performed on the sample of Dow Jones Industrial Average (DJIA) firms. Positive Sentiment presents SENT is more than zero. CPOI denotes the call-put open interest ratio. BIOI stands Blau (1977) index of open interest dispersion across calls and puts. OIIR presents growth rate of aggregated open interest. SENT is Baker and Wurgler (2006) investor sentiment index. CPVM denotes call-put trading volume ratio. BIVM stands Blau (1977) index for volume. VMIR presents growth rate of total trading volume. LAG- is the lagged independent variable. Superscripts *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Variables	CPOI	BIOI	OIIR
SENT	-0.000 (0.982)	-0.000 (0.952)	0.393 (0.809)
SENT2	-0.016 (0.655)	0.000 (0.897)	-0.053 (0.991)
CPVM	-0.002*** (<0.001)		
LAG-CPOI	0.990*** (<0.001)		
BIVM		0.006*** (<0.001)	
LAG-BIOI		0.960*** (<0.001)	
VMIR			-0.001***

			(0.004)
LAG-OIIR			-0.106*** (<0.001)
Constant	0.014*** (<0.001)	0.017*** (<0.001)	0.213** (0.042)
N	13,223	13,183	13,215
Adjusted R^2	0.980	0.936	0.011

Table 8. Impact of negative sentiment on trading behavior – Dow Jones

Identical models and tests as in Tables 4 performed on the sample of Dow Jones Industrial Average (DJIA) firms. Negative Sentiment presents SENT is less than zero. CPOI denotes the call-put open interest ratio. BIOI stands Blau (1977) index of open interest dispersion across calls and puts. OIIR presents growth rate of aggregated open interest. SENT is Baker and Wurgler (2006) investor sentiment index. CPVM denotes call-put trading volume ratio. BIVM stands Blau (1977) index for volume. VMIR presents growth rate of total trading volume. LAG- is the lagged independent variable. Superscripts *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Variables	CPOI	BIOI	OIIR
SENT	0.016** (0.019)	0.000 (0.993)	0.581 (0.367)
SENT2	0.022*** (0.006)	0.000 (0.856)	1.488** (0.049)
CPVM	-0.001*** (<0.001)		
LAGCPOI	0.975*** (<0.001)		
BIVM		0.007*** (<0.001)	
LAGBIOI		0.938*** (<0.001)	
VMIR			0.000* (0.055)
LAGOIIR			-0.044*** (<0.001)
Constant	0.029*** (<0.001)	0.027*** (<0.001)	0.147* (0.091)
N	28,537	28,464	28,433
Adjusted R^2	0.948	0.884	0.003

Table 9. Impact of negative sentiment on trading behavior – Dow Jones(-0.3842<Z<0)

Identical models and tests as in Tables 4 performed on the sample of Dow Jones Industrial Average (DJIA) firms. Negative Sentiment presents SENT is less than zero. CPOI denotes the call-put open interest ratio. BIOI stands Blau (1977) index of open interest dispersion across calls and puts. OIIR presents growth rate of aggregated open interest. SENT is Baker and Wurgler (2006) investor sentiment index. CPVM denotes call-put trading volume ratio. BIVM stands Blau (1977) index for volume. VMIR presents growth rate of total trading volume. LAG- is the lagged independent variable. Superscripts *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	CPOI	BIOI	OIIR
SENT	0.013 (0.346)	-0.000 (0.809)	0.243 (0.888)

SENT2	0.002 (0.967)	-0.001 (0.829)	1.329 (0.809)
CPVM	-0.002*** (<0.001)		
LAGCPOI	0.989*** (<0.001)		
BIVM		0.008*** (<0.001)	
LAGBIOI		0.943*** (<0.001)	
VMIR			0.001*** (<0.001)
LAGOIIR			-0.032*** (<0.001)
Constant	0.016*** (<0.001)	0.024*** (<0.001)	0.098 (0.402)
N	20,971	20,911	20,923
Adjusted R^2	0.975	0.891	0.001

Table 10. Sentiment interactions – Dow Jones

Presents findings from equation 4 of differential relations between open interest and return volatility across sentiment deciles for Dow Jones firms. OIIR denotes growth rate of aggregated open interest. BIOI stands Blau (1977) index of open interest dispersion across calls and puts. VMIR presents growth rate of total trading volume. BIVM stands Blau (1977) index for volume. Superscripts *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	OIIR	BIOI	VMIR	BIVM	Constant	N	Adjusted R^2
TOTAL	0.012*** (<0.001)	1.321*** (0.003)	0.001*** (<0.001)	1.056*** (<0.001)	-0.075 (0.732)	42,051	0.010
1	0.012*** (0.001)	1.824 (0.411)	0.003*** (<0.001)	3.289*** (<0.001)	-0.661 (0.548)	4,254	0.040
2	0.015*** (<0.001)	-5.886*** (<0.001)	0.000*** (<0.001)	1.178*** (<0.001)	3.557*** (<0.001)	4,285	0.017
3	0.015*** (<0.001)	8.860*** (<0.001)	0.001*** (<0.001)	0.503 (0.223)	-3.413*** (<0.001)	4,251	0.013
4	0.008*** (0.001)	-0.010 (0.992)	0.002*** (<0.001)	1.299*** (<0.001)	0.184 (0.695)	4,052	0.054
5	-0.001 (0.706)	-4.663*** (<0.001)	0.000*** (<0.001)	0.638*** (0.002)	2.827*** (<0.001)	4,327	0.011
6	0.006* (0.072)	5.224*** (<0.001)	0.000*** (0.001)	0.746** (0.010)	-1.931*** (0.001)	4,027	0.009
7	0.004* (0.067)	0.731 (0.393)	0.001*** (<0.001)	1.344*** (<0.001)	-0.095 (0.825)	3,915	0.027
8	0.017*** (<0.001)	2.263* (0.066)	0.000*** (<0.001)	0.865*** (<0.001)	-0.596 (0.329)	4,379	0.014
9	0.005** (0.030)	1.757* (0.082)	0.001*** (<0.001)	0.868*** (<0.001)	-0.419 (0.405)	4,279	0.020
10	0.020*** (<0.001)	4.145** (0.017)	0.000*** (<0.001)	1.337*** (<0.001)	-1.503* (0.076)	4,282	0.015

This finding has implications regarding sentiment risk and limits to arbitrage, indicating that managers and investors should give additional consideration to behavioral risks for opaque, small capitalization stocks relative to larger firms closely tracked by market professionals. Future research can explore the joint roles of visibility, limits to arbitrage, and information asymmetry in enabling sentiment transmission.

5. Conclusion

Our study contributes important insights to the literature on investor sentiment, options trading behavior, and underlying asset price dynamics. Our findings uncover an asymmetric relation between market-wide sentiment and the call-put ratio, with a heightened sensitivity emerging primarily during periods of severe pessimism. We document intriguing nonlinearities and reversals in how open interest metrics relate to return volatility when transitioning from moderate to extreme negative sentiment regimes. Importantly, we also find initial evidence that firm size acts as a key moderator, with the influence of sentiment propagating more strongly from options market activity to stock volatility for smaller, likely more opaque firms. This points towards a role for limits to arbitrage and information asymmetry in enabling sentiment-driven mispricing.

These results carry significant implications for both academic researchers and industry practitioners. Theoretically, they highlight the need to allow for asymmetric, nonlinear responses to sentiment fluctuations rather than simplistic linear assumptions. The patterns also suggest gaps in existing theories around cross-market sentiment spillovers that future models must address. From a practical standpoint, the findings emphasize how small, difficult-to-value stocks may be more vulnerable to sentiment-induced swings, underscoring the importance of closely monitoring options trading metrics like the put-call ratio when evaluating downside behavioral risks for such firms. For investment managers, incorporating sentiment signals could enhance market timing strategies and better pinpoint sentiment-driven mispricings.

Moving forward, several promising research directions emerge. Examining alternative options market indicators like implied volatility could shed light on whether similar asymmetric sentiment effects exist. Investor-level data could identify the specific trader types driving put versus call demand imbalances. Supplementary sources like news media, short interest, and attention proxies may illuminate the underlying mechanisms translating pessimism across markets.

Finally, as technologies like algorithmic trading grow and small investor participation expands, understanding the intricate links between time-varying investor sentiment, derivatives trading activity, and underlying asset pricing will likely only grow more crucial. This study takes an important first step toward mapping those connections and their potential real-world impact on portfolio risks.

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