Implied Volatility Spread, Options' Greeks and the Cross-Section of Stock Returns

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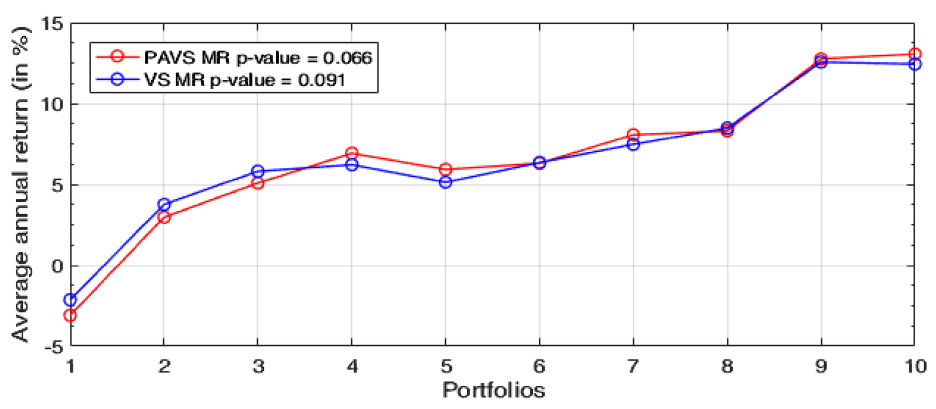
Abstract

This paper examines the relation between the information contained in the two first Greeks of options - Delta and Gamma - and the pricing of stocks. More precisely, I sort the cross section of US equity stocks on a **Probability Adjusted Implied Volatility Spread (PAVS)**, defined as the difference between the ratio Delta/Gamma of a zero-delta straddle strategy. I show that a zero-cost trading strategy on this measure provides statistically significant average monthly returns. This measure improves the spread from the deviation of the Put-Call parity of Cremers and Weinbaum (2010) as it implicitly retrieves the probability distribution of stock returns, contained in the option pricing model, to get the views of market participants about future stocks prices.

The Paper in a Nutshell

A spread on the ratio Delta/Gamma between an ATM call and ATM put (30-day maturity) has **stronger** monotonic relationship with stock returns than a spread between the implied volatility of an ATM call and ATM put (Bali and Hovakimian 2009; Cremers and Weinbaum 2010), i.e. 6.6% vs 9.1%. The monotone relationship test follows the method of Patton and Timmermann (2010).



PAVS refers to Probability Adjusted Implied Volatility Spread.
VS refers to Implied Volatility Spread.

A spanning test of VS on PAVS gives,

$$PAVS = \underset{(4.04)}{0.15\%} + \underset{(70.46)}{0.97}\ VS + e \qquad (1)$$

The sample period ranges from February 1996 to December 2017 and results are on monthly basis.

Related Research

Proxies of risk characteristics conveyed by option prices:

Implied Volatility Spread: cf. Cremers and Weinbaum (2010) and Bali and Hovakimian (2009).

$$VS = \sigma_c{}^{ATM,30} - \sigma_p{}^{ATM,30}$$

Realized-Implied Volatility Spread: cf. An et al. (2014) and Bali and Hovakimian (2009).

$$RVOL - IVOL = \sqrt{var(R_{i,d})} \times \sqrt{252} - mean(\sigma_c^{ATM,30}, \sigma_p^{ATM,30})$$

Implied Volatility Innovations (ΔCVOL-ΔPVOL): cf. An et al. (2014).

$$\Delta CVOL_{i,t} = CVOL_{i,t} - CVOL_{i,t-1}$$
$$\Delta PVOL_{i,t} = PVOL_{i,t} - PVOL_{i,t-1}$$

Risk-Neutral Skewness: cf. Conrad, Dittmar, and Ghysels (2013), Xing, Zhang, and Zhao (2010), and Bali, Hu, and Murray (2017).

$$QSKEW = \sigma_c^{OTM,30} - \sigma_p^{ATM,30}$$

$$SKEWNP = \sigma_c^{OTM,30} - \sigma_p^{OTM,30}$$

Risk-Neutral Kurtosis: cf. Bali, Hu, and Murray (2017).

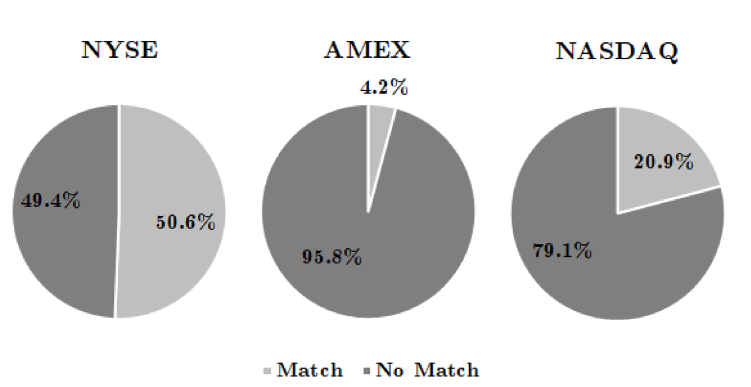
$$KURTNP = (\sigma_c^{OTM,30} + \sigma_p^{OTM,30}) - (\sigma_c^{ATM,30} + \sigma_p^{ATM,30})$$

Data

OptionMetrics and CRSP/Compustat

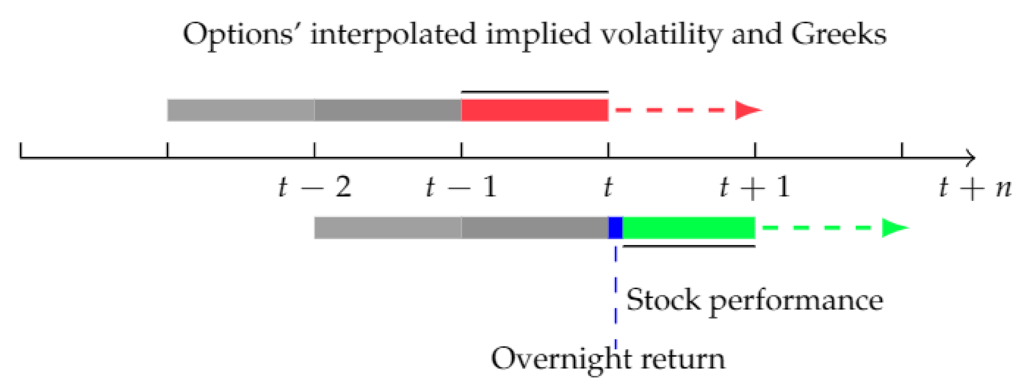
- Merger of OptionMetrics and CRSP/Compustat databases
- Standardized option prices from OptionMetrics
- interpolated implied Volatility and the Greeks of ATM options with 30 days expiration
- American style option prices through binomial tree (CRR model)

Data on stock returns are obtained from the Center for Research in Security Prices. I employ daily and monthly returns from 1996 to 2017 for all individual securities covered by CRSP with common shares outstanding.



OptionMetrics and the Overnight Bias

A possible concern is the non-synchronicity between OptionMetrics and CRSP stock price quotes: option markets close two minutes after the underlying stock markets until 2008 in OptionMetrics. To mitigate the look-ahead bias, the purchases and sales of stocks take place at the opening of trading on the day after the option signal is observed, thus ignoring the first overnight return.



Model

Zero-delta Straddles

Coval and Shumway (2001) built zero-delta straddles by being long the amount ω in a call option and the remaining (1-ω) in a put option with same strike and maturity.

$$\omega = \frac{-\Delta_p}{\Delta_c - \Delta_p} \qquad (2)$$

The delta of the straddle strategy (S) is thus equal to $\Delta_S = \omega\Delta_c + (1-\omega)\Delta_p = 0$. The call and put options have the subscript c and p, respectively.

- By construction zero-delta straddle positions should not suggest any direction about the underlying asset price.
- Strong deviations from put-call parity should indicate the direction towards which option market participant expect the underlying stock to trade over the next month.

Decomposition of PAVS

Taking the ratios of the normalized Delta and Gamma (i.e. Δ_c^N/Γ_c^N and Δ_p^N/Γ_p^N) from the call and put in isolation is informative about how much the deviation from put-call parity violates this neutral position on the underlying asset.

$$\frac{\Delta_S^N}{\Gamma_S^N} = \omega\frac{\Delta_c^N}{\Gamma_c^N} + (1-\omega)\frac{\Delta_p^N}{\Gamma_p^N} \qquad (3)$$

And decomposing the Greeks according to Black-Scholes model leads to,

$$PAVS = \omega\frac{\sigma_c\sqrt{t}}{h(-d_1^c)} - (1-\omega)\frac{\sigma_p\sqrt{t}}{h(d_1^p)} \qquad (4)$$

where the implied volatility of the underlying security retrieved from either the ATM call and put options with 30 day maturity (σ_c and σ_p). And,

- $h(d_1) = \frac{\phi(d_1)}{1-\Phi(d_1)}$ is the hazard rate
- $h(-d_1) = \frac{\phi(d_1)}{\Phi(d_1)}$ is the reversed hazard rate
- $d_1 = \frac{\log(S/X)+(r+\sigma^2/2)t}{\sigma\sqrt{t}}$
- $\Phi(.)$ is the CDF for a standard normal
- $\phi(.)$ is the PDF for a standard normal

Hazard Rate and Options

The hazard function answers the question "what is the probability of an event given that the event has not already occured."

For instance, this expression for the *call* option is equivalent to ask: "what is the *risk neutral* probability that a call option will end up in-the-money over one month, conditional on being currently near-the-money."

$$h(-d_1) = \lim_{dS\to 0} \frac{\mathbb{Q}\left[K < S_T | K \geq S_0\right]}{dS} \qquad (5)$$

The ratio $\frac{\Delta^N}{\Gamma^N}$ brings a much larger set of information as it implicitly retrieves the probability distribution of a stock return, contained in the option pricing model, to get the views of market participants about future stocks prices.

PAVS Interpretation

PAVS contains at least 3 levels of information:

1. The put-call parity deviation from a neutral position (straddle),
2. The option market participant expectations about stocks price to trade higher in the future (Bali and Hovakimian 2009),
3. The likelihood of a positive or negative price jump contained in the option pricing model (hazard rate).

Thus, PAVS condense the 3 levels of information into the risk of a positive price jump.

Empirical Evidence

Monotonic Relationships

Significant evidence of up trends in sorting stocks on PAVS. Findings are not persistent when sorting stocks on VS.

	Equal-Weighted Portfolios				Cap-Weighted Portfolios			
	Full Sample		Sub-Sample		Full Sample		Sub-Sample	
	Jan 1996 - Dec 2017		Apr 2008 - Dec 2017		Jan 1996 - Dec 2017		Apr 2008 - Dec 2017	
	PAVS	VS	PAVS	VS	PAVS	VS	PAVS	VS
10-1 (in %)	1.29	1.16	1.31	1.17	1.05	0.70	1.14	0.32
t-stat	(7.63)	(6.82)	(6.02)	(5.29)	(3.77)	(2.19)	(3.09)	(1.03)
MR pval	0.07	0.09	0.48	0.22	0.43	0.34	0.42	0.74
Up pval	0.00	0.00	0.00	0.00	0.01	**0.16**	0.02	**0.20**
Down pval	0.97	0.93	0.59	0.63	0.81	0.95	0.60	0.25

Spanning Regressions

Estimations of the spread from the PAVS decile portfolios over the VS remains significant for value-weighted portfolios (t-stat=4.381).

Int	VS	QSKEW	SKEWNP	KURTNP	ΔPVOL-ΔCVOL	RVOL-IVOL	Adj-R^2
Panel A: Equal-Weighted Spreads							
0.15***	0.97***						0.96
(4.04)	(70.46)						
0.18***	0.95***	-0.05**	-0.04**	0.00	-0.02	0.00	0.97
(4.76)	(55.38)	(-2.00)	(-2.07)	(0.02)	(-1.45)	(0.84)	
Panel B: Cap-Weighted Spreads							
0.67***	0.542**						0.38
(3.80)	(2.48)						
0.82***	0.72***	0.00	-0.22*	0.14	0.09	0.10**	0.47
(4.39)	(6.44)	(0.02)	(-1.67)	(0.88)	(1.10)	(2.00)	

* Significance at the 10% level ** Significance at the 5% level *** Significance at the 1% level
t-stat presents the Newey and West (1987) t-statistic, adjusted using three lags.

Transaction Costs

The spread remains also significant after accounting for transactions costs (CW t-stat=2.28, EW t-stat=3.31). Transaction costs are computed following Hasbrouck (2009) method and Novy-Marx (2015) application to complete the set of transaction costs for all individual stocks (euclidean distance between size and idiosyncratic volatility).

Additional Control Variables

BETA: One-Year regression based on daily data. The model is the FF-3 Factors model.

SIZE: log(Market equity).

Book-to-Market Ratio (BM): following the definition of Fama and French (1993).

Momentum (MOM): following the definition of Jegadeesh and Titman (1993).

Cumulative Prospect Theory (CPT) Value: is the CPT investor's psychological value of a stock based on a 60-month rolling window, see Barberis, Mukherjee, and Wang (2016).

Skewness, Co-skewness, Kurtosis and Co-kurtosis: are computed using daily returns over the past one year, cf. Harvey and Siddique (2000) and Lambert and Hübner (2013).

Probability of Informed Trading (PIN) and **Probability of Bad News** (PBN): are individual stock estimates based on IBES analyst forecasts and are retrieved from Stephen Brown website. Overall, the short side of the PAVS is related to stocks with higher PBN (sell signal).

Double Conditional Sort

First sort on VS, then a second sort on PAVS. With

$$VS = \sigma_c - \sigma_p$$
$$PAVS = \omega\frac{1}{h(-d_1^c)} - (1-\omega)\frac{1}{h(d_1^p)}$$

	Return in t+1 (in %)						Prob of Bad News (PBN) in t					
	PAVS 1	2	3	4	PAVS 5	MR pval	PAVS 1	2	3	4	PAVS 5	Average
VS 1	-0.98	-0.04	0.33	0.56	0.45	0.19	48.46	50.06	48.11	42.86	39.43	45.78
2	0.08	0.70	0.49	0.59	0.57	0.45	42.76	43.97	39.11	35.83	35.15	39.36
3	0.05	0.52	0.66	0.53	0.57	0.53	40.34	41.75	36.10	32.63	33.24	36.81
4	0.20	0.61	0.79	0.80	0.79	**0.05**	41.92	43.68	38.71	34.43	34.81	38.71
VS 5	0.09	0.96	1.22	1.31	1.35	**0.04**	46.95	49.03	47.08	45.03	42.70	46.16
						Average	44.09	45.70	41.82	38.16	37.07	

Across the quintile formed on VS, PAVS distinguishes stocks with high vs low PBN what leads to subsequent higher return.

Main Findings

My main results are easily summarized.

1. The method sets a neutral framework that improves the spread from the deviation of the Put-Call parity of Cremers and Weinbaum (2010),
2. The probability distribution contained in American style option prices are informative about future stock return (bearish vs bullish signal),
3. Option price sensitivities (Greeks) contain complementary information to the implied volatility for predicting future stock return.

Forthcoming Research

- Replicate OptionMetrics' option Greeks estimation procedure (American style option with CRR model)
- Apply the probability adjusted measure to different level of option moneyness, see (SKEWNP, QSKEW, and KURTNP).
- Compute cumulative one-year jump returns based on the daily returns of PAVS decile portfolios, see Bali and Hovakimian (2009).