5-2021

FORECASTS AND IMPLICATIONS USING VIX OPTIONS

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A Thesis

Submitted for partial fulfilment for the Bachelor's Degree in Finance (University Honors Scholar Program) to the department of Finance

College of Business and Technology, East Tennessee State University

By

Spencer Stanley

East Tennessee State University

March 2021

Declaration by student

I, Spencer Stanley, hereby declare that the work presented herein is original work done by me and has not been published or submitted elsewhere for the requirement of a degree program. Any literature date or work done by others and cited within this thesis has been given due acknowledgement and is listed in the reference section.

Spencer Stanley

Place: East Tennessee State University

Date: March 12, 2021

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Dr. William Trainor

(Supervisor/Mentor)

Professor of Department of Finance

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Certificate

Certified that the thesis titled "FORECASTS AND IMPLICATIONS USING VIX OPTIONS" submitted by Mr. Spencer Stanley towards partial fulfilment for the Bachelor's Degree in Finance (University Honors Scholar Program) is based on the investigation carried out under our guidance. The thesis part therefore has not been submitted for the academic award of any other university or institution.

Dr. William Trainor

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Professor of Department of Finance

Abstract

This study examines the Chicago Board Option Exchange (CBOE) Volatility Index (VIX) which is the implied volatility calculated from short-term option prices on the Standards & Poor's 500 stock index (S&P 500). Findings suggest VIX overestimates average volatility by approximately 3% but explains 55% of S&P 500's proceeding month's volatility. The implied volatility (IV) from options on the VIX add additional explanatory power for the S&P's 500 proceeding kurtosis values (a measure of tail risk). The VIX option's volatility smirks did not add additional explanatory power for explaining the S&P 500 volatility or kurtosis. A simple trading rule based on buying the S&P 500 whether the VIX, IV from the options on the VIX, and the VIX option's volatility smirk decline over the preceding month results in an additional 0.96% return in the following month. However, this only occurs approximately 10% of the time and does not outperform a simple buy-and-hold strategy as the strategy has the investor out of the market the majority of the time.

Acknowledgement

I would like to express my sincere gratitude to Dr. William Trainor Professor of Department of Finance for his continuous guidance, advice, effort, and assistance throughout the research and overall process.

I am grateful to my external examiner Assistant Professor Dr. Joseph Newhard Department of Economics for his support, encouragement, and advice during this project.

I am also grateful to Dr. Karen Kornweibel, Director of Honors and Midway Scholars, The Honors College for granting me the invaluable opportunity of participating in the Honors Scholars Program and supporting me through the process.

List of Abbreviations

ATM - option is said to be “at the money” if the strike price is equal to the current spot price of the security

CBOE – the world's largest options exchange with contracts focusing on individual equities, indexes, and interest rates

ITM - A call option is “in the money” if the market price is above the strike price. A put option is “in the money” if the market price is below the strike price.

IV - implied volatility which is a metric that captures the market's view of the likelihood of changes in a given security's price

OTM - A call option is “out of the money” if the market price is below the strike price. A put option is “out of the money” if the market price is above the strike price.

S&P 500 Index - an index that is based on the 500 largest publicly traded companies in the U.S.

VIX – a real-time market index representing the market's expectations for volatility over the coming 30 days.

VXV/VIX3M - a constant measure of 3-month implied volatility of the S&P 500 Index options

I. Introduction

In 1973 the Chicago Board Options Exchange (CBOE) was founded and became the first stage for trading listed options. Twenty years later in 1993, the CBOE created the CBOE Volatility Index (VIX). The VIX is an indicator of market volatility and measures investor risk. The VIX is often referred to as “the fear index" (CBOE History).

The VIX is the implied volatility (IV) calculated from the prices of a compiled profile of put and call options on the S&P 500 Index. A call option is a financial contract that gives the buyer of the contract the right, but not the obligation to buy the equity at a specified price (known as the strike price) within a specific time period. In contrast, a put option is a financial contract that gives the buyer the right to sell the equity at a specified price on or before a specific expiration date. However, options on the VIX which itself is calculated from option prices behaves differently than typical stock options. First, the options on the VIX are not priced to the index due to the VIX not being a tradable asset, i.e. you cannot buy or sell the VIX. Alternatively, the options are priced to the volatility futures with the same settlement date. Second, when the options settle, they are moved to a Special Opening Quotation (SOQ) which is under the symbol VRO. Third, the options are “European exercise.” In layman’s terms, this means the holder is unable to exercise them until the expiration date; they also are automatically exercised. Finally, the IV from the options on the VIX naturally declines over time.

Another important measurement to consider is the graphs of the VIX Index options, which commonly form "smirks." A smirk occurs when ATM options have a lower IV than the ITM or OTM options, the graph-plotted data forms a line that resembles a "smirk." Also, when both the ITM and OTM options have a higher IV, the graph can be referred to as a "smile." The data of the smirks aided in the overall research since the IV of the options were provided from this. Examination of this information was important to determine whether the IV was increasing or decreasing the further the options were OTM.

Although there are many indicators that are utilized when dealing with market volatility, the VIX is one of the most quoted volatility metrics due to its perceived reliability. With the VIX, investors are given the ability to determine the expected market volatility over the next 30 days based on options on the S&P 500. Options on the VIX will help or improve since the option prices are based on the expected future value of the VIX. This will allow for a more accurate forecast on future volatility or future returns. Overall, this study incorporates the true VIX value, the implied volatility from the options on the VIX, and the VIX option's volatility smirks to determine if one or a combination of the measures can predict changes in the market return. The results from the research produced a useful trading rule; when the VIX and IV of VIX options fall from the preceding month and the smirk from the options decrease, the return is 1.80% - compared to the average S&P 500 return of 0.84%. This is a significant increase of 0.96%; however, this 1.80% return only happens 10.47% of the time, which is not effective since the sum of money would only be invested a tenth of the total time. Further results are listed in Section 5: Results/Trading Rules.

II. Overview of VIX, Implied Volatility, & Smirks

A. History of VIX

The VIX is a measure of the market's expectation of volatility derived from the S&P 500 index options. The VIX is calculated by:

1) Selecting the options to be included in the calculation – a variety of call and put contracts in two consecutive expirations around the 30-day mark.

2) Calculate each option's contribution to the total variance of its expiration. This is heavily dependent on the option's current price, the strike price, and strike price increment of neighboring strikes.

3) Sum all of the contributions from step two to find the total variances of the first and second expiration dates.

4) Calculate the 30-day variance by interpolating the two variances from step three. The weights of the two variances, which must add up to 1, are dependent how close each expiration is from the desired 30-day mark.

5) Take the square root of the number from step four to find the volatility as a standard deviation and finally,

6) Multiply the standard deviation by 100 to find the end VIX index value.

For example, if the VIX index is calculated to be 16, it should be interpreted that a hypothetical S&P 500 option with 30 days left until expiration has an annualized implied volatility of 16 percent (VIX Calculation). If the VIX is trading at 20, which is right around the long-term average, then it would be translated to an implied volatility measure of 20%. In turn, this means that over the next 30 days, the VIX has 66.7 percent, or one standard deviation, probability of trading within a range that is 20% higher or 20% lower than the current price.

Figure 1.1 represents the VIX Index from 1990 to 2021 which is the entirely of its existence including some backdating before it was originally introduced. A few important takeaways from the figure are the minimum value, the maximum value, and the dates these occurred on. The lowest the VIX has ever dropped was on November 24, 2017; the index hit 8.56 midday. First, the market activity tends to decrease closer to holidays, and second, since the VIX is calculated from option prices (which factor in time), the index would be lower due to less time and opportunity for a move (Macro Option). The market had high stability overall during this time.

In contrast, on October 24, 2008, the index hit as high as 89.53 (NAIC Capital Markets). This spike can be explained by the financial crisis the United States was undergoing. Both of these values provide examples of how the VIX moves in relation to large, impacting events.

Figure 1.1 - VIX Index Chart (Maximum Time frame)

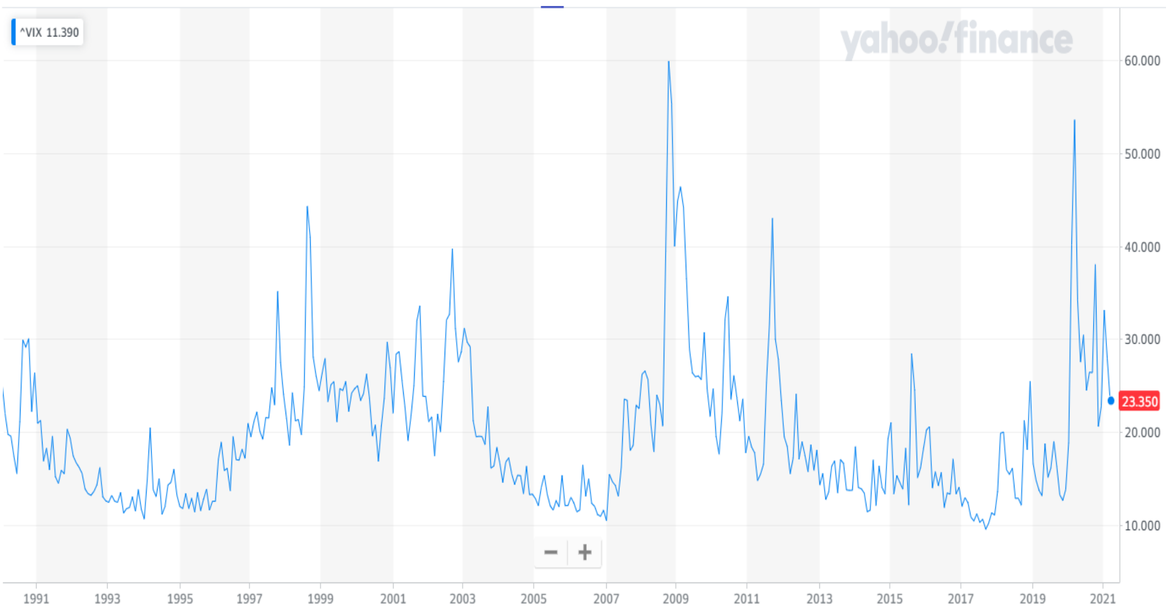

Figure 1.2 shows the VIX from March of 2020 to March of 2021. During March of 2020, the VIX spiked similarly to the 2008 financial crisis. This was due to the spread of COVID-19, which was expected to heavily impact the economy. The smaller increases such as the one in November 2020 and February 2021 can be attributed to negative news regarding employment reports, new/developing COVID strains, and interest rates.

Figure 1.2 VIX Index Chart (March 2020 to March 2021)

Trading options on the VIX provides traders a pathway to trade volatility without requiring them to account for other factors that are normally involved in options trading. Volatility indicators can add value to a trader's repertoire as they are able to provide insight into the trading range as well as increases and decreases of an equity's price (The Economic Times, 2017). Trading VIX options has many benefits including the ability to measure or predict future market risk. It is important to note that when trading VIX options, the trader is betting on VIX futures, not the actual VIX price. In early 2018, the VIX climbed 115% while the S&P 500 decreased over 4% in one trading day (Mackenzie, 2020). This data shows that while the VIX is a measure of the S&P 500, it is merely a measure of implied volatility.

Investors primarily take advantage of this measure when reducing risk. For example, if an investor is tracking the VIX and notices it takes a sharp move upward, then the implied volatility, or chance of a large move, is increased. During large market sell offs, the VIX has a tendency to spike. In this situation, one might choose to mitigate their risk exposure and enter more stable equity options, along with trading the options on the VIX. "The VIX options offer the ability to hedge an equity portfolio better than other index options, even products that trade based on a portfolio's benchmark index directly…" (Aramian, 2014). Some investors also use the VIX to confirm a bottom, or commonly known as a market reversal. According to Investor's Business Daily research, a VIX increase of more than twenty percent above its 10-day simple moving average line can aid in confirming a positive reversal (Lehtonen, 2020). Along with these two applications of the VIX, it is simply a useful tool to indicate when the overall market has uncertainty in the future.

B. Calculation of VIX

In order to test the hypothesis if the implied volatility from the options on the VIX can precisely predict changes in the actual VIX price, models, graphs, and equations must be formulated and analyzed. Three of the main models used for options pricing are the Black-Scholes Merton model, the Mean Reverting Model, and the Heston Model (Aramian, 2014).

In 1973, Fischer Black, Robert Merton and Myron Scholes developed the initial Black-Scholes Merton model. The model has six underlying assumptions in order to apply it.

The model assumes:

(1) Volatility is constant over time (lognormal distribution of prices)

(2) At any given time, stocks are just as likely to move upward as they are to move downward

(3) The stock pays no dividend

(4) Options can only be exercised upon expiration

(5) No commissions are charged

(6) Interest rates remain constant (Shnide & Takale, 2012).

Essentially, the Black-Scholes Merton call option formula is determined by multiplying the current stock price by the cumulative standard normal probability distribution function. Next, the net present value of the strike price multiplied by the cumulative standard normal distribution is subtracted from the figure that resulted from the first calculation (Shnide & Takale, 2012).

The Mean Reversion Model has been altered and reformulated several times; however, the base model has stood the test of time. The mean reversion theory states that an asset or equity's price and returns historically will return to the long-term average level of all of the data points. In modern day trading, traders will use trendlines such as the 50-day simple moving average in order to predict future stock price moves. If applied to volatility, then it is the assumption that an option's volatility will tend to revert to its complete average over time.

As did the Black-Scholes Merton Model, the mean reversion model also has a few assumptions of the "…underlying asset, St , has the following dynamics, under risk-neutral measure"

St = exp(Xt)

dXt = h θ(t) − κXt − vt 2 i dt + √ vtdW(0) t

dvt = (a(t) − bvt)dt + σ √ vtdW(1) t

where the constant κ is the mean-reversion speed for the asset; the constant b is the mean-reversion speed of the volatility; the deterministic function θ(t) represents the equilibrium mean level of the asset against time; the function a(t) is the equilibrium mean level of the volatility against time; the process vt is the volatility of the underlying asset, which follows the Heston (1993) stochastic volatility model; the constant σ is the volatility coefficient of the volatility process; and W (0) t and W (1) t are correlated Wiener processes with correlation coefficient ρ. This proposed model is reduced to the Heston model if the mean-reversion speed, κ, is equal to zero" (Wong et al., 2009).

As mentioned above, the Heston model includes the same equation that the mean reversion does; the only difference is the mean-reversion speed must equivale to 0. The Heston model assumes that the movements in the asset's price is a continuous time process; although this may be true, the recorded measurements of the asset's prices are in discrete time. This flaw brings one to the method of Euler discretization (Dunn et al., 2015).

The Heston model is expressed as:

$$dSt = \mu(St, t)dt + \sigma(St, t)dWt$$

After the Euler discretization, the model is improved to:

$$St+dt = St + \mu(St, t)dt + \sigma(St, t) \sqrt{\ } dtZ$$

All three of the models discussed are utilized when pricing options on the VIX; therefore, understanding the methods and framework is crucial to this study.

In conclusion, the VIX index, which tracks the implied volatility (IV) of put and call options on the S&P 500 Index. Although there are many indicators that are utilized when dealing with market volatility, the VIX is one of the most quoted volatility metrics due to its accuracy and reliability. With the VIX, investors are given the ability to determine the expected market volatility over the next 30 days. The purpose of this research is to determine if the implied volatility from the options on the VIX can precisely predict changes in the actual VIX price. Therefore, as the implied volatility smiles or smirks from the options on the VIX become stronger, the VIX price would correlate.

C. VXV/VIX3M Calculation

The VXV (CBOE S&P500 3-Month Volatility Index) is a measure of the market's volatility based on the implied volatility of S&P 500 options for a fixed time period. The difference between the VXV and the VIX is simply the time horizon. Where the VIX measures the implied volatility of the S&P 500 options 30 days from expiration, the VXV measures the implied volatility of the S&P 500 options three months, or approximately 93 days from expiration.

The VXV can be calculated using the same steps as the VIX calculation, with only the time of the initial options chosen altered to three months to the expiration date.

D. Implied Volatility, Smiles, and Smirks

Implied volatility is defined as "a metric that captures the market's view of the likelihood of changes in a given security's price" (Ganti, 2020). Investors are able to utilize implied volatility to predict future moves and future supply/demand. Implied volatility is derived from a stock's call and put options. As option buyers are willing to pay more per contract and option sellers have a higher demand, the option price will increase. In turn, the implied volatility will increase, leaving the stock with a larger range of expected movement. On the other side, if the option buyers decrease the amount they are willing to pay and the option sellers decrease their amount demanded, the options price will decrease and will lower the implied volatility. Market sentiment drives options prices and the option prices drive implied volatility; from this information, investors can determine the magnitude of expected moves for the stock.

Implied volatility represents a one standard deviation chance in the stock price, which encompasses about 68% of occurrences around the stock price. To determine the stock price in one year with 68% accuracy, an investor would take the current stock price +/- (current stock price * implied volatility). As shown above, this information is very valuable when assessing risk.

The Black-Scholes Merton model, which was explained in the Models subsection, expects that the implied volatility should be the same across varying strike prices; this would create a flat curve. The fact the prices are higher away from the money suggests kurtosis, or fat tails, since the BSM model assumes lognormality. However, the IV is generally biased and, therefore, overstated. When the IV is not constant among strike prices, this produces volatility smiles, which morphed to volatility smirks after the 1987 “Black Monday” stock market crash (Benzoni et al. 2010). A study conducted by tastytrade produced the graph below (Figure 1.1) (tastytrade, 2013). This demonstrates the implied volatility compared to the realized volatility. As shown, the IV is overstated more than 80 percent of the time.

Figure 2.1

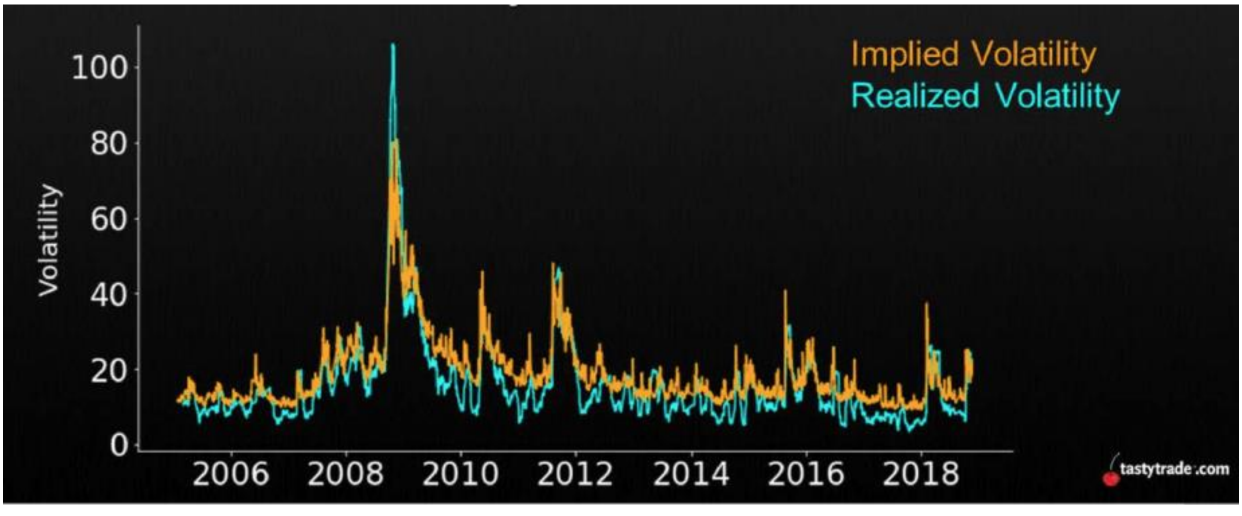

Figure 2.2 (below) provides an example of a volatility smile on the left and a volatility skew on the right. For the smile, the implied volatility increases as the option strike prices become increasingly ITM of OTM. However, for the reversed volatility skew, the implied volatility increases as the option strike prices become increasingly ITM and decreases as they become increasingly OTM. An important point to mention is that for a forward volatility skew, this graph would be skewed in the opposite direction.

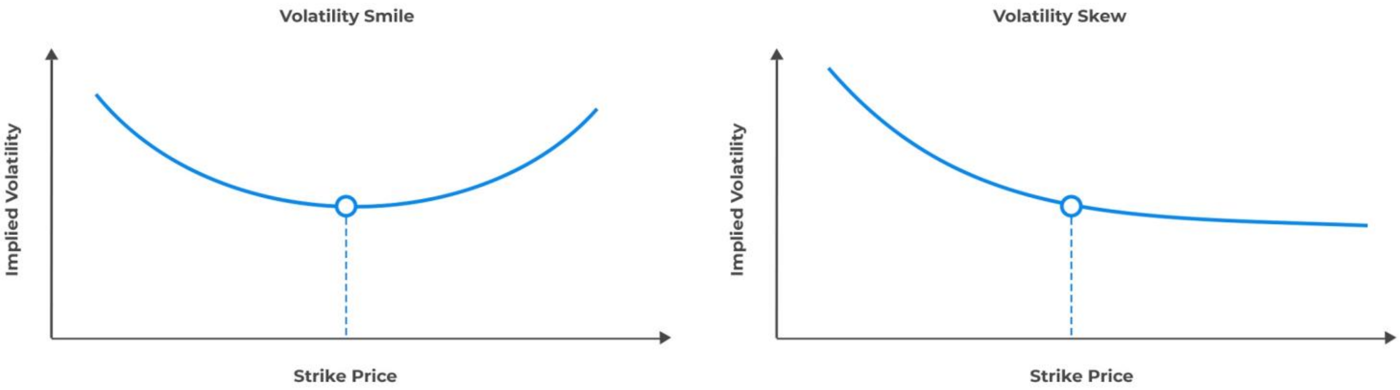

Figure 4.2 (below) provides an example of a volatility skew graph for the S&P 500 Options on July 17, 2013 and September 2, 2015 (Bloomberg).

III. Expectation/Hypothesis

From the research conducted, we expected to derive four main conclusive trading points. First, does the VIX value truly predict the volatility of the S&P 500? Although the VIX is believed to track the volatility, for research purposes, it is important to check the data. From this, does the VIX help to explain future returns of the S&P 500? Second, does the IV of the VIX help to explain future values of the VIX itself? Third, if the VIX does predict future returns and IV predicts the VIX, then the IV could also predict the future returns based on the transitive property. Finally, does the IV of the VIX explain kurtosis, or in other words, can large moves be expected in one direction or the other?

From these points, it will be important to not only determine a conclusion to each question, but if the data is able to predict future returns, are the results significant enough to form trading rules?

Table 3.1

Symbol	Underlying Price	Type	Expiration	Data Date	Strike	Last	Bid	Ask	Volume	Open Interest	IV	Delta	Option length	% Strike
VIX	12.34	call	3/22/2006	2/28/2006	12.5	0	0.9	1.1	0	0	0.8009	0.5179	22	0.012965964
VIX	11.39	call	4/19/2006	3/31/2006	12.5	0.45	0.4	0.5	57	9126	1.0332	0.3917	19	0.097453907
VIX	11.59	call	5/17/2006	4/28/2006	12.5	0.6	0.55	0.6	13	27981	1.1091	0.4327	19	0.078515962
VIX	16.44	call	6/21/2006	5/31/2006	17.5	0.7	0.6	0.7	42	4881	0.6625	0.381	21	0.064476886
VIX	13.08	call	7/19/2006	6/30/2006	12.5	1.9	1.75	1.9	285	4530	1.6592	0.6237	19	-0.044342508
VIX	14.95	call	8/16/2006	7/31/2006	15	1.35	1	1.3	71	16661	1.116	0.5437	16	0.003344482
VIX	12.31	call	9/20/2006	8/31/2006	12.5	1.2	1.1	1.25	119	5942	1.3415	0.5454	20	0.015434606
VIX	11.98	call	10/18/2006	9/29/2006	12	1.75	1.55	1.65	56	26337	1.6194	0.5731	19	0.001669449
VIX	11.1	call	11/15/2006	10/31/2006	11	0.8	0.7	0.75	2728	7386	0.8503	0.5598	15	-0.009009009
VIX	10.91	call	12/20/2006	11/30/2006	11	0.75	0.65	0.8	359	11761	0.9704	0.5349	20	0.008249313
VIX	11.56	call	1/17/2007	12/29/2006	12	1.3	1.25	1.35	1202	27294	1.6384	0.5355	19	0.038062284

To produce the information below (regressions, smirk graphs, trading rules, etc.), daily data regarding VIX call and put options was gathered from DeltaNeutral. An example of this can be viewed in Table 3.1. Although the table only includes call options from 2006, a mixture of put and call options from the S&P 500 were recorded from 2006 to 2020. The columns included in the data were the symbol of the index (VIX), the underlying option price, the type of option (call or put), the expiration date of the option, the date the data was recorded, the strike price of the option, the last price, the bid price, the ask price, the volume, the open interest, the implied volatility, the delta the option length (days), and the % of strike.

Table 3.2

	.25Delta IV	.5 Delta IV	-.25Delta IV	-.5 Delta IV	Average .5IV	Smirk
Average	129.70%	127.28%	68.95%	71.11%	99.20%	-67.24%
Median	132.29%	125.77%	57.62%	56.90%	97.25%	-73.72%
St. Dev.	30.89%	36.33%	44.33%	48.37%	24.65%	57.84%
Minimum	33.65%	33.70%	-29.00%	8.92%	33.46%	-215.73%
Maximum	213.17%	239.91%	354.28%	377.35%	215.32%	113.41%
Lower 5% CI	79.10%	68.37%	25.14%	21.81%	70.42%	-148.46%
Upper 5% CI	181.33%	188.87%	145.21%	156.21%	133.70%	22.44%

Table 3.2 contains rows that determine the average, median, standard deviation, minimum value, maximum value, lower five percent average, and the upper five percent average for each of the columns listed. In column five, the average of the 0.5 IV delta is listed, which is the average of the 0.5 Delta Implied Volatility values for both the call and put options. In this table, the smirk values are crucial to the overall research. The smirk values indicate whether the smirk was up or down and how significant the move was. For example, the average smirk was down 67.24% which is shown by the second row in the seventh column. As mentioned in the introduction, the most valuable trading rule incorporates the smirk data and therefore, should be emphasized. Smirks are calculated by the value of the (-.25 delta - .25 delta) divided by 0.5 delta from the options at each date, see Mixon (2011).

Table 3.3

	Option IV	VIX	Actual SD	Skew	Kurtosis	Vix SD
Average	129.96%	19.48%	16.23%	-5.91%	74.38%	117.99%
Median	127.03%	16.73%	12.96%	-6.83%	46.60%	104.96%
St. Dev.	42.69%	8.86%	12.49%	72.07%	171.71%	54.28%
Minimum	33.70%	9.51%	4.85%	-310.37%	-134.10%	50.02%
Maximum	264.74%	59.89%	90.83%	207.82%	1223.69%	453.02%
Lower 5% CI	65.82%	11.09%	6.09%	-109.23%	-94.74%	63.74%
Upper 5% CI	195.86%	39.54%	37.43%	98.99%	342.44%	227.95%

Table 3.3 (above) contains rows that determine the average, medium, standard deviation, minimum value, maximum value, lower five percent average, and the upper five percent average for each of the columns listed. All of the columns are important to consider for this research; however, it is important to note that the standard deviation is very large for most of the variables and contains a large range within the data points. The second column (Option IV), which contains the values for the implied volatility of the put and call options from Table 3.1, is important since the results in the trading rules are dependent upon it. Second, the VIX average is 19.48%, and the actual SD is recorded at 16.23%. To further the research, skew and kurtosis of the graphs were also analyzed and recorded (Columns five and six). Finally, the VIX standard deviation was recorded at an average of 117.99%.

Next, the use of regressions was included to determine if the variables selected were significant or not. The tables below are examples of this. For the first section of Table 3.4 (below), the Regression of VIX SD on IV has a very weak R-square value; therefore, it does not provide much value to the overall research. Also, the T-Stat, which measures the size of the difference relative to the variation in your sample data, is not significant at -1.97. For the second section, the Regression of the SD on the VIX (2006-2010), has a much higher value for R-Square than the first section, but it is a moderate - high value. This shows higher correlation between the SD and the VIX. The value of the T-Stat is 8.71. Finally, for the third section of the table below, the Regression of the SD on the VIX (2010 to 2020), has a .41 R-Square which is a weaker value, and the T-Stat is 9.54, which is significant.

Table 3.4

Regress Vix SD on IV			
Variables	*Coefficients*	*t Stat*	*Adjusted R Square*
Intercept	1.42	10.93	0.02
VIX Value	-0.19	-1.97	
Regress SD on VIX, 2006 to 2010			
	Coefficients	*t Stat*	*Adjusted R Square*
Intercept	-0.04	-1.24	0.62
VIX Value	1.09	8.71	
Regress SD on VIX, 2010 to 2020			
Variables	*Coefficients*	*t Stat*	*Adjusted R Square*
Intercept	-0.03	-1.44	0.41
VIX Value	0.95	9.54	
		*, **, *** Significant at 10,5,1 respectively	

For the first section of Table 3.5 (below), the Regression of Kurtosis on Smirk, IV, and VIX has a very weak R-square value; therefore, it does not provide much value to the overall research. Also, the T-Stat for each of the variables, which measures the size of the difference relative to the variation in your sample data, is not significant. For the second section, the Regression of the Skew on the IV and VIX also has a weak R-Square value, which proves the correlation between the variables and the Skew is almost non-existent. The value of the T-Stat for both of the variables is low. Finally, for the third section of the table below, the Regression of the Kurtosis on the IV and VIX has a .008 R-Square value and low T-stat values which does not provide additional information for the research.

Table 3.5

Regress Kurtosis on Smirk, IV, VIX			
Variables	*Coefficients*	*t Stat*	*Adjusted R Square*
Intercept	1.29	2.35	0.003
Smirk	-0.03	-0.074	
IV	-0.02	-0.04	
Vix	-2.73	-1.47	
Regress Skew on IV and VIX			
Variables	*Coefficients*	*t Stat*	*Adjusted R Square*
Intercept	-0.03	-0.11	-0.009
IV	-0.06	-0.45	
Vix	0.21	0.34	
Regress Kurtosis on IV and VIX			
Variables	*Coefficients*	*t Stat*	*Adjusted R Square*
Intercept	1.3	2.43	0.008
IV	-0.02	-0.05	
Vix	-2.74	-1.86	
		*, **, *** Significant at 10,5,1 respectively	

For the first section of Table 3.6 (below), the Regression of SD on VIX has a moderate-strong R-square value. The T-Stat is at 14.61, which shows a very significant value. For the second section, the Regression of the SD on the Smirk, IV, and VIX has an R-Square value of .55, which is also a moderate-strong value, and a T-Stat for the VIX value of 10.86, which is significant. Finally, for the third section of the table below, the Regression of the SD on the IV and VIX has a .56 R-Square value and a very significant T-stat value when regressed on the VIX. This is the most important table for the overall research.

Table 3.6

SD Regressed On VIX			
Variable	*Coefficients*	*t Stat*	*Adjusted R Square*
Intercept	-0.042	-2.71	0.55
VIX Value	1.05	14.61	
Regress SD on Smirk, IV, VIX			
	Coefficients	*t Stat*	Adjusted R Square
Intercept	0.002	0.06	0.55
Smirk	0.02	0.99	
IV	-0.014	-0.69	
VIX Value	0.98	10.86	
Regress SD on IV and VIX			
	Coefficients	*t Stat*	Adjusted R Square
Intercept	-0.004	-0.15	0.56
IV	-0.026	-1.78	
Vix	1.03	14.33	
		*, **, *** Significant at 10,5,1 respectively	

Smirks

For this section, the graphs of the options analyzed were studied; these graphs primarily form what are commonly labeled "smirks." Examples of this can be seen below. First, a quick overview of smirks and how they are calculated is pertinent. Option pricing models, such as the Black-Scholes Merton Model and the CBOE mathematical model, are utilized. The calculation of these models can be seen in Section II. Regardless of the strike price, these pricing models assume that the implied volatility of the option for the expiration should be exactly the same. In other terms, they assume lognormality. This is important because when ATM options have a lower IV than the ITM or OTM options, the graph-plotted data forms a line that resembles a "smirk." Also, when both the ITM and OTM options have a higher IV, the graph can be referred to as a "smile." The overall research considered whether or not the smirk was down or not from the previous month; this has the possibility to provide more information due to the fact that it allows the implied volatility on options to be taken into account. The smirks further provide information that show OTM and ITM options normally have a higher demand than ATM options.

Figure 3.7

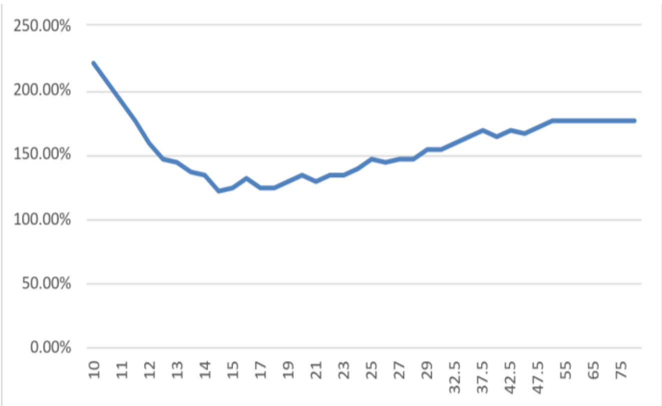

Figure 3.7 is a graph of the VIX Index from September 30, 2019. As the strike price decreases or increases away from the ATM strike price (16.48), the implied volatility increases; therefore, this is an example of a volatility smirk.

Figure 3.8

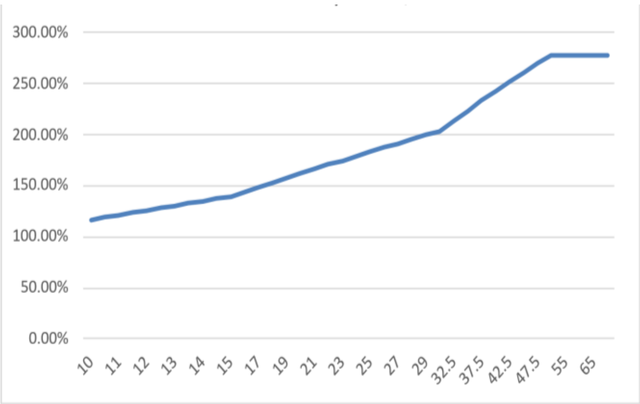

Figure 3.8 is a graph of the VIX Index from June 30, 2014. As the strike price increases away from the ATM strike price (11.63), the implied volatility increases; therefore, this is an example of a volatility smirk that is "up."

Figure 3.9

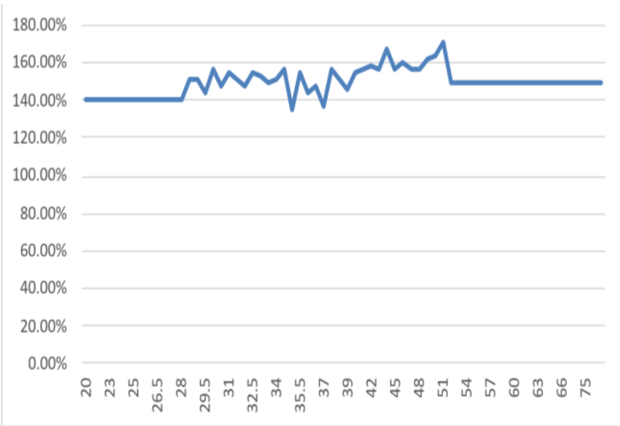

Figure 3.9 is a graph of the VIX Index from April 30, 2016. Instead of a smile, this is more of a “grin” due to the fact the plotted line does not increase or decrease when the strike prices are further from the ATM strike price.

Figure 3.10

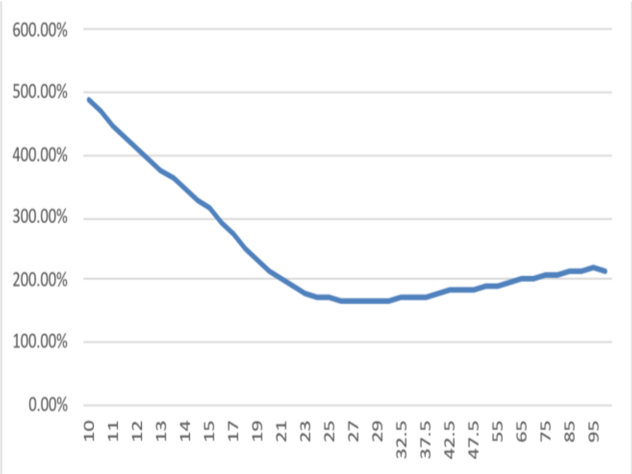

Figure 3.10 is a graph of the VIX Index on August 31, 2020. As the strike price is increasingly less than the ATM strike price, the volatility drastically increases. As mentioned, this can be due to extreme events. With COVID-19 casting doubt into investors, the demand for ITM options are heavily increased here. This creates a line that holds the curvature of reverse skew.

IV. Results/Trading Rules

The following section of this research paper will apply the research discussed above to the market and establish trading results. A simple trading rule based on buying the S&P 500 whether the VIX, IV of the VIX, and the VIX's volatility smirk declined over the preceding month results in an additional 0.96% in the following average monthly return. However, this only occurs approximately 10% of the time and does not outperform a simple buy-and-hold strategy.

The data in Table 4.1 (below) is primarily what the conclusions of the research are based on. Similar to the regressions and other graphs, the data is derived from monthly ending option prices from 2006 to 2020. Overall, the table includes the monthly percent gain from investing in the S&P 500 in different circumstances. For each column, the average median, standard deviation, minimum and maximum values are listed, along with the percentage of time the circumstance in the column occurs.

Table 4.1

	SPY Return	3M T-Bill	IV Falls	VIX Falls	VIX & IV Fall	Smirk Falls	VIX & IV Fall, Smirk Down
Average	0.84%	0.10%	0.75%	1.04%	1.63%	0.93%	1.80%
Median	1.36%	0.02%	1.28%	1.46%	1.51%	1.36%	1.42%
St. Dev.	4.32%	0.14%	4.41%	3.61%	2.84%	4.05%	2.72%
Minimum	-16.52%	-0.01%	-16.52%	-9.40%	-6.05%	-9.40%	-3.00%
Maximum	12.70%	0.57%	10.91%	9.93%	8.51%	12.70%	8.51%
% in market	100%	100%	50.00%	54.65%	20.35%	51.74%	10.47%

The first two columns (SPY Return and 3M T-Bill) simply contain the average of monthly SPY and 3-month Treasury Bill returns. The next five columns are derived from research. The third column (IV Falls) contains the percentage return for when the implied volatility of the VIX fell the previous month. The average monthly return this provides is .75%, which only occurs half of the time, and this is also lower than the average return for the S&P 500. Therefore, this is not a strategy that would be valuable to utilize.

Column four (VIX Falls) contains the percentage return for the month after the VIX value of the previous month fell. This proves to provide a much better return than when the IV falls, and this occurs around 55% of the time. Next, column five (VIX & IV Fall) contains the percentage return for the month after the VIX value and the IV of the VIX both decrease. The average is a 1.63% return, which is approximately double what the S&P 500 produces; however, this only occurs 20% of the time.

Column six contains the percentage return for the month after the smirk on the graph falls; in this case, the average return is .93%, which is not significant. Finally, column seven, which holds the most important information to the study contains the percentage return for the month after the VIX and IV fall, along with the smirk down. The monthly percent return in this case is 1.80%, which significantly outperforms the S&P 500. Similar to the other situations that outperform the S&P, this strategy only occurs 10% of the time. Also, when this happens, the market is doing relatively well overall; therefore, this isn't an effective strategy.

It is important to compare these results with previous research to either contrast or add evidence to further trading rules. In 2010, Xing, Zhang, and Zhan found that future stock returns are predictable based on the implied volatility skew, but immediate returns are not. "Stocks exhibiting the steepest smirks in their traded options underperform stocks with the least pronounced volatility smirks in their options by 10.9% per year on a risk-adjusted basis" (Xing et al., 2010). This is important since the research we have conducted also studies the smirks in their traded options. A solid point to mention is that we did not take into account the steepness of the smirks, and this could possibly add additional information to the proposed trading rules.

Another work that discusses implied volatility and the skew measures associated is titled, "What Does Implied Volatility Skew Measure?" by Scott Mixon, who is a director at Lyxor Asset Management in New York, NY. "A main conclusion from the analysis is that many popular skew measures are strongly influenced by the levels of volatility and kurtosis implicit in the distribution" (Mixon, 2011). Although this study doesn't include stock market returns, it does research the skew measures and how they're influenced by the levels of volatility of volatility and kurtosis. Our research could add further evidence to this by examining our smirk graphs and the regressions pertaining to smirks (which looks at volatility and possible kurtosis).

V. Conclusion

This study examines the Chicago Board Option Exchange (CBOE) Volatility Index (VIX) which is the implied volatility attained from short-term options on the Standards &

Poor's 500 stock index (S&P 500). Findings suggest VIX overestimates average volatility by approximately 3% but explains 55% of S&P 500's proceeding month's volatility. The value of the VIX, implied volatility of the VIX, and the graphs of volatility smiles/smirks were utilized in this study to determine and establish trading rules for the S&P 500 index. Overall, five different combinations of the variables listed above (VIX, IV of VIX, Smirks) were analyzed to determine the monthly returns for each. The two most useful strategies formed from this analysis were from the VIX and IV decreasing from the month before, which created a 1.63% average monthly return and from the VIX and IV decreasing from the month before, along with the smirk graph down, which created a 1.80% average monthly return. Both of these values are significant when considering the S&P 500's average monthly return is .84%; however, the two conditions that outperform this value only occur 20% and 10% of the time, respectively.

This research provides implications that might be useful for individuals who aspire to only be exposed to the market occasionally. For example, someone who wants to heavily mitigate their risk might choose the strategy that allows for a 1.80% monthly return instead of investing with a simple buy-and-hold strategy. Furthermore, the research could be applied when investors are adding to or drawing out of their initial positions. For example, if the VIX and IV decreased from the preceding month's values and the smirk graph was down, an investor who is considering withdrawing funds from their positions would benefit from holding them, and an investor who is considering adding more shares to their positions would benefit from buying during this situation.

When considering future research opportunities, it would be useful to see if this strategy might also be effective when dealing with other investments such as cryptocurrency. Another future research idea might be to look at different timeframes, such as quarters or years, and apply the same strategy. Finally, the variables could be paired with other market measurements to further the research.

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