VIX, VIX Futures, and VIX ETNs : Strategies for Success

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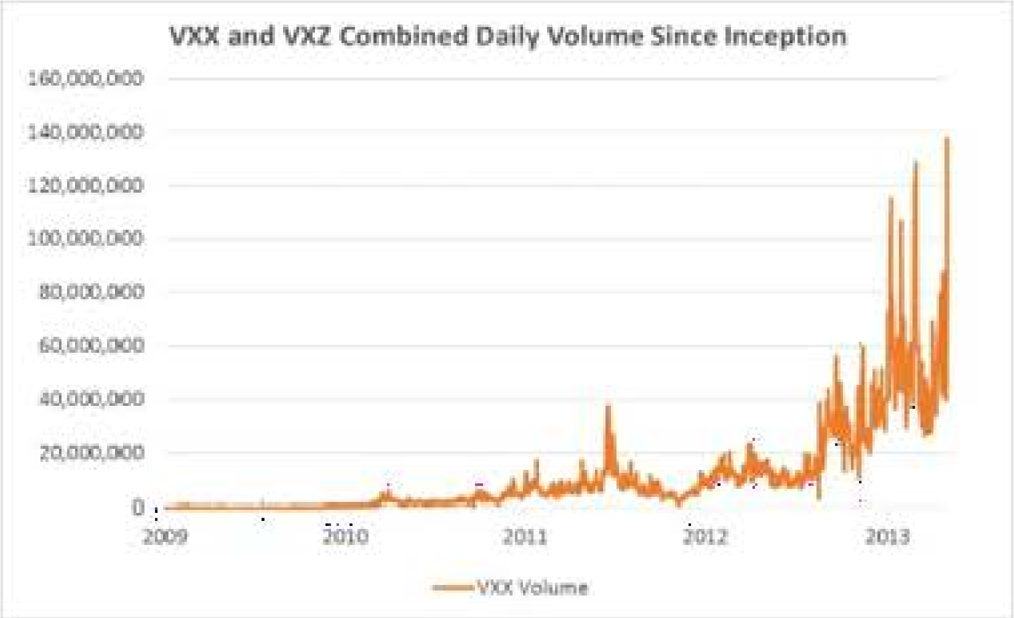
Introduction: Why You Should Learn to Trade the VIX Index

You never know who's swimming naked until the tide goes out
-Warren Buffet

We tend to think of investing as a way of making returns on capital. However, we often forget that there is another <u>equally important</u> aspect of investing: preservation of capital. If investing were a sport, generating investment ideas represents the 'offense', while capital preservation represents the 'defense'. And like sports, strong defense is required for winning in investing; one simply cannot make money after he loses his capital. Thus, we have decided to write a book that contains practical tips and strategies for playing great portfolio defense, using the VIX index, VIX futures, and VIX ETNs as the vehicle.

The VIX index and its related products represent the *fastest growing segment* of the financial derivatives market. They have become immensely popular in the recent years among both retail and institutional investors, since they offer greater liquidity and transparency than traditional options and futures. For example, the liquidity of VIX futures have eclipsed that of S&P 500 options since 2011, and their average trading volumes have grown from less than one thousand contracts/day to over 150 thousand contracts/day from 2004 to 2013. Similarly, the average daily volume of VXX, the most actively traded VIX ETN in the market, has *quintupled every year since 2009* to become one of the most actively traded ETFs (average daily volume of VXX has reached almost 100 million shares per day). Thus, VIX futures and ETNs are now part of mainstream finance, and can no longer be treated as a niche area within options trading. Their combined volumes have eclipsed that of traditional S&P 500 derivatives, making them the de-facto products for expressing views on market volatility.



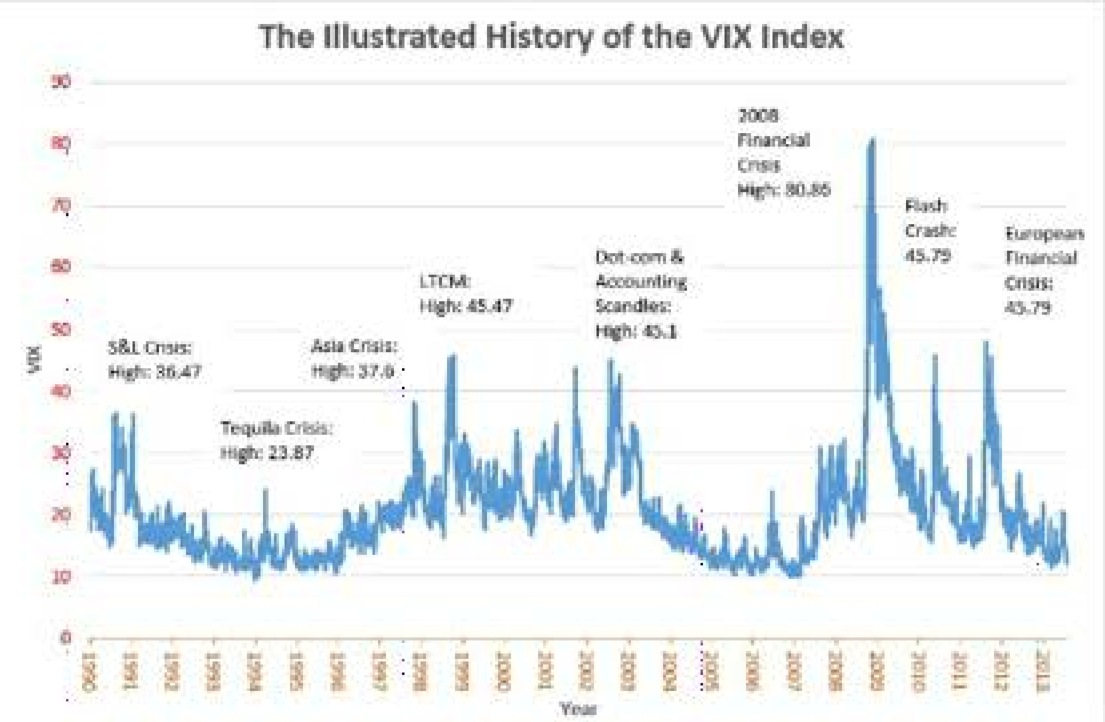
Parabolic: The daily volume of VIX ETNs (VXX and VXZ) have quintupled every year since 2009 to become one of the most actively traded ETFs in the world.

How This Book Is Different from All Other Options Books You'll Find on Amazon

Unfortunately, the public's knowledge and understanding of the VIX index products have not kept pace with their tremendous growth. The reality is that these products have only been trading actively for the past four years, and there is a dearth of quality resources for learning about these products. Since the VIX index is an indicator of S&P 500 option volatility, many existing materials about the VIX index is typically taught with professional option traders in mind as the audience. As a consequence, too many of those resources either 1) assume too much prior knowledge, or 2) overcomplicate the concepts with esoteric financial mathematics, while providing little emphasis on practical intuition. This book aims to address this gap, and serve as a practical and accessible guide for traders and investors alike that are new to the VIX index, equity derivatives, or volatility investing.

Why Bother Learning About the VIX Index?

The story of the VIX index is a tale of panic, fear, and crashes. Launched in 1993, the VIX index has become the most widely watched indicator of investor sentiment in the world. High readings of the VIX index indicate bearish investor sentiment, while low readings suggest investor optimism. Due to this behavior, the VIX index is said to have a strong *negative* relationship with the stock market. There's NOTHING ELSE IN THE MARKET THAT PREDICTABLY DOES BETTER WHEN THE STOCK MARKET CRASHES! The index tends to spike when the stock market does the worst, and fall the hardest when the stock market does the best. For example, the all-time high of the VIX (89.53) was registered on October 24th, 2008, one of the darkest days in modern finance. On the other hand, the all-time low of the VIX (9.31) was registered on December 22nd, 1993, in the middle of the great 90's bull market. Thus, the VIX index is an insightful gauge of investor's bearish sentiment (like the Put/Call ratio, except more intuitive). Its significance in the investing universe comes from its distinctly inverse relationship to the stock market.



Polar Opposites: The above chart shows how the eight biggest spikes in the VIX index have coincided with the eight biggest sell-offs in the S&P 500 since 1990.

Portfolio hedging with the VIX index and its derivatives is about effectively harnessing this inverse relationship. In another words, how does one take MAXIMUM advantage of the fact that the VIX index provides a hedge to the S&P 500? In this case, 'efficiency' requires knowing when and when not to long or short VIX futures and VIX ETNs, as well as the reasons behind the timing. In order to achieve this level of proficiency, one must have a three-tiered understanding of the VIX index, VIX futures, and VIX ETNs: product knowledge, analytical framework, and implementation techniques. It is easy to see why product knowledge and implementation techniques are important for success.

Analytical framework, however, tends to be less emphasized in typical trading/investing education. A framework is crucial for self-directed trading/investing, since it allows one to independently create strategies in the future. Thus, we have spent extra effort introducing analytical frameworks for all products covered in this book.

The Organization of this Book

The book is organized into three parts: the VIX index, VIX futures, and VIX ETNs. The order of the three parts reflects the fact that the VIX index is the primary index, while the futures and ETNs are its derivatives. Each part is further divided into chapters on product knowledge, analytical framework (product properties), and implementation.

What do we mean by "product knowledge"? Product knowledge just means knowing how each financial instrument works. For example, in order to trade futures, you need to know which exchange they trade on, what multiplier the contract is traded with, the minimum price increment, etc. It's basically like knowing where the clutch, steering wheel, and the stick is for driving a car on manual transmission. Thus, the chapters on product knowledge include basic overviews of each product, its features and specifications, discussions of the pros and cons, use cases, as well as limitations.

After we cover the basics of the product, we go on to teach you how to THINK about these products. In other words, our goal is to provide you with an analytical framework for the VIX index, VIX futures, and VIX ETNs. Having an analytical framework is a must if you want to actually understand the price action of these products. Without one, for example, a trader has no clue whether a futures contract is trading rich or cheap.

Lastly, the implementation sections discuss sample strategies, the pros and cons of each, simulation results, the common pitfalls, and risk management. These are the nitty-gritty details on how to place your first trade and manage its entire lifecycle from entry to exit. In addition, we will spend a lot of time showing real examples of how to manage your risk when trading VIX futures and VIX ETNs to minimize the risk of blow-ups.

On final word - each chapter's material builds upon previous chapters', so we highly recommend the reader to follow the book in order.

Additional Benefits of This Book

As pragmatic investors ourselves, we understand that no one wants to read about math when reading a book about the markets. Therefore, we have done the following things to maximize the book's value to the reader.

All Concepts Explained in Plain English to Improve Retention and Readability: In this book, you will find clear explanations of the VIX index, VIX futures, and VIX ETNs that are written with the practical trader in mind. True, many fundamental concepts that underpin the VIX index come from option theory. Unfortunately, option theory is one of the most misunderstood and poorly taught areas in finance, because most education material out there (books, courses, etc) explain concepts in an overly mathematical fashion. Unfortunately, being that best at deriving Black-Scholes formula or reciting all the greeks does not make you the best trader. Thus, we have spent extra effort to ensure that all material is explained in the clearest manner without sacrificing completeness.

Wealth of Examples: The best way

to learn how to invest is by doing. The second best way is to study a ton of examples. This book contains over 50 charts and examples to help thoroughly explain the concepts presented. It also contains ten back-tests of actual VIX futures and VIX ETN strategies to illustrate how certain VIX strategies have performed in the past. These types of analysis can be extremely tedious and time-consuming to perform without the right infrastructure; therefore, we have decided to provide as many of them to save time for the reader.

Keen Focus on Practical Knowledge: Learning a new product can be tough, especially when one does not know what is important and not. For example, one can spend decades becoming a master of financial engineering. However, very little knowledge in that field DIRECTLY applies to practical trading. Similarly, one could spend years learning about the VIX index by drilling deep into the fine nuances of skew, convexity, second/third order option greeks… or save time by focusing on acquiring practical knowledge. Life is too short for re-learning all the complex math that our smarter forefathers have solved for the future generation. Our job is to take practical knowledge and start making money trading. That does not mean that we will skimp on the facts; it just means that overly theoretical models will be skipped to make room for discussing the nuances of each product that actually matter in real life.

* * *

The market tends to reward calculated risk and punish complacency. The price of complacency can be extremely high, as we have found out in 2008 and countless other times in history. Portfolio hedging is like health insurance. No one thinks they need one until they get sick. Unfortunately, it becomes too late by then to purchase insurance, because the market will raise its premiums to oppressive levels. VIX futures and VIX ETNs work the same way. Fortunately, there are many predictive factors one can learn about the VIX index that can help one implement efficient portfolio hedging strategies. Just like one can predict his future health conditions by his health habits, investors can assess the expected return from VIX futures and ETNs based on market variables.

Time is now to start learning about the VIX index, VIX futures, and VIX ETNs. The old adage goes ‘don’t close the stable door after the horse has bolted’. Prudent investing requires one to develop a flexible mindset about hedging, and to actively prepare for adverse scenarios if the need arises. It requires one to maintain an objective view of the market, and to avoid falling into the trap of thinking that hedging will never be required. The markets are and always will be cyclical. With the S&P 500 in the fourth year of its historic rally since

2009, the odds of a market correction occurring will only increase with time. Fortunately, the VIX index is also hovering near the lows, providing investors with a great entry point. Thus, regardless of one's market view, time is ripe for learning about the VIX index and its derivatives, which are one of the most powerful hedging instruments available in the market.

Finally, the book also covers how to make money EVEN IF the market does not EVER sell-off. That's right. The beauty of trading the VIX index is that it allows you to make money even if the market is STABLE. In fact, shorting VIX futures and VIX ETNs have been one of the most profitable strategies in the past 5 years. It has been so profitable, when done right, that most professional options traders and sophisticated hedgefunds never talk about it in public (understandably). But don't worry – both parts 2 and 3 of this book will cover simple tips on how to short VIX futures and VIX ETNS the right way.

We hope all readers to gain valuable insights from this book, and wish everyone success in investing.

To Your Volatility Trading Success,

John Hwang
Silvertrend, LLC

Preface: Understanding Volatility Jargon

Before we start the discussion of the VIX index ($VIX), we will provide a quick overview of crucial pre-requisite knowledge for understanding the concepts in this book. One cannot understand $VIX without fully understanding the basic concepts in option theory, namely the following:

- The difference between historical and implied volatility
- How to interpret implied volatility properly in option trading context
- The meaning of 'volatility trading', and how money is made trading options

The reason why these concepts are important is because $VIX and S&P 500 options are closely related, as we will see in the first chapter when we introduce $VIX. Seasoned option traders who know these concepts inside and out can proceed directly chapter one; others will benefit from reading the rest of this section.

Two Types of Volatilities

Everyone is familiar with the concept of market volatility; higher the volatility, bigger the market moves. In the context of options, however, volatility takes on very specific meanings. There are two variations of the term, historical volatility and implied volatility, which are completely different things. Much of people's confusion about implied volatility comes from misunderstanding the differences between the two terms. In order to clarify these concepts, we will define the terms individually as well as highlight their differences.

Historical Volatility

In the options jargon, historical

volatility (or "realized" volatility – these are the same things) is simply a number that measures the volatility of daily market returns for a specific time period in the past. Historical volatility quantifies market volatility, so that it can be measured, compared, and analyzed easily. For example, a thirty day historical volatility number will quantify how volatile the market has been for the previous thirty days. A sixty day historical volatility will do that for the previous sixty days, and so on. Notice that historical volatility cannot be discussed without specifying a timeframe as well.

The three key points about historical volatility are the following:

- It is calculated purely from historical data. Future estimates of any kind are not used.
- It is measured as a standard deviation of historical daily returns
- It is presented as an annualized figure in terms of volatility points, i.e.

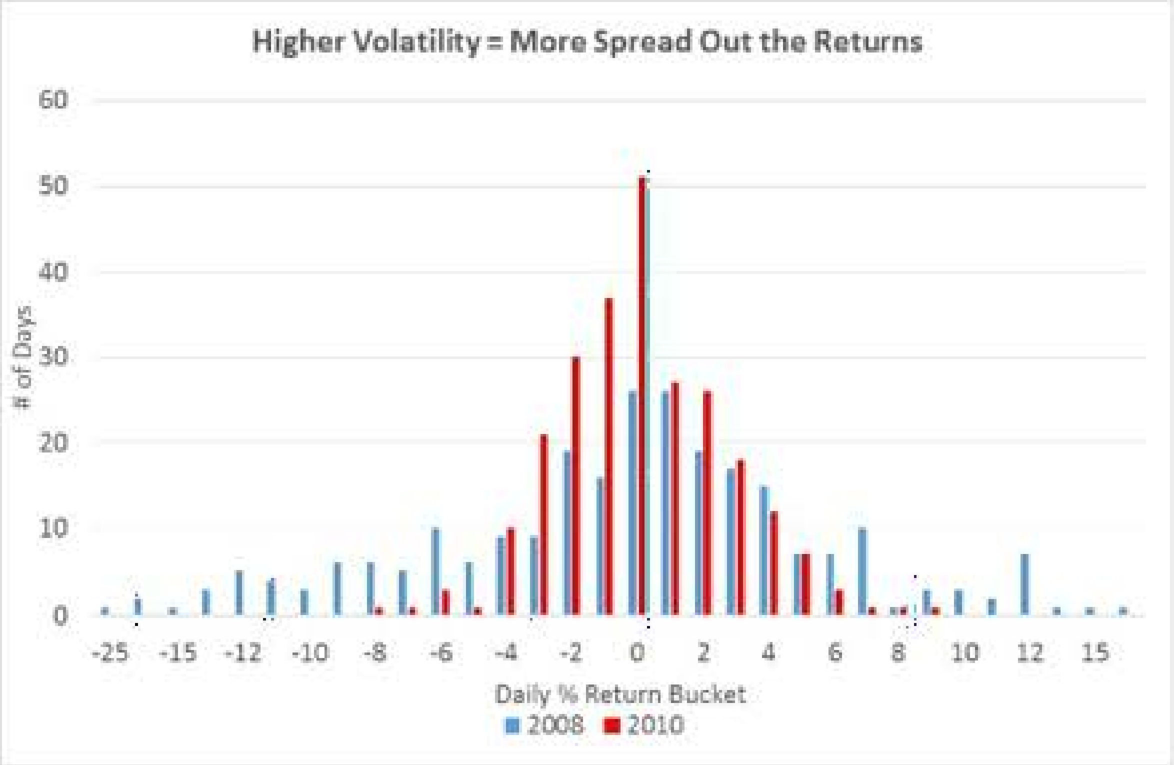
The first point illustrates that historical volatility is a backward looking metric of volatility. It is calculated purely from historical price data, and hence contains no information about future expectations. Instead, the number will allow us to quantify what has already occurred. If the market was more volatile in one month than in another, historical volatility will capture that the difference in terms of numbers.

Table: Examples of Backward Looking and Forward Looking Metrics

Backward Looking Metrics (i.e. data)	Forward Looking Metrics (i.e. guesses)
Analyst Price Targets **P/E Ratios** **GDP data** **Last week's weather**	Analyst Earnings Estimates Projections GDP Forecasts Weather forecasts

The second point shows that historical volatility is calculated as a standard deviation of market returns. In the context of historical volatility, standard deviation is a metric that quantifies the variation of returns around the average return in the past. In another words, it indicates how spread out or clustered the returns have been around the mean during the look-back period. Higher market volatility means that the daily returns have been more spread out. Quiet markets, on the other hand, would be categorized by daily returns that are clustered around the historical average.

To visualize this difference, see the two histograms below which shows the distribution of daily returns for Mosaic common stock (MOS) in 2008 and 2010. The two years were chosen because the stock experienced extremely different levels of volatility for these years (110% in 2008 versus 40% in 2010). As we can see, the blue distribution (2008) is much more spread out than the red distribution (2010), which is clustered around the center with fewer observations in either tails.



The third point concerns the presentation of the historical volatility number. After the standard deviation is calculated for historical daily returns, the figure is multiplied by the square root of 252 in order to annualize the volatility figure (from daily volatility to annual volatility). This step finalizes the calculation. The annualization is done as a market convention, which makes comparing historical volatilities easier by standardizing different lengths of time to the unit of one year.

Therefore, the formula for calculating historical volatility can be expressed as the following:

$\sqrt{252} \times$ Standard Deviation of Historical Daily Returns , or roughly
$16 \times$ Standard Deviation of Historical Daily Returns

Implied Volatility

If historical volatility is a backward looking measure of volatility, implied volatility is a forward looking metric. Examples of forward looking metrics include analyst estimates of stock price, weather forecasts, and GDP predictions. The common characteristic is that these numbers are estimates of future events. In the same vein, implied volatility is an estimate of market volatility in the future.

These estimates of future volatility of the market are made by the options market. The actual mechanism of this is very similar to how the insurance markets work. After all, options are a form of insurance used for hedging market exposure.

- One way to interpret options is to think of them as insurances against adverse scenarios in the stock market. Put options insure portfolios against drops in the market. Call options insure the shorts against market rallies.
- The key feature of any insurance contract is that its premium adjusts according to the probabilities of events; otherwise, insurance contract writers will lose more money in payouts than receipt of annual premiums. For example, cancer insurance premiums are higher for smokers in order to reflect the higher risk of cancer.
- For options, the premiums fluctuate based on people's expectation of future volatility. Higher premium implies higher risk of market volatility, and lower premium reflects the opposite. This is simply because high market volatility increases the chances that op-

tion contract will pay off. Conversely, it is unlikely that options pay off when the market moves slowly. In this case, the premiums will adjust down as the demand for portfolio insurance decreases.

- We can tell what the insurance company thinks of a person's health prospects by seeing how high or low his or her insurance premiums are. Similarly, one can infer from options price what the market thinks will the market volatility in the future. This future volatility figure derived from option premium is implied volatility.

The parallels for implied volatility can be found in many places. For example, insurance premiums can be analyzed to determine the probability that the insurance company is assigning to various disasters. In poker, pot odds can be analyzed to determine the breakeven probability of winning a hand. In horse racing, odds can be analyzed to measure the probabilities of each horse winning.

The common feature of these examples is that each case involves a metric that one can analyze to derive estimates of future events. By the same token, implied volatilities tell us the options market's estimate of the future range of stock market's movements.

Key: The Implied Volatility of an Option Indicates What the Market Thinks of the Future Volatility of the Underlying Stock or Index

How to Interpret Implied Volatility

When traders say a stock moves with 'X vol', what does that mean? Implied volatility is usually presented in the annualized percentage form, just like historical volatility. In its annualized form, implied volatility indicates the one standard deviation move for the market in one year. However, people may find volatility figures for shorter timeframes more useful, since one year is beyond investors' typical holding periods. In practice, 30 day or 60 day implied volatilities are most commonly used. Adjusting annualized volatility figure to shorter timeframes can be done by using the following method:

Table: How to Convert Annualized Volatility to Any Timeframe

Conversion Target	Formula
Daily Volatility	$\frac{\text{Annualized Implied Volatility}}{\text{sqrt(252)}}$
Weekly Volatility	$\frac{\text{Annualized Implied Volatility}}{\text{sqrt(52)}}$
Monthly Volatility	$\frac{\text{Annualized Implied Volatility}}{\text{sqrt(12)}}$
Quarterly Volatility	$\frac{\text{Annualized Implied Volatility}}{\text{sqrt(4)}}$

Implied volatility is used most commonly to answer questions like ‘how much does the market think XYZ stock will move on a daily basis?’ The most commonly made adjustment is to convert the annualized implied volatility figure in terms of a daily volatility figure. Daily volatility figure indicates the standard deviation of daily returns. The same logic applies for weekly, monthly, and quarterly volatilities. For example, suppose implied volatility of an option is 32%. We can divide this number by 16 (which is approximately the square root of 252) to get 2% for the daily volatility figure. The number shows that the option is pricing 2% a day movement during the lifetime of the option. In general, the daily volatility calculation is simplified by dividing by 16, which is an approximation of the square root of 252. This method is also called Rule of 16.

Generally, the following are considered the ‘key' levels of implied volatility for the S&P 500 index:

- Historical volatility of 16% implies that S&P 500 will move with 1% a day
- Historical volatility of 24% implies that S&P 500 will move with 1.5% a day
- Historical volatility of 32% implies that S&P 500 will move with 2% a

day

- Historical volatility of 40% implies that S&P 500 will move with 2.5% a day

These levels the key psychological levels that professional traders tend to watch. Since 1950, the historical volatility of the stock market has been around 16%, which equates to 1% move per day on average. Thus, a 32% historical volatility regime will feel much faster, given that the market's moving twice as much per day. In general, any level above 24% is considered abnormally high for historical volatility.

Applying the Insights to Volatility Trading

Let us look at another misunderstood term: 'volatility trading'. Like many finance jargons, the phrase is over-stylized and unnecessarily ambiguous for most traders and investors. Volatility trading can simply be paraphrased as "buying undervalued options and selling overvalued options." The main way to decide whether an option's 'overvalued' or 'undervalued' is to evaluate the plausibility of the implied volatility estimate embedded in the option. For example, if one believes that implied volatility is too low compared to his view of future volatility, then the option is undervalued to the trader. Of course, the trader needs to have good reasons to believe why his view is correct (and the market's view isn't). Simply put, volatility trading refers to the process of buying options with cheap implied volatilities and selling options with expensive implied volatilities.

Example: Suppose one believes that Microsoft stock will move around 2% a day for the next month (32% annualized volatility), because the investors will feel more insecure about the stock as the earnings date approaches. He sees that one month ATM Microsoft straddle is priced at implied volatility of 24%, which converts to daily volatility of 1.5%. According to his view, the Microsoft one month ATM straddle is undervalued, and should be purchased.

Another Example: Suppose Google ATM options expiring in two months is priced at 32% implied volatility. However, he sees that the earnings release does not come for another three months, and believes that the Google stock will not move more than 1% a day until the earnings release (16% in annualized terms). According to this view, Google two month ATM options are overpriced, and hence should be sold.

In the above examples, the trader compares the market's view of implied volatility against his own to make trading decisions. This process is akin to how horse racing bets are made. In this case, one compares the house odds to his personal opinion of the odds of each horse winning to find overvalued and undervalued bets. One must remember, however, to do the proper homework and have a sound basis for making any contrarian bets.

There is another way of determining which options to buy and sell. Instead of comparing one's own estimate of future volatility to implied volatility, one can also just focus on the supply and demand of options. For example, if one believes that option demand will be higher, then he can bet on higher implied volatilities by purchasing options. In this case, one is trading options simply based on the view that someone else in the future will be willing to buy higher or sell lower. The purchase or sale is made solely with the goal of flipping the position over to others at a profit.

<u>Example</u>: Suppose Google ATM options expiring in two months are priced at 32% implied volatility again. This time, however, the earnings will fall the day before the Google options' expiry. Since there is a catalyst before option expiry date, trader believes that the im-

plied volatility could squeeze higher to 36% volatility. With that profit target in mind, he may buy the Google options for short term gains without having a view on how much the Google stock will actually move.

In the above example, trading decision was made because one believed that implied volatility itself will appreciate. One did not explicitly factor in a view on future volatility. Instead, the main view expressed is that the implied volatility level will increase due to higher demand.

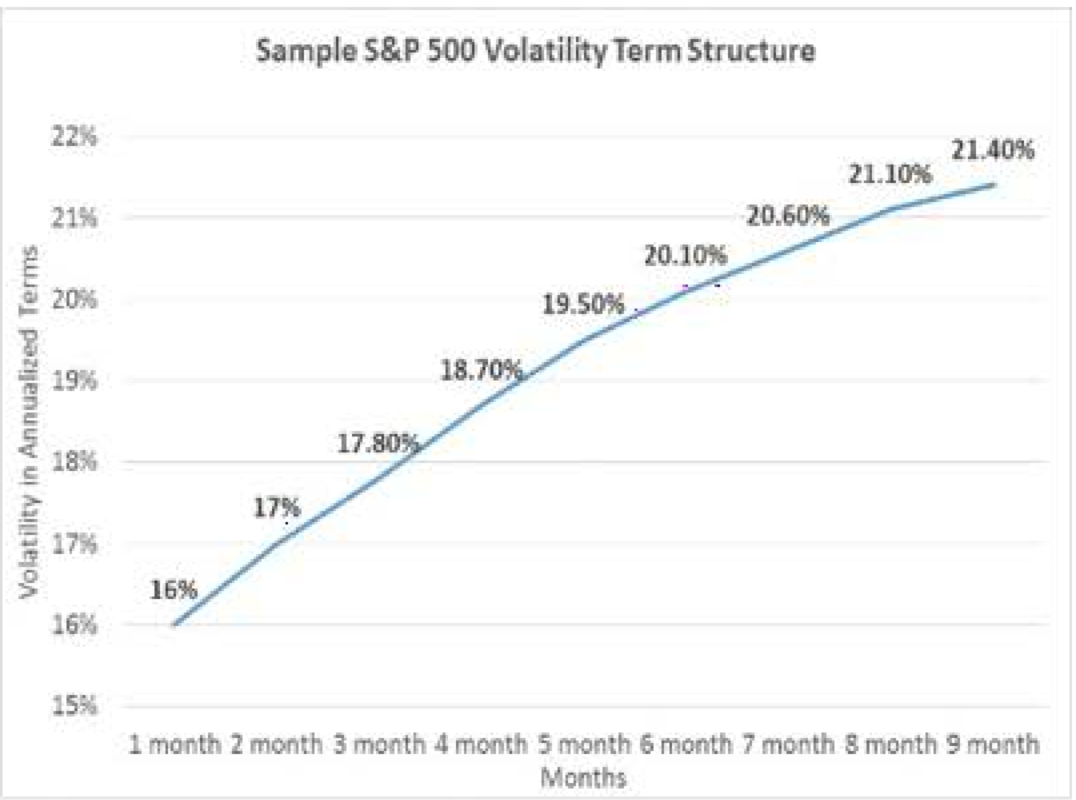
Regardless of the approach, volatility trading means buying and selling options based views on implied volatility.

Key: The two main approaches to making volatility trading decisions are:

Comparing implied volatilities with one's own view of future volatility, or *taking views on supply/demand for options*

Term Structure of Volatility

The last option trading lingo we will cover is 'term structure of volatility', or simply term structure (The 'curve' is another synonym that refers to the same concept). The terminology simply refers to the relationship of implied volatilities between options of different expiries. For example, option expiry dates for the S&P 500 index can span from 1 week to 3 years, and options of different expiries tend to have different implied volatilities. This is because the risk of insuring a portfolio varies depending on how far the option expiry date is from now. When the term structure is plotted as a graph of implied volatilities across different expiries, the plot is called a 'volatility curve'.



In normal market environments, this volatility curve for S&P 500 tends to slope upward with time to expiry. In another words, option implied volatilities normally tend to be higher for longer term contracts. Why? All things equal, insuring something for a longer term is more risky than insuring something in the short run, and hence the insurer will demand a higher premium. Imagine an insurance company has the choice of underwriting fire insurance for three weeks versus three months. The company should be more hesitant to walk into a longer term commitment, and hence will demand a higher premium. Similarly, longer term options tend to have higher implied volatiles than shorter term options. This effect is commonly known as the term premium.

In addition to term premium, the upward sloping term structure can be explained by liquidity premium. Longer dated options are not as actively as traded compared to short dated options, because the ranks of market participants shrink with expiry. This is mainly because most investors have little natural need for trading options that expire two, three, or more years in the future. Lack of interest, coupled with lack of liquidity tends to make shorter dated options more attractive for trading, especially for option writers (sellers). It is much harder to liquidate longer dated options, since bid ask spreads tend to be much wider than that of short dated options. In addition, the amount of liquidity available will be much smaller due to lack of interest. Therefore, it is a safer bet for market makers to sell longer dated options with additional premium that compensates them for the lack of liquidity.

When the markets are under stress, however, the slope will most likely flatten or invert due to spike in shorter dated volatility. We will go into greater detail in later chapters when we formally introduce VIX futures. There are many more dynamics that drive implied volatilities and the term structure. However, with the discussion presented in this preface, the reader is hopefully equipped with the essential understanding of important volatility concepts to derive full value from our discussion of the VIX index and other VIX derivatives.

Summary

- The VIX index is a market index that measures implied volatility
- There are two types of volatilities in option jargon: historical volatility and implied volatility
- Historical volatility is a backward

looking measure

- Historical volatility measures standard deviation of daily returns in the past period
- Implied volatility is a forward looking measure
- Implied volatility is a number that reflects the options market's estimate of future volatility
- Volatility trading means buying undervalued options and selling overvalued options
- Term structure refers to the relationship of implied volatilities between options of different expiries
- Term structure, when plotted, is called volatility curve
- Term premium and liquidity premium explain the higher implied volatilities for longer dated options

Part One: The VIX Index

Chapter One: Introduction to the VIX Index

The VIX index ($VIX) is a weighted measure of implied volatility for S&P 500 ($SPX) options.

Unfortunately, this commonly used definition of $VIX is too abstract for many investors. For example, it is not immediately clear why investors should pay attention to it, let alone trade it. Essentially, it is not obvious from the definition why investors should care about $VIX, and how it relates to investing. To make $VIX easier to understand, we will use the analogy of $SPX to highlight how we can use the index and why it is useful for investors.

Why is $VIX Important?

$SPX is a weighted average of stock

prices for the 500 largest companies in the U.S. The fluctuations in $SPX tell us whether stock prices, overall, are higher or lower. The index is useful because it communicates this information concisely in a single number. It does the messy calculation for investors and saves them time and money. In addition, one can study the index's historical data to discover useful properties about the stock market.

Similarly, the VIX index is a weighted average of 30 day maturity implied volatilities for S&P 500 options. $VIX helps investors understand how implied volatilities are changing, in aggregate, in a concise manner. It allows investors to quantify how people's expectations of future market volatility have changed. The historical data for $VIX is available to everyone, and it can be studied for discovering useful patterns in implied volatility.

If tracking implied volatility were unimportant, $VIX would be insignificant as well. Essentially, analyzing $SPX volatility provides investors with unique insights that cannot be garnered from studying other market indices. $VIX provides those insights in mainly two forms, which are explained below.

Short Term Expectations Indicator: Since $VIX is a measure of 30 day implied volatility, it reflects the market's expectation of short term future volatility by definition. We mentioned in the preface that implied volatility reflects how market participants feel about the market. High implied volatility reflects uncertainty, and low figure reflects confidence. Therefore, $VIX levels tell investors whether the market expectations, in aggregate, are aligned (stable) or dispersed (unstable).

Market Sentiment Indicator: Related concept is that $VIX is a market sentiment indicator. Humans tend to be bearish about the stock market when facing high uncertainty, and bullish during stable environments. There is plenty of academic and empirical evidence that supports this statement. For example, mutual fund in-flows (buys) tend to be at the highest when the markets are stable and trending upwards, and at the lowest when the markets are on a downtrend. That is because humans tend to be risk-seeking when the markets are stable, and risk-adverse in the face of uncertainty. This implies that $VIX reflects market sentiment; the index tends to be low when the overall market sentiment is bullish, and high when it is bearish.

Another reason why $VIX is a sentiment indicator is the following. Recall that $VIX tracks implied volatility, which reflects the price of insuring against stock market volatility. The demand for insurance is at the highest when investors are bearish (read: fearful). If investors were bullish, then there would be little interest in protecting portfolios against losses, and hence implied volatility will be low. To summarize, $VIX levels reflects investor sentiment, which coincides with fluctuations in options demand.

Lastly, $VIX is important for investors as a diversification device. One cannot directly trade the VIX index (we will discuss that later in this chapter). However, CBOE and Wall Street developed a suite of products (such as VIX futures and VIX ETFs/ETNs) that give investors exposure to $VIX. Alternatively, investors can trade S&P 500 options to gain exposure to implied volatility. Studies from academia and industry have shown that inclusion of volatility products in equity portfolios help improve risk profile of equity portfolios. Interestingly, it has also been shown that one can make money shorting the VIX index and its derivatives as well. In the later chapters, we will also look at how to make money trading $VIX-related products from both long and short sides.

Main Features of the VIX Index

For a market index to be widely used and trusted, it must be calculated with a transparent, replicable methodology. It also needs to be published frequently enough in order to be very useful. Otherwise, the index could be manipulated by certain interest groups (such as LIBOR) or become too stale to be useful (like real estate indices that publish monthly with a lag). The VIX satisfies these usability requirements, since it has the following features.

- Systematic Methodology: $VIX follows a purely systematic methodology such that all market participants can replicate it if they wish to do so. Absence of discretionary element makes the index more trustworthy and responsive. If discretionary elements existed, CBOE would not be able to publish the index intraday.
- Transparency: $VIX uses market prices of real $SPX puts and calls to calculate implied volatilities. The VIX is calculated from mid-market prices

from $SPX options' electronic screen markets. Since actual trade prices happen around mid-market prices, $VIX does a fair job reflecting the reality.

- Frequency: $VIX is calculated intraday. High refresh-rate of data increases its usefulness as a market indicator, since it always presents the most up to date information.

The Importance of Indexing

$VIX was the first index ever to aggregate option volatility information concisely and transparently into a single number, sparking disruption to the archaic options marketplace. Indexing, in general, makes data analysis more convenient and efficient. For example, the S&P 500 index provides investors a fast and reliable estimate of U.S. equity market performance. Options, however, benefited more from indexing than any other asset class, because options are inherently more complex.

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problems of the options market. Before the advent of the VIX index, gauging the overall level and changes of implied volatility was nearly impossible due to the large number of option types and maturities. For a single expiry, there can be more than two hundred options with different strikes and types (put or call). To complicate matters, each option behaves differently from day to day, since every strike has unique supply and demand factors driving implied volatility. One cannot simply interpolate the implied volatility change of one strike to every other options. For example, the implied volatility change of a single strike says very little about how much the entire options market moved in aggregate.

For an accurate estimate of aggregate implied volatility changes, implied volatility changes must be tracked on a strike by strike basis, gathered, and summed, which is a very involved process. In addition, Black-Scholes calculations have to be run on hundreds of different strikes at every second, which would require over a thousand different market data inputs to be updated as well. The VIX index simplified the problem by doing these computations on behalf of everyone at the exchange level and broadcasting the result in the form of a single number.

The VIX index also helped improve transparency of the options market by making option volatility data more accessible. The index updates intraday and is transparent since it is based on live option mid-market data. In addition, extensive historical data is available for the past two decades for free online. This is a large step forward from the past, when transparent implied volatility data was difficult to obtain. Calculating option volatility is not an easy task, since it requires tools that most people do not understand or have access to. Even today, tools that allow people to track listed option volatility come with steep price tags. In the 90's and early 2000's, the problem was much worse. Equity options as an industry was dominated by floor market makers and investment banks with the capital and desire to invest in high tech computers and calculators that could churn out accurate implied volatility estimates. Therefore, the VIX index helped democratize option trading and disseminate option volatility information to a wider group of investor base.

How to Interpret the VIX

Let's now dive into some practical stuff.

What does it really mean when $VIX is at 20, 30, or 40? The index is represented in annualized percentage terms (like 30), just like normal option implied volatility. However, it is easier to develop a feel for the $VIX when we convert it into a daily volatility figure using the rule of 16 that we learned in the preface. Daily volatility figure is more useful than an annualized figure because market volatility is felt on a *daily* basis. If all investors checked the market just once a year, then thinking of volatility in annualized terms is the right approach. However, most investors tend to mark-to-market on a daily basis; therefore, using annualized figure is not appropriate for risk management. Therefore, annualized volatility is most commonly converted to a daily figure.

Converting $VIX to Daily Implied Volatility Number

VIX level	Daily Implied Volatility	Weekly Implied Volatility
8	0.5%	1.1%
16	1.0%	2.2%
24	1.5%	3.3%
32	2.0%	4.4%
40	2.5%	5.5%
48	3.0%	6.7%
56	3.5%	7.8%
64	4.0%	8.9%
72	4.5%	10.0%
80	5.0%	11.1%

Example: Suppose the VIX index is currently 24. The rule of 16 says 24 equates to 1.5% daily volatility. (24 divided by 1.5) Therefore, we can conclude that S&P 500 options with thirty day maturity are indicating 1.5% movement per day for S&P 500 for the next thirty days. We can say that this number is comparatively low for 2008 standards (when the market moved more than 2% a day on average), but high for 2013 standards (when the markets are moving little more than 0.6% a day, so far).

<u>Another Example:</u> We can convert the VIX into weekly, monthly, and quarterly volatilities as well. For example, the VIX at 16 represents an expected annualized change of 16. To compute monthly expected change, we divide 16% by square root of 12, which gives ~ 4.6%. In another words, the VIX at 16 implies that the market is expected to change roughly 4.6% in the next month.

What is 'High' or 'Low' for VIX?

Where do we draw the line in the VIX? What is considered a 'high' level or a 'low' level? There are many ways of answering this question, but we will first look at the range of levels seen for $VIX in the past twenty years. This will give us a historical perspective of what $VIX should be in 'normal/bull market/ stable' versus 'abnormal/bear market/ unstable' environments.

First, take a look at the table below which shows the yearly average, maximum, and minimum figures for $VIX since inception. The right most column also shows whether that year was within one year from a recession as defined by National Bureau of Economic Research.

Year	High	Average	Low	Recessionary Cycle
1990	36.47	23.36	14.72	Yes
1991	36.2	18.38	13.95	yes
1992	20.51	15.43	11.51	
1993	17.3	12.68	9.31	
1994	23.87	13.94	9.94	
1995	15.74	12.42	10.36	
1996	21.99	16.47	12	
1997	38.2	22.38	17.09	
1998	45.74	25.60	16.23	
1999	32.98	24.36	17.42	
2000	33.49	23.30	16.53	Yes
2001	43.74	25.77	18.76	Yes
2002	45.08	27.28	17.4	Yes
2003	34.69	21.98	15.58	
2004	21.58	15.48	11.23	
2005	17.74	12.81	10.23	
2006	23.81	12.81	9.9	
2007	31.09	17.54	9.89	Yes
2008	80.86	32.69	16.3	Yes
2009	56.65	31.48	19.47	Yes
2010	45.79	22.55	15.45	Yes
2011	48	24.20	14.62	
2012	26.66	17.80	13.45	
2013	18.99	13.93	11.3	

We mainly note the following.

- For normal markets (non-recessionary cycle years), $VIX averages around 17
- In contrast, for abnormal markets (recessionary cycle years), $VIX averaged 24.7, which is significantly higher.
- Normal markets also saw $VIX range normally from 10 to 30 (at the 25% and 75% percentiles).
- Abnormal markets saw $VIX move in a much wider range, typically from mid-10's to low 40's. In 2008, $VIX even breached 80, and had multiple months where the VIX averaged above 50. <u>Also, none of the years had an average level of $VIX higher than 33.</u>

Thus, our preliminary investigation tells us the following. First, $VIX seems to have a strong support at 10 (a level in the 8's and below has never been seen), but upper bound seems to range wildly depending on the year. Second, $VIX tends to move very differently based on market regimes. In this study, we used

NBER recession to separate $VIX into abnormal and normal regimes, during which $VIX averaged around 25 and 17 respectively. Finally, it seems that 40 is a hard level to break for $VIX. $VIX has seen the absolute yearly high of 40 or higher in only seven of the past twenty three years. In addition, $VIX has never averaged above 32 for more than a year. Over shorter horizons (less than three months), however, $VIX has seen averages of up to 58. Thus, one can say that 40 is a soft resistance level for $VIX that holds more strongly over longer time horizons.

Finally, the fact that $VIX has moved within a strong lower bound and a soft upper bound suggests that $VIX is a mean reverting (read: range bound) indicator. We will discuss what this really means and why it is important in the next chapter. But first, let us discuss the calculation methodology behind $VIX.

(The Non-Technical) Explanation of

the VIX Calculation Methodology

Trading $VIX does not require a detailed understanding of its calculation methodology, similar to how driving a car does not require understanding the mechanics of engines. However, the knowledge of full technical details is essential for aspiring market makers, arbitrageurs, and serious option traders. For the day-traders of $VIX-related products, precision counts immensely. CBOE's own white paper on $VIX is an excellent resource, which provides a walk-through of the exact algorithm that the CBOE uses to calculate the index. For the rest of us, we provide a summary of the key points of the algorithm here. Again, full technical details provided in the CBOE white paper is worth every bit of time to solidify concepts discussed in the rest of the book.

Let us go back to the first definition of $VIX that we provided:

"The VIX index is a weighted measure of implied volatility for S&P 500 ($SPX) options."

This definition, however, does not tell us which specific $SPX options are used nor how the weighting is done. Here, we will elaborate on these elements, which should provide a good understanding of the factors that drive the VIX index.

Which $SPX Options Are Measured in the VIX Index?

Let us reiterate that the aim of the VIX index is to constantly track thirty day maturity option volatility. How can this be accomplished? In the ideal world, one should calculate a weighted average of implied volatilities for $SPX options that expire in thirty days, every day.

Unfortunately, there is a problem: thirty day constant maturity options do not exist every day. Regular S&P 500 options expire once a month, so by definition, there is only one day in the month that has a thirty day maturity option listed. If options were listed every day of the year, CBOE would just take all the options that expire in thirty days, compute their implied volatilities, average, and publish. In reality, there are less than fifteen expiry days for each calendar year.

How do we fix this problem? CBOE solves this problem by interpolating 30 day implied volatility from two sets of option expiries. Interpolating is just a fancy word for guessing. Before learning how CBOE makes these guesses, let us look at the rule for how CBOE chooses these two sets of option expiries.

- First, use the first two monthly expirations. Call these two expiries 'near-term' and 'far-term'. For example, if today is April 1st, 2013, use the April and May $SPX expiries, which fall on the third Friday of each month. In this case, April is the 'near-term' and May is the 'far-term' expiry.

- If the 'near-term' expiry is only one week away, discard, and replace with the third monthly $SPX expiry. Now, we are just left with the second and third month expiry dates. For example, on April 12th, 2013, which is exactly one week away from April 19th, 2013 (the third Friday in the month of April), $VIX will roll from April and May $SPX expiries into May and June $SPX expiries.

<u>Another Example:</u> On December 5th, 2013, $VIX will be calculated from December, 2013 and January, 2014 expiry $SPX options. On December 16th, 2013 (a week before December 2013 option expiry), however, $VIX will consist of January 2014 and February 2014 $SPX options.

Key: Don't stress the details. The important point to remember is that

$VIX's composition changes on a monthly basis.

We have decided on which expiries to use. Now, within each expiry, how does CBOE decide on what options to include? There are two additional parameters to think of now: strike and type (put or call). Basically, CBOE does the following, *for both near-term and far-term expiry options*:

- CBOE determines which strike is closest to the level where $SPX futures (forwards) are trading at. This strike is also called the anchor or ATM strike.
- CBOE then selects all calls with strikes above the anchor strike and all puts with strikes below the anchor strike. In another words, all out of the money (OTM) puts and calls are selected.
- CBOE then throws out all options that have $0.00 bids. This is done to make sure that options with zero-premiums have no influence in $VIX calcu-

lation.

- Finally, CBOE calculates a weighted average of implied volatilities with the remaining options.

<u>Example:</u> Suppose September 2013 $SPX futures (ESU13) are trading at 1602, on June 28th, 2013. $VIX will be calculated with July and August 2013 $SPX option expiries. Anchor strike for both expiries is assumed to be 1600. Then CBOE takes all puts below 1600 strike and all calls above 1600 strike that have non-zero bids, and calculates a weighted average of implied volatilities of these options (including anchor strikes). This is done for both expiries.

<u>VIN and VIF – The Two Things that Make Up the VIX Index</u>

Now, we have two numbers, one for the July expiry (near-term) and another for the August expiry (far-term). CBOE calls the former VIN and the latter VIF.

Key: A weighted average of implied volatilities is calculated separately for each expiry using only OTM options, resulting in two numbers, VIN and VIF.

Interpolating Implied Volatility: Now that we have two numbers, we just need to interpolate the thirty day point. Essentially, CBOE takes VIN and VIF, and weighs each according to how close the near and far term expiries are to the thirty day point. This is best explained through examples.

Example: On June 28th, 2013, $VIX will attempt to track July 28th, 2013 expiry implied volatility (exactly thirty days removed). VIN will consist of July 19th, and VIN of August 16th expiry options. There are 9 days separating July 19th and July 28th, as opposed to 19 days that separate July 28th and August 16th. Since VIN is closer to the 30 day maturity than the VIF, actual $VIX will be close to VIN. (In fact, VIN will be roughly 19/28 ~ 70% of $VIX, whereas VIF will be roughly 9/28 ~ 30% of $VIX)

<u>Another Example:</u> On July 17th, 2013, $VIX will consist of August and September expiry options ($VIX would have already rolled since there's only two days remaining to the July 19th, 2013 expiry). On this day, August expiry happens to be exactly thirty days away. Therefore, VIN will be equal to $VIX, and VIF will contribute nothing to $VIX.

The full formula for interpolation is given below.

$$\$VIX = \sqrt{\$VIX * \left(\frac{N_{far} - N_{30}}{N_{far} - N_{near}} \right) + \$VIF * \left(\frac{N_{30} - N_{near}}{N_{far} - N_{near}} \right)}$$

N_{near}: Number of minutes to settlement of near term options

N_{far}: Number of minutes to settlement of far term options

N_{30}: Number of minutes in thirty days

<u>Facts about the VIX index that Even</u>

Most Professionals are Unaware Of

The truth is that many traders and investors, even the professionals, do not take the time to fully acquaint themselves with the VIX methodology. That, however, is a mistake, since there are several nuances in the methodology that have practical consequences. Below, we present a list of commonly overlooked aspects of $VIX that cannot be learned without digging deeper into $VIX calculation methodology.

Fact1: To be included in the VIX index calculation, an option must have a non-zero bid on the screen market, namely $0.05 or higher. Very out of the money options in the first few months tend to have no bids. In fact, most of these far out of the money options are effective worthless, and hence should have no contribution to the VIX index. However, CBOE's rules state that the screen offers cannot be lower than $0.05. This causes a problem. Because CBOE's methodology uses mid-market prices of screen options markets, and the average of \$0.00 and \$0.05 being \$0.025, every 'worthless' option will have a contribution of \$0.025 to \$VIX if left unchecked! In order to prevent these options from having any artificial contribution to the VIX level, the methodology simply excludes them.

The example below clarifies exactly how this filtering is done. Notice that the 1075 and 1080 strike put options are not included in the calculation, despite having \$0.05 bids. That is because CBOE discards all options below the first strike that has a \$0.00 bid. In this case, 1085 strike put has a \$0.00 bid. Since 1075 and 1080 strikes are below the 1085 strike, they will not be included in the final calculation.

Expiry	Strike	Put/Call	Bid	Ask	Included?
August 16th, 2013	1050	P	0	0.05	No
August 16th, 2013	1055	P	0	0.05	No
August 16th, 2013	1060	P	0	0.05	No
August 16th, 2013	1065	P	0	0.05	No
August 16th, 2013	1070	P	0	0.05	No
August 16th, 2013	1075	P	0.05	0.1	No
August 16th, 2013	1080	P	0.05	0.1	No
August 16th, 2013	1085	P	0	0.1	No
August 16th, 2013	1090	P	0.05	0.1	Yes
August 16th, 2013	1095	P	0.1	0.2	Yes
August 16th, 2013	1100	P	0.15	0.25	Yes

Fact2: The set of options that comprise the VIX index can change at any moment. Every time CBOE recalculates the index, it repeats every detail of the methodology, including checking whether each option has a non-zero bid or not. One moment, there could be 120 options that have zero bids; the next, there could be 130 of them. Therefore, the number of options represented in the VIX will shrink and expand according to market conditions. Generally, the following factors will affect the number of options included in $VIX calculation:

Passing of Time -> Less Options Included as More Options Decay
Higher Volatility -> More Options Included as Option Premiums Elevate.

Fact3: The VIX methodology counts time to expiry in terms of minutes, not in days. Therefore, the weights used to interpolate the thirty day point change intraday, in fact, every minute. Most other interpolation methods used in finance, however, use one business day as the minimum unit. Hence, if one were to interpolate the VIX using business day convention, the value of the VIX index will be different, given the same exact set of options and prices. This confuses most market professionals who are used to thinking about maturities in terms of whole calendar or business days.

Fact4: Once a month, for one minute, $VIX will consist purely of VIN. This happens on the day when there is exactly thirty days remaining until the settlement of near-term expiry options. The reason for the brevity is because the weighting for the next-term options changes minute by minute. Under the minute convention, the expiry date of the next-term options will be considered exactly thirty days for only one minute - 9:30:00 am to 9:30:59 am EST. From 9:31 am EST and on, the weight for the VIF will again be a non-zero number. These special days are also the settlement dates for VIX futures and options; we will study their expiry mechanism in greater detail in a later chapter.

Fact5: CBOE publishes two other indices, VXB and VXA, which are VIX indices calculated with just the bids or just the offers of S&P 500 options. The VIX index, in comparison, uses the mid-market prices. The difference between VXA and VXB roughly reflects the bid offer spread of S&P 500 options. Notice that VXA will always greater than VXB, since VXA represents the offer price.

Other CBOE Indices

$VIX is by far the most important volatility index, but it is not the only one published by CBOE. The table below a comprehensive list of CBOE volatility indices with short descriptions. Twenty three indices are currently being published in five different categories. Many of these volatility indices are part of CBOE's efforts to promote the spread of volatility indexing concepts to options for non-US equities indices.

Volatility Type	Ticker	Underlier	Note
Stock Indices	VXN	NDX (Nasdaq 100)	
Stock Indices	VXO	OEX (S&P 100)	
Stock Indices	VXD	DJX (Dow Jones)	
Stock Indices	RVX	Russell 2000	
Stock Indices	VXV	S&P 500	Tracks 3 Month Implied Volatility of $SPX
Interest Rates	VXTYN	10 Year Treasury Note	Price Volatility of 10 Year Note Futures
Interest Rates	SRVX	Interest Rate Swap	1 Year Swaptions on 10 Year U.S. Dollar Interest Rate Swaps
Commodities	OVX	USO	Crude Futures
Commodities	GVZ	GLD	Gold
Commodities	VXSLV	SLV	Silver
FX	EVZ	Euro (FXE)	Euro Currency
Foreign Equities E	VXEFA	EFA	MSCI EAFE Index
Foreign Equities E	VXEEM	EEM	MSCI EM
Equity ETF	VXFXI	FXI	China
Equity ETF	VXGDX	GDX	Gold Miners Stocks
Equity ETF	VXEWZ	EWZ	Brazil
Equity ETF	VXXLE	XLE	Energy Sector
Single Stocks	VXAZN	Amazon	
Single Stocks	VXAPL	Apple	
Single Stocks	VXGS	Goldman Sachs	
Single Stocks	VXGOG	Google	
Single Stocks	VXIBM	IBM	
Vol-of-Vol	VVIX	VIX	Measures 1 Month Implied Volatility of VIX Options

Encouraged by the wild success of $VIX, three volatility indexing trends have emerged in the recent years: globalization, sophistication, and spread to other asset classes. These trends are a reflection of the universal appeal of indexing benefits of volatility instruments, as well as the growth in demand for derivatives products in general.

Globalization: The VSTOXX, volatility index for EuroStoxx50 index, was the first non-US volatility index to be launched. Since then, the ranks have increased globally. Most global indices that represent the entirety of developed market equity capitalization have adopted a volatility index as of 2013. In Asia, there's the VNKY (Japan), VHSI (Hong Kong), and VKOSPI (Korea). For Europe, there's the VDAX (Germany), VCAC (France), and VFTSE (UK), to name a few.

These trends have been helped by the standardization of calculation methodology. The $VIX methodology has been commonly adopted for many of them, making international volatility index comparisons easy. Never before has been comparing equity derivative valuations across globally simpler than it is now. These indices are published by exchanges and distributed freely (with delay in some cases). Global volatility analysis has been a game dominated by large investment banks, but these indices have leveled the playing field quite a bit. Finally, the success of VIX futures served as a further catalyst for countries to create local volatility futures markets, similar to VIX futures. Unfortunately, the growth of global VIX-like derivatives market has been slower than many have expected, with only VSTOXX index gaining traction.

Sophistication: The recent trend has been creation of strategy indices that incorporate systematic rules regards buying and selling VIX futures. For example, CBOE publishes three VIX futures indices (VXP, VXN, VXTH) that involve systematically selling VIX futures or buying VIX calls. In addition to CBOE, many other companies have initiated creation of strategy indices to ride the popularity of VIX futures among investors. For example, Standard and Poor's has a suite of VIX futures based indices that track the performance of investing in VIX futures, the most famous being SPVXSP (S&P VIX Short-Term Futures Index). Wall Street has also created a suite of VIX futures strategy indices, the most famous example being Barclays SPXVPM index (S&P Dynamic

VIX ETN).

Why is Wall Street and other companies like S&P creating VIX futures strategy indices? Note that many of these indices are packaged into ETNs or ETFs. For example, SPXVPM index from Barclay's is traded in the market under ticker XVZ. Some of them are wildly successful (like Credit Suisse's TVIX – measured in trading volume) and others have been struggled (XVIX). Generally, the more complex the strategy behind the VIX ETF or ETN, the less traction it has gotten.

Spread to Other Asset Classes: Volatility indices have spread to other asset classes as well. As of 2013, there are volatility indices that track implied volatilities for options on gold (GVZ), silver (VXSLV), crude oil (OVX), and currencies (EVZ). What triggered this? Notice these volatility indices all track ETF options, not the options for the real spot market for each commodity. In some sense, spread of volatility indices has been enabled by the tremendous growth of ETFs.

Price Index ≠ Performance Index

Lastly, investors should be aware of another important fact about $VIX. $VIX is not a performance index; it is a price index, if we consider implied volatilities to be prices. This means that the historical data of $VIX does not reflect the performance of owning options. Rather, it reflects the change in the cost of purchasing options. For example, if $VIX doubled within a certain amount of time, that does not mean that one doubled his money. Rather, it just shows that option costs have doubled. Why? That is because the performance of owning options depends on factors other than implied volatility, such as time decay.

What's the difference? In general, the performance of an asset consists of capital gains and cash flow components. The change in a pure price index does not include cash flow-related P&L, examples of which include coupons (for bonds) and dividends (for stocks). For example, if a dividend paying stock doubled from $20 to $40, then one's total performance from owning the stock is greater than 100% (accounting for dividends). However, the stock price alone would indicate that the investment return was just 100%. The lesson is this: do not take historical price data literally for performance data.

Why is this the case for $VIX? Suppose we were to create a performance index of owning options. This will involve book-keeping of option P&L, which is largely tracking the cost of carrying the options positions. Carry is what investors pay for the benefit of owning options. Think of it like insurance premium that amortizes each day, instead of in a lump sum. For example, if the markets do not move, options will bleed time value, and become less valuable over time. Essentially, owning options costs money, and none of it is reflected in the $VIX calculation methodology. Instead, all $VIX does is tracking current levels of implied volatilities.

Example: If the markets did not move at all for an entire month, monthly options will have lost 100% of their value. $VIX, however, is not affected by how certain options performed over time, and will be tracking a new set of thirty day expiry options (which is why $VIX seems to never dip below 10, even though options expire worthless – i.e. $0 – all the time).

10 year treasury yield index is another index that is not a performance index. 10 year treasury yield index tracks the yield levels of a basket of treasury bonds around the 10 year maturity. The yield itself is interpolated like $VIX. Similarly, the index does not track the performance of owning 10 year bonds. For example, bonds pay cash coupons periodically. Bond coupons are conceptually similar to options

carry, because they represent the cash flow from ownership. None of this cash flow matters to the index, because it is not part of the index methodology. In the same vein, $SPX is not a true performance index, either. As mentioned, $SPX does not reflect performance of reinvested stock dividends. Rather, $SPX assumes that those dividends never happened. To get a real sense of how the stock market performed <u>with dividends</u>, investors can study the S&P 500 Total Return Index.

<u>Case Study: Will the VIX Ever Spike Again?</u>

With memories of the 2008 Financial Crisis still fresh in our minds, many people have been puzzled by sustained low levels of $VIX index this year. The lowest close of the index has been 11.30 in 2013, which is remarkable in light of the ongoing economic slump in Europe and slowdown in China. **The question is, can this seemingly endless lull last**

for the rest of the year?

Looking at the data, it is hard to imagine a year without a spike in volatility. The table below shows the VIX index's highest closing level for each year since the inception of the index. The current year to date high of 18.99, if remained intact, will be recorded **as the fourth lowest in the index's 24 year history.** This is a sharp change from the incredibly volatile regime that investors have lived through in the recent history. From 2007 to 2011, **we had five straight years where the VIX spiked above 30,** which is a crucial level for options traders, since it reflects an expectation that the market will move more or less 2% a day in the near future. 2012 was the year that broke that streak, with the index peaking at high 20's. Then 2013 caught everyone off guard with its sheer immobility even in the face of multiple scary headlines.

Table: Distribution of Maximum Level of VIX, Broken Down by Year, Since

1990 (as of May, 2013)

^VIX	Max < 15	15 < Max < 20	20 < Max < 25	25 < Max < 30	30 < Max
1990 36.47					36.47
1991 36.20					36.2
1992 20.51			20.51		
1993 17.30		17.3			
1994 23.87			23.87		
1995 15.74		15.74			
1996 21.99			21.99		
1997 38.20					38.2
1998 45.74					45.74
1999 32.98					32.98
2000 33.49					33.49
2001 43.74					43.74
2002 45.08					45.08
2003 34.69					34.69
2004 21.58			21.58		
2005 17.74		17.74			
2006 23.81			23.81		
2007 31.09					31.09
2008 80.86					80.86
2009 56.65					56.65
2010 45.79					45.79
2011 48.00					48
2012 26.66				26.66	
2013 18.99		18.99			
% Probability	0.00%	16.67%	20.83%	4.17%	58.33%

However, statistics tell us that it won't be wise to get used to low volatility continuing forever. If the current low vol regime continues and 18.99 does become the high for entire 2013, then it is likely that the following year will be more volatile. **For every year that was quiet enough to avoid a 20+ print in $VIX, the following year registered a surge in $VIX to above 20.** Even during the great bull market of the early 90's, low volatility years have brought on higher volatility years. Most importantly, $VIX has had spiked above 30 at least once in more than half the years since 1990, despite the market having enjoyed some incredible bull runs within that timeframe.

What's the lesson? **The lesson here is to not be married to multi-year investments that are hard to get out of.** It is hard to time when the exactly $VIX will spike, just like it is hard to time the S&P 500. We are not making a call for an imminent collapse in the market. However, it is a fact that volatility mean reverts; hence, it is most likely that $VIX will be higher in the ensuing 2-3 years. High volatility usually spells disaster for people's risk appetite, and hence lower returns and poorer liquidity for investments. Being married to illiquid investments in those times may be a kiss of death, because selling out of those assets will become especially more difficult.

Recap

- The primary benefit that $VIX

provides is indexation of implied volatility, which greatly simplifies tracking changes in option values.

- Historically, VIX has ranged typically in the mid to high 10's range.
- During bear markets, VIX has averaged significantly higher numbers, i.e. mid 20's.
- VIX is expressed in annualized terms, but can be converted into a daily implied volatility number via the rule of 16.
- VIX consists of two sets of options: near term and far term. For the most part, these are the first and second month expiry $SPX options.
- VIX is a weighted average of two numbers: VIN and VIF.
- Volatility indices like VIX have spread to other countries as well as asset classes. Most famous examples are VSTOXX and GVX.
- VIX is not a performance index. Hence, the historical prices of VIX does not tell one how much money he or she

could have made/lost trading VIX.

- VIX has seen spikes above 30 in more than 50% of the years since 1990.

Chapter Two: The Properties of the VIX Index

We have learned what $VIX is, how to interpret the number, and how the number is calculated. We have not learned, however, how the index behaves and what drives its changes. Of course, $VIX ticks intraday because option prices change; after all, the index is calculated from mid-market prices of options. Thus, the factors that move $VIX are the same ones that move option prices (implied volatilities). In this section, we will study historical data of $VIX to find whether there are predictable patterns in $VIX's behavior under various market conditions.

We will mainly study two aspects of the VIX index. First, we will learn an intuitive pricing framework for $VIX. Investors value common stocks using a myriad of different valuation methods (dividend discount model, multiples, free cash flow, to name a few). With $VIX, we will see that the process is much simpler. Second, we will study how $VIX behaves in relation to other asset classes and under different market conditions. Understanding these technical properties will help investors and traders alike in deciding *when* to buy (and sell) $VIX, and *why*.

How the $VIX is Priced

How does the market (aggregate of options market participants, to be specific) decide on the price of $VIX? Most of the readers may be aware that $VIX and S&P 500 have an inverse relationship, meaning they tend to move in opposite directions. Beyond that, many are puzzled at exactly why implied volatilities move certain amounts, and some mistakenly attribute it to 'fear' and 'greed'. Emotions certainly are a factor that affects demand for options, but we will see that there is a structured process to estimate changes in $VIX. 'Fear Index', a nickname oft assigned to $VIX, is misleading, as it exaggerates the role that emotions play in determining the price of options.

Fortunately for investors, the pricing process does not require a PhD in financial mathematics to understand. In fact, investors will benefit from just knowing two facts:

- Implied volatility of $SPX options do not deviate much from historical volatility. To paraphrase, option markets' expectations of future volatility are not so different from the recent market volatility. If deviations do occur, they don't last long. Contrast this with the stock market, where irrational valuations can persist for years.
- Implied volatilities reflect a 'discount' or 'premium' to historical volatilities, which oscillate based on market conditions in a fairly predictable fashion.

These two facts, combined, provide investors with a framework of understanding how $VIX moves (it's not always greed and fear!).

Property #1: $VIX Generally Tracks Historical Volatility

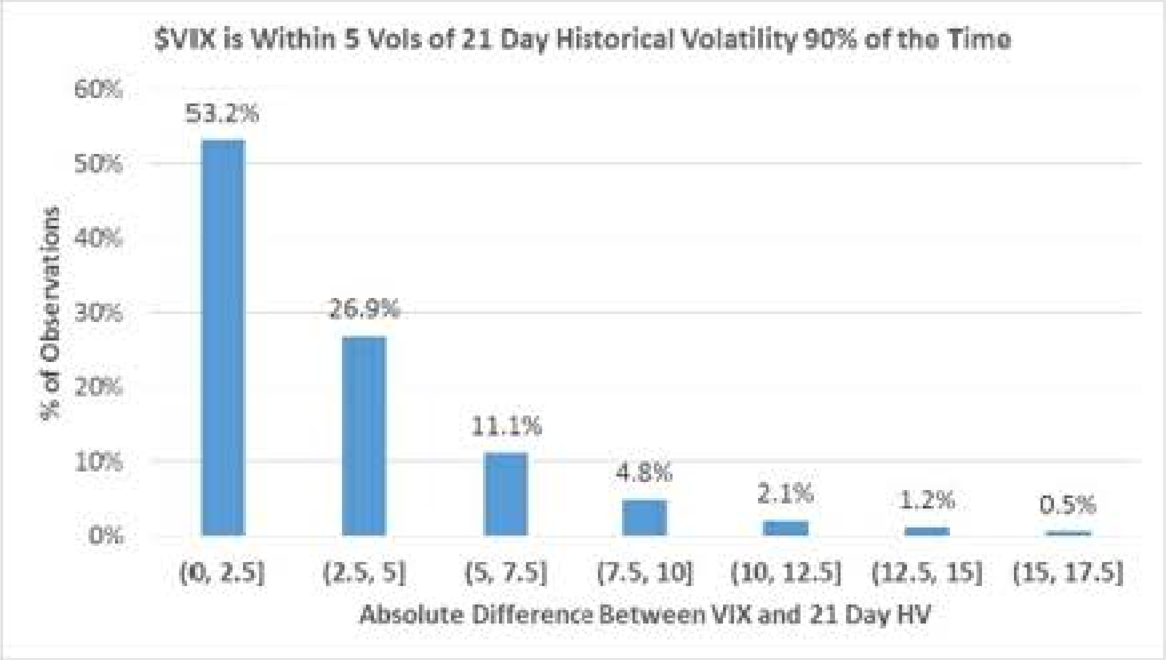
$VIX does not track historical volatility perfectly, but their relationship is very close. The correlation between $VIX and 21 business-day (roughly 30 calendar days) historical volatility (21D HV) has been 80% for the past two decades. This implies the following: option traders tend to price options using historical volatility as a major input, on a daily basis. The two do not have live in separate worlds; the high correlation number confirms that.

Question for the reader: Imagine you are a market maker for $SPX options. Let us assume that you are the only one making markets, so you don't get to 'cheat' by looking at others' markets. How would you go about making your first option market?

A reasonable first step is to set implied volatility equal to historical volatility calculated from recent data. If you had a strong reason to think that the future will be different from the past, then you may add a discount or premium based on that view. In most cases, however, there is no reason to believe that the future, especially in the short term, will be very different from the recent past. Status quo will be the best estimate of the near future if there is no imminent market catalyst (such as Nonfarm Payrolls announcement). Even if the sentiment in the market was bearish, for example, the market would not get so far ahead of itself as to drive $VIX straight to bearish levels.

More concrete example: if 21 day historical volatility is 8 (0.5% per day movement in $SPX, using rule of 16), $VIX has no business getting ahead of itself and jumping to 32(implying 2% per day movement in $SPX). Moving 0.5% versus 2% per day are two drastically different scenarios; consequently, option purchasers at these levels will be paying hefty carry costs for their positions. If status quo prevails, long option positions will lose too much money as the options decay (32 – 8 = 24 vol points per day!). Essentially, this is akin to paying a twenty year old man paying seventy year old man's health insurance premiums because of his fear of getting sick). As such, unsustainable levels are rejected by the market, mostly when one side capitulates. Similarly, $VIX would not stay at low levels if the markets were volatile (historical volatilities were high). For example, $VIX would not be at 16 if 21-day HV is at 32 (2% per day movement in the $SPX).

To verify that the market works this way in real world, let's take a look at the historical distribution of the difference between $VIX and 21 day historical volatility. We will subtract the one year trailing average of the spread from the $VIX to remove any biases. Since 1993, the adjusted $VIX fell within 2.5 volatility points of 21 day HV more than 50% time, and within 7.5 vol points almost 90% of the time. $VIX deviated from historical volatility by more than 12.5 vol points in less than 2% of total observations.



This shows us one way to trade options; trading the historical volatility-implied volatility spread. If $VIX diverged widely from historical volatility, one could bet on the spread between $VIX and historical volatility narrowing. For example, if $VIX and 21 day HV are at 22 and 8 respectively (14 volatility point spread), we know that this difference is extremely rare compared to historical standards. Therefore, there is a potentially profitable set up selling options (shorting implied volatility, i.e. $VIX), if one were to believe that the future won't be that different from status quo. The same principle applies to the other direction as well; if $VIX (implied volatilities) is severely depressed relative to 21 day HV, then the risk/reward for buying options is favorable. In fact, many professional option traders use the spread between HV and $VIX as a signal for buying and selling options. This signal is often called an IR signal (implied-realized volatility signal).

Is the Option Market Smarter Than You?

People often say option market is ‘smart’. Sure, option markets tend to attract professionals with sharp minds. Option traders tend to be more mathematically inclined than pure stock traders. But is the option market good at predicting volatility in the future? Not good as you think.

The truth is that implied volatility is not any better than historical volatility at predicting future volatility. In fact, since 1993, 21 day historical volatility predicted future 21 day volatility more accurately than implied volatility by a small margin (58% to 42% in 240 observations). In another words, the recent status quo predicted future market volatility better than the options market, by a small margin. Practically speaking, neither have a significant edge over another when it comes to estimating future volatility. Essentially, the data tells us that the option market does not have special insights about the future.

This is also why it may be sensible to price implied volatility, i.e. $VIX, around historical volatility. If historical volatility is a decent predictor of future volatility, then there is no reason for the market to collectively decide that it will be otherwise. Since $VIX is shown to have no special powers predicting the future, we can conclude that wild predictions are more likely to miss the target.

Instead of taking $VIX at face value as the 'best' indicator of future volatility, investors should focus on the market sentiment that is reflected by $VIX. When $VIX is at 16 when 21 day HV is at 12, the data indicates that option sellers are willing to sell options only at a premium to historical volatility. This reflects that the market is not complacent about the future, since it is charging a premium for selling insurance on market volatility. As such, one can analyze the spread of $VIX to historical volatility to detect the overall market sentiment like complacency, neutrality, fear, or optimism. For example, if 21 day historical volatility started from a high level, say 40 annualized, but $VIX was only at 28, then it would be a sign of optimism. Why? Because historical volatility suggests a status quo of turbulence, but $VIX, which is an estimate of future volatility, suggests reduction in volatility.

Believe it or not, we have just covered some sophisticated concepts in financial mathematics.

Stochastic Volatility: One of the biggest weaknesses of the Black-Scholes model for option pricing is that it makes an assumption that volatility is constant. However, we all know that markets go through phases of peace and war, and hence that assumption is problematic. Essentially, stochastic volatility means 'non-constant' volatility.

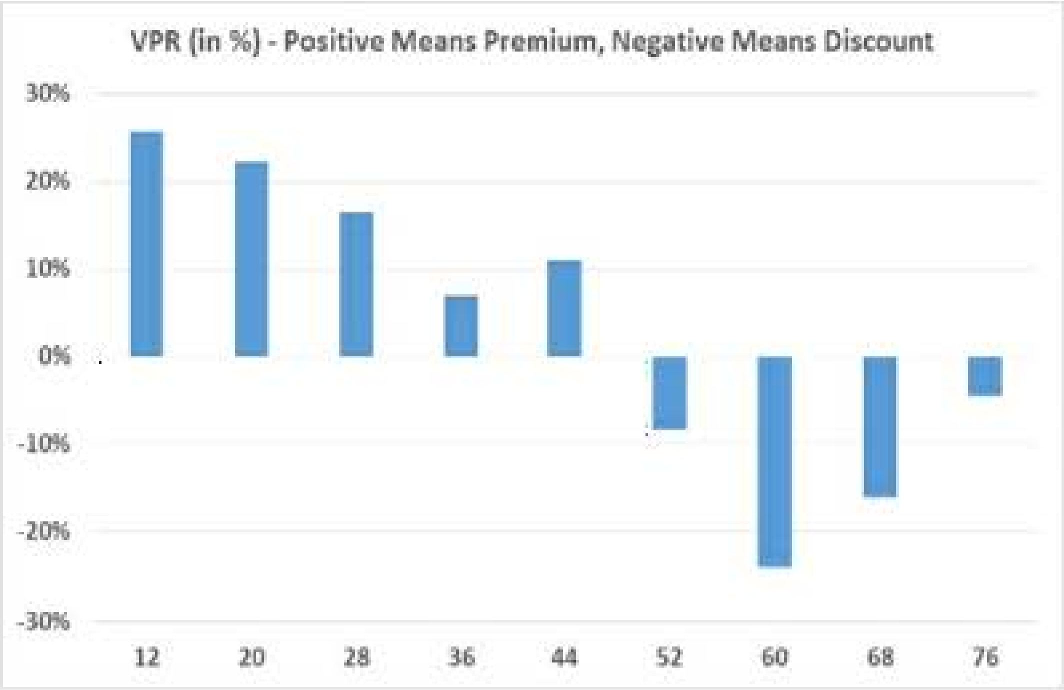
Stochastic Volatility Model: Most models in modern finance that describe this 'non-constant volatility' assume that future volatility is dependent on past volatility. This is what we just covered empirically.

Property #2: Volatility Risk Premium Fluctuates

We will now discuss volatility risk premium (VPR) to wrap up our discussion of VIX pricing. VPR is just a fancy word for the difference between implied volatility and historical volatility. It refers to the degree of discretion that the option market uses to price options. The number tells us how much the option market thinks the future will be different from the past. Fortunately, it does not require a PhD to understand how professional option traders price VPR. There are mainly two rules that govern this number.

- During times of stability, VPR tends to be positive. (\$VIX - historical volatility > 0)
- During crisis, VPR tends to be negative. (\$VIX - historical volatility < 0)

Let us verify this by looking at how a) the magnitude and b) the sign of VPR changes with the level of historical volatility. The following chart shows the % VPR (VPR divided by HV) for various buckets of HV since 1993. We first observe that VPR clearly decreases with market volatility. In other words, during high volatility regimes, \$VIX tends to be priced at discounts to historical volatility. For example, VPR averaged a negative number for every HV bucket above 44. Below 44, the average VPR unilaterally decreased with HV. In addition, we confirm that VPR tends to be a high positive number during times of stability (HV at 20 and under). This implies that market participants demand a premium to the status quo for selling options ($VIX) when the absolute level of premium is low.



On why VPR is high during low volatility regimes: Market volatility tends to come and go in cycles; in other words, volatility tends to mean revert. Therefore, it is a terrible risk reward to sell options, i.e. short implied volatility, when volatility is low. The reward side of the equation is capped, since the market inherently has some amount of volatility. Meanwhile, the risk side is relatively enormous, since corrections are inevitable even during the strongest of bull markets. Option market makers are aware of this, and hence are unwilling to sell options without a premium to historical volatility when the markets have been stable. Essentially, VPR is a way of option market makers to price in the risk of a correction in $SPX. $VIX tends to be low during uninterrupted bull markets. However, all bull markets must eventually suffer corrections of various sizes. The longer a stable regime sustains itself, the higher the chances of correction become.

On why VPR is low or negative during high HV regimes: Mean-reversion of volatility tends to work the other way as well. Markets tend to calm down after a spell of instability and crisis. As soon as the market suspects that high levels of volatility cannot be sustained forever (or the worst has passed), it starts pricing $VIX at a discount to historical volatility. In other words, negative VPR suggests that options market is betting on re-nomalization, i.e., stability. Essentially, negative VPR is options market's way of pricing in retracements during market pull-backs. Equity indices, throughout its history, have always snapped back from drawdowns. Assuming this holds true going forward, it is rational for investors to bet on retracements during market sell-offs.

In essence, retracements are bearish for implied volatility for two reasons:

- Retracements imply that the market has found support. This reduces selling pressure, and increases the chance that the market won't accelerate to the downside in the future.
- Existence of support improves market sentiment, which reduces protection/insurance demand.

Key: VIX pricing is mainly a two-step process.

First, price implied volatilities not too far from historical volatility.

Second, apply a discount when

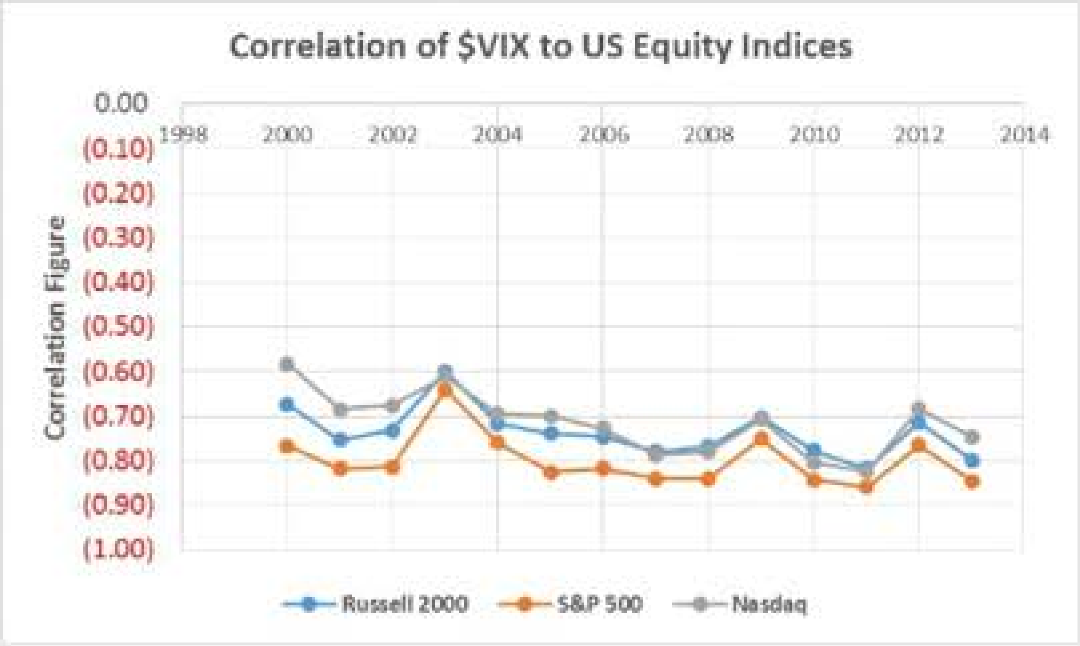
historical volatility is high (and markets have found a support). Alternatively, apply a premium when historical volatility is low.

Technical Property: Negative Correlation to Risky Assets

Let's now move on and discuss how $VIX behaves in relation to other asset classes. In the past decade, market pundits and academics alike have been raving about the benefits of using $VIX as a hedge for equity portfolios. Unfortunately, most of these recommendations were made after 2008 happened; the horses had already left the stable. Regardless, their points are valid: $VIX is beneficial to portfolios, because it can help lower the risk of equity portfolios. $VIX itself is not tradable or investible (we will discuss why in the next chapter), but VIX futures and VIX ETNs are. We will discuss how to trade VIX futures and VIX ETNs in later chapters – but first, let's lay out some of the reasons why $VIX has the ability to hedge equity portfolios.

The key feature of $VIX is that it has consistent negative correlation to risky assets. In other words, $VIX tends to move in the opposite direction of domestic and global stock indices, as well as many commodities, junk bonds, and corporate bonds. In theory, this property makes $VIX a good instrument for diversifying portfolios. In the later chapters, we will study specific ways to approaching investing in $VIX-related instruments such as VIX futures and ETNs. But first, let's look at some data that illustrates how exactly $VIX relates to other asset classes.

Consistency Across timeframes: $VIX has been negatively correlated to the S&P 500, Russell, and Nasdaq 100 on all major time frames (yearly, quarterly, monthly). The following chart shows the yearly correlation number between $VIX and the three major U.S. equities since 2000. The number never went higher than -0.6 (note the negative) in 13 years, which shows consistency.



What is this important? It is because there is no other asset class that has such high, consistent inverse relationship with the stock market. Treasury bonds and gold are typically viewed as hedges to the stock market. In reality, they have both had an inconsistent track-record at that. In the past twenty years, gold and 20 year Treasuries have had zero and -0.3 correlation to $SPX, respectively. <u>Gold, in particular, has had multiple regimes of *positive* correlation to $SPX.</u> As of June 2013, we are currently seeing such a regime. 20 year Treasuries have also had multiple regimes where it decoupled from the stock market. In essence, people are running out of places to hide from the equity market. The run-up in the gold and bond markets in the past ten years have been so remarkable, that holding all three assets – stocks, bonds, and gold – is no longer the surest and the simplest way to form a diversified portfolio. In light of this, $VIX's consistency is appealing to investors who desire a strong hedge to stock portfolio.

Across globally: Most major global stock indices are negatively correlated to $VIX as well. This is mostly a by-product of the fact that all global stock indices are somewhat positively correlated to $SPX itself. Large sell-offs in $SPX tend to spoil global market/ investor sentiment, and triggers other indices to sell off in sympathy. Therefore, even investors that do not specialize in U.S. stock market have something to gain by having exposure to $VIX-related derivatives. This is especially beneficial for investors that hold emerging market indices, which have poorly developed vanilla options markets on their own. Essentially, they can piggyback on U.S. equity derivatives markets to hedge their local equities market exposures. Of course, the hedge will not be perfect, and is based upon estimates of correlations; thus, these cross-index hedges, need to be scrutinized further before they are implemented.

Below is a table that shows yearly correlation figures between $VIX and European, Emerging Market, and Developed Asia stock markets. Not that almost all figures are lower than -0.3. Even more remarkable is that almost every index had a negative correlation to $VIX for almost every year since 2000.

Table of Correlations Between the VIX Index and Global Equity Markets

	Europe			Emerging Market			Developed Asia	
	Dax	EuroStoxx	EAFE	China	EEM	EWZ	EWY	Nikkei
2000	-0,46	-0,39				-0,33	-0,29	0,04
2001	-0,49	-0,38	-0,69			-0,43	-0,48	-0,23
2002	-0,58	-0,52	-0,68			-0,31	-0,47	-0,15
2003	-0,46	-0,41	-0,33		-0,36	-0,41	-0,40	-0,06
2004	-0,35	-0,34	-0,61	-0,32	-0,53	-0,47	-0,44	-0,11
2005	-0,25	-0,26	-0,64	-0,41	-0,61	-0,48	-0,39	-0,01
2006	-0,57	-0,38	-0,69	-0,58	-0,71	-0,66	-0,61	-0,08
2007	-0,44	-0,45	-0,78	-0,66	-0,78	-0,76	-0,72	-0,09
2008	-0,33	-0,33	-0,79	-0,74	-0,77	-0,74	-0,69	-0,13
2009	-0,51	-0,50	-0,72	-0,62	-0,71	-0,70	-0,61	-0,08
2010	-0,56	-0,61	-0,78	-0,67	-0,77	-0,73	-0,67	-0,18
2011	-0,60	-0,38	-0,84	-0,71	-0,79	-0,74	-0,75	-0,18
2012	-0,48	-0,47	-0,69	-0,57	-0,67	-0,61	-0,57	-0,08
2013	-0,25	-0,33	-0,72	-0,57	-0,65	-0,57	-0,40	0,06

Across asset classes: How does $VIX behave in relation to bonds (fixed income) and commodities? There are two takeaways from the table below. First, riskier bonds tend to be more negatively correlated to $VIX. The reason for this is that low-credit quality bonds tend to be more equity-like than bond-like in terms of their return characteristics. Thus, junk bonds tend to be highly correlated to the stock market, which explains its strong negative relationship to $VIX. We also note that bonds with higher credit quality behave similarly to $VIX, as we can see from the Treasuries' positive correlation figures to $VIX. Second, crude tends to be negatively correlated to $VIX (more so since 2009), whereas gold has shown an inconsistent relationship with $VIX. To summarize, asset classes that are levered to the economy (junk bonds, crude oil) and $VIX tend to move in opposite directions. Meanwhile, what are perceived as safe-havens (Treasuries, Gold) have had positive to neutral relationships to $VIX.

Table of Correlations Between the VIX Index and Fixed Income and Commodities Markets

	Fixed Income			Commodities	
	Junk Bonds	Corporate	Treasuries	Crude	Gold
2006		(0.14)	0.02	0.00	(0.14)
2007		0.22	0.35	(0.16)	(0.38)
2008	(0.36)	(0.28)	0.45	(0.29)	0.07
2009	(0.55)	(0.16)	0.26	(0.48)	(0.10)
2010	(0.67)	0.02	0.48	(0.59)	(0.14)
2011	(0.72)	0.14	0.57	(0.44)	0.04
2012	(0.55)	0.17	0.51	(0.41)	(0.24)
2013	(0.55)	0.10	0.39	(0.48)	(0.29)

Option Volatility Mean Reverts

If we had to nail down the most important property of $VIX, or implied volatility in general, it would be mean-reversion. Mean reversion is the most useful (read: practical) property of volatility one can know. Mean reversion makes $VIX special as an asset-class, along with its negative correlation to stock market. Finally, it is what makes $VIX easier to trade than the stock market.

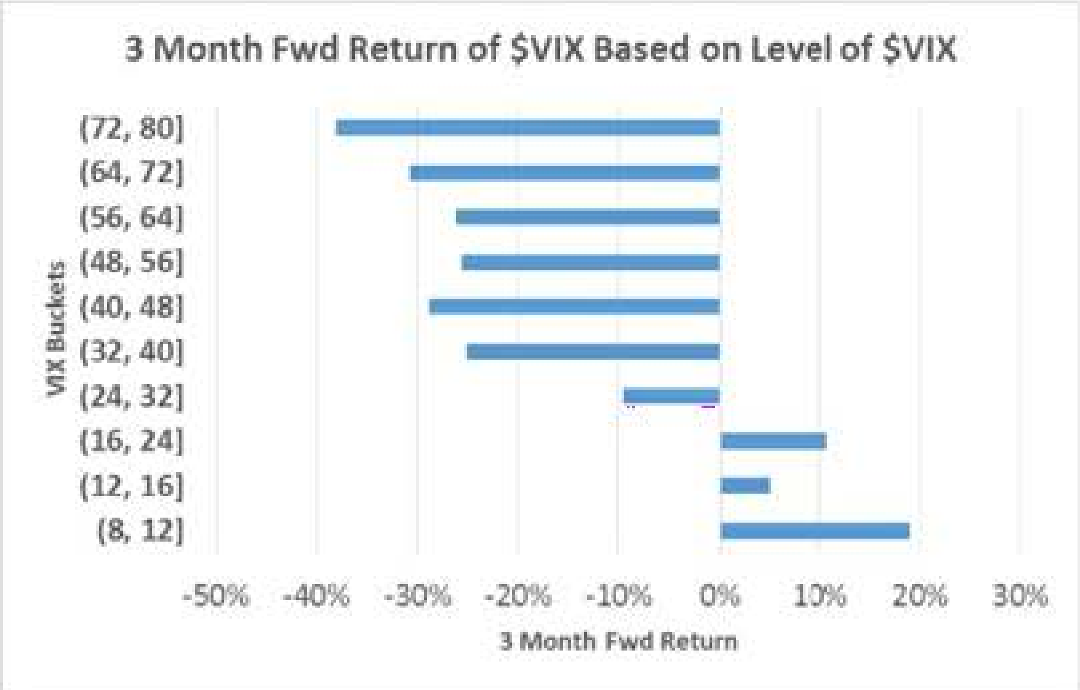
Simply put, the term refers to the fact that $VIX does not trend. $SPX is not a mean reverting index, because it is marked by a clear long term trend that can be explained by real economic variables such as earnings and inflation. On the other hand, $VIX does not have the dynamics that support a trend for the long term. In fact, it rarely ever trends for more than a month or two, until it reaches a peak and comes back down.

Why can't volatility trend? Suppose volatility were to trend in either direction perpetually. An uptrend in $VIX would mean perpetually increasing volatility for the S&P 500. The assumption of a trend would indicate a self-reinforcing cycle of increasing uncertainty for the market participants. However, the market is a place where uncertainty is resolved through price discovery and flow of information. Perpetual growth in uncertainty would be paradoxical, as it would indicate that the market is creating more uncertainty instead of solving it. It would imply that the price discovery process is somehow reinforcing more uncertainty over price. That is why uncertainty rarely persists over long periods in the market (in fact, in the world), and hence persistent uptrends in $VIX are impossible. If $VIX, in fact, kept climbing to extremely high levels, it would literally mean the end of the markets (and potentially, the world, depending on what caused the crisis). Ironically, that scenario will ultimately result in $VIX going to zero (non-existent markets = no market volatility, by definition).

By the same token, perpetual downtrend in $VIX is also impossible. By definition, complete certainty of the future of the market is impossible. The economy is the sum of economical transactions made by humans. As long as there is economic activity, the variables that determine the value of the stock market will change, and thus the value of the stock market will fluctuate – call this natural state of flux 'inherent volatility'.

Why is this important for trading/investing in $VIX? Since there is no such thing as long term trend in volatility, we would expect the extremes of volatility to be rejected by the market. Essentially, there is no point buying $VIX after a certain point, if it gets too high. Similarly, there is little point selling $VIX at low levels, especially if it's already depressed. In addition, mean reversion forces strengthen especially around the extremes of volatility. The higher $VIX climbs, the more attractive it becomes for shorting, and vice versa when $VIX falls. Thus, the level of $VIX becomes a key determinant for making trading/investing decisions in $VIX. To take advantage of this, when the markets become too stable or too unstable, option traders tend to bet the other way.

Is this empirically true? The bottom chart summarizes how different starting levels of $VIX influence the future three month distribution of $VIX. It shows that high levels of $VIX are followed by lower $VIX levels in the future, and vice versa for low levels of $VIX. For example, whenever $VIX dipped below 12, it snapped back almost 18% on average in just three months. Conversely, $VIX shed almost 30% in three months whenever it spiked above 40.



Such consistency of mean reversion at the extremes is, in fact, used by option traders to position for either spikes or sell offs in volatility. And it works. When the VIX index started from 12 or below, the index ended up above 12 more than 75% of the times. In contrast, extremely elevated levels of the index were always met by reversals; $VIX went lower 95% of the times in three months when $VIX was 40 or higher. One must note, however, that mean reversion tends to work with less consistency around the intermediate levels of volatility. In fact, when $VIX was between 12 and 24, there was no strong bias to either side. In another words, mean-reversion cannot be counted to tilt the distribution in one way when $VIX is oscillating in the middle of the historical range. In any case, this data points to a useful trading rule: buy $VIX when it's below 12, sell it is above 48. Of course, there are some catches to this, and we will see that later chapters when we discuss VIX futures.

Corollary Property: Extremes of $VIX Tend to Signal Great Buying Opportunities

Ever heard of the phrase, “buy when others are fearful?” This phrase was coined centuries before $VIX was even invented. Here, we will prove that using $VIX.

The question is whether the future returns of $SPX (stock market) are better when bought during high $VIX regimes. When $VIX is high, the market sentiment tends to be poor – or ‘fearful’, although fear does not fully capture all emotions that consist ‘bearish sentiment’. The answer is yes, especially if the holding period is reasonably long (more than one year). Chart below shows the variation in one year $SPX returns given different levels of $VIX at the time of purchase. Basically, we want to confirm whether buying stocks when $VIX is high compensates investors with outsized returns. We verify this in the chart; since 1990, investors have made 25% more on average, over a one year holding period, when they bought $SPX when $VIX was above 40.

Of course, there is a caveat. This type of analysis suffers from a small sample problem. This is because $VIX does not climb to extremely high levels very often; for example, $VIX was above 40 in just 3% of trading days in the past two decades. Even in the past 100 years, the broad market (measured by Dow Jones or S&P 500) experienced corrections of 40% or more on very few occasions. Luckily, the markets have always rebounded, as well as in 2004 and 2009, and the market was able to weather the 2000-2002 crises and the 2008 Financial Crisis. However, we cannot perform an extremely robust statistical test on whether the markets represent the best opportunity to buy when the bearish sentiment is high (clearly, this type of approach does not apply to individual stocks, which can easily go into bankruptcy). Therefore, perhaps we should qualify 'buy when others are fearful' with the assumption that the markets will always rebound; and whether that is true or not is subject for another discussion.

$VIX Spikes Much Faster than It Falls

Another useful property to know about $VIX is that $VIX rises faster than it falls. This is because $VIX tends to move inversely to the stock market, which falls faster than it rises. The reason for this is because wealth tends to be destroyed faster than it is built. Every bubble in history – the dot-com bubble in 2000's, the South Sea bubble in 18th century, Dutch Tulips in 17th century, the housing market in 2006 – ended much faster than it took to occur. Essentially, belief in an idea (or manic belief) takes longer to crystallize than to shatter. Essentially, the speed at which $VIX tends to rise highlights how fragile markets really are.

At the same time, $VIX takes a disproportionately long time to fall back to normal levels, after spiking. The main culprit for the drag is the market's tendency to be skeptical of recoveries, especially after large corrections. Risk appetite dips after crashes, which makes it difficult for stock market valuations to increase, even in the face of improving data. Continued skepticism and fear of a dip back down, therefore, deters $VIX from falling down to normal levels, since option demand is buoyed by the skepticism in the market. This sentiment can last for years, as we have seen in the case of the 2008 Crisis. Eventually, however, historical volatility starts drifting lower as the market stabilizes, and long volatility positions start to hemorrhage money. Based on our framework, we would presume that $VIX follows historical volatility down, until it fully renormalizes. The cycle consummates.

Just how much faster does $VIX rise than it falls? Below is a table of major VIX spikes since 1993. It shows how long it took for the crises to peak and to trough. For example, the 2008 Financial Crisis took almost nine months (185 trading days) to peak, and 510 trading days to trough. The rightmost column shows the ratio of those two figures (number of days to re-normalization divided by number of days to peak of $VIX); we can see that $VIX, on average, took about three times longer to renormalize than for it to peak (ratio of 3). However, the recent crises – Flash Crash and European Financial Crisis – took only 30 something days to peak and almost a year to renormalize, putting the ratio above 7. This shows that the markets have become better at shrugging off skepticism after stock market crashes.

Table: Notable Volatility Spikes in the

Last Twenty Years

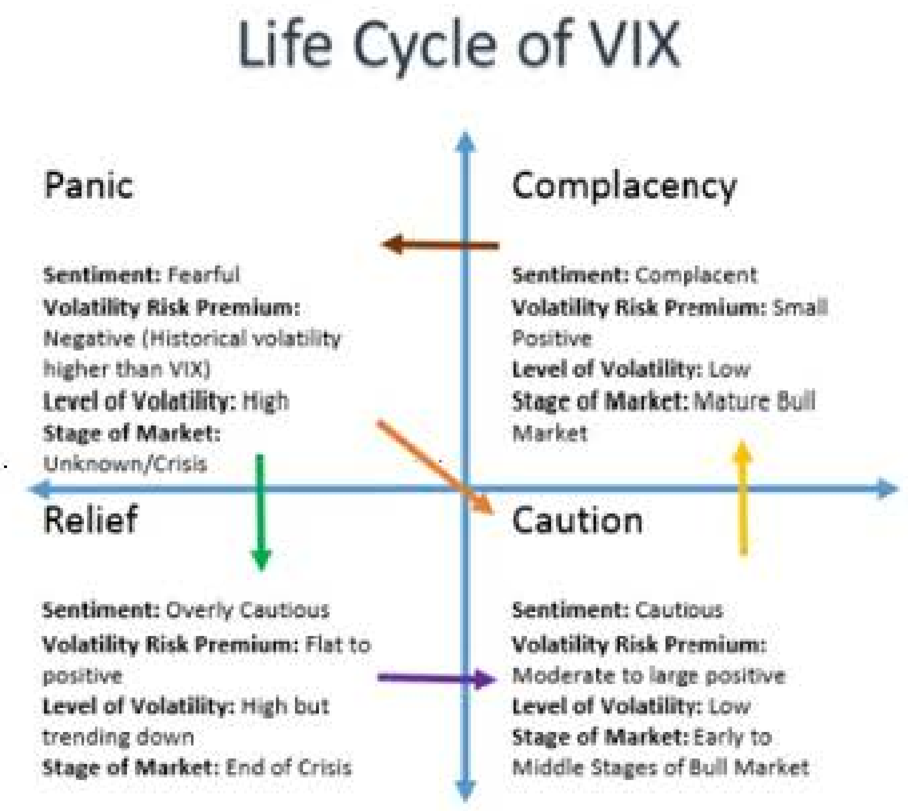
Crisis Description	Cycle Start	Cycle Peak	Cycle Trough	Days to Peak	Days to Trough	Ratio
LTCM	16.23	45.74	17.42	93	281	3.02
Dot-Com Bubble	18.76	43.74	17.4	80	189	2.36
Accounting Scandles	17.7	45.08	18.4	80	284	3.55
Financial Crisis	17.01	80.86	15.59	185	510	2.76
Flash Crash	15.59	45.79	15.81	36	264	7.33
European Financial Crisis	15.95	48	14.82	32	228	7.13

Putting Everything Together: The Lifecycle of the VIX

We just used the word 'cycle' to describe how $VIX rises and falls during crises. In fact, there is no more perfect word to describe the behavior of $VIX than the word 'cycle'. We have learned the following facts about $VIX:

- It is a market sentiment indicator
- It tends to track historical volatility
- It is priced at a premium or discount to historical volatility, depending on whether volatility is low or high
- It mean reverts. Extremes don't last forever. It is more difficult to predict $VIX when it is in the middle of the range. While it mean reverts, it tends to rise faster than it falls

All this is visually summarized in the following chart. Each quadrant represents a different market state. There are several distinguishing factors for determining which quadrant the market falls into in the present. They are sentiment, the level of$ VIX, and volatility risk premium. Combined, these factors represent a way to characterize the 'state of the market'.



Caution Stage: The normal market state is characterized by positive volatility risk premium, moderately cautious investor sentiment, and low to moderate levels of $VIX. Historical volatility tends to be low (sub-16). Markets tend to be in this state during the initial to middle phases of a bull market. People are cautious during these stages, since the memories of the last crisis are still fresh. Option volatilities are expensive relative to historical volatility, often by 6 or 7 volatility points or more. In other words, VRP averages 6 or 7 percentage points. Hedges start costing money because they are not purchased at cheap levels. Ironically, the cautious sentiment makes it tough for markets to sell off, and the market continues to rally.

Complacency Stage: After months or years of cautious treading, the bears start to tire and capitulate. This usually happens after multi-year bull market runs such as 2005-2007 or 2010-2012. Complacency sets in, and volatility risk premium shrinks to low levels. Option traders and hedgers, who have lost a lot of money buying options, start to puke hedges, which further depresses volatility risk premium. Psychologically, people get used to the idea that markets are not volatile, and become more aggressive selling out of the money options to chase yield.* However, such aggressive yield seeking behavior is rewarded, as long as the market fails to sell off. (* skew flattens)

Panic Stage: Historical volatility finally starts picking up, usually caused by an unforeseen or marginalized catalyst that suddenly takes the center stage. If the catalyst goes away and the market comes out unscathed, then we go back to the caution stage. If not, panic sets in in full force. Volatility starts to rise sharply, and $VIX skyrockets in order to catch up. Market starts accelerating to the downside, but tradable supports have not been formed; this leaves a big question mark as to when the bleeding will stop. Option premiums shoot up, but they start looking cheap relative to historical volatility. There is not much visibility in the market. Whatever caused the crisis shows no sign of progress. Uncertainty causes fear, which triggers investors to make irrational decisions, like paying egregious options for downside puts. There is no market consensus at this point, and things start looking like crap shoot.

Relief Stage: This stage marks the last and the longest stage of the cycle. At this point, a tradable support has been formed. Markets are still abnormally volatile, but investors start to get used to volatility. Signs of a resolution to the crisis start sprouting. Hedgers and speculators start to monetize long volatility positions, putting selling pressure on implied volatilities. $VIX starts to get priced at a discount to historical volatility, as the options market prices in mean reversion of $VIX. A tradable high in $VIX is formed. Investors are still fearful of further sell-off, but they become more price sensitive with hedging as they start thinking more rationally. Sentiment is marked by extreme caution. Historical and implied volatilities start their multi-month (or multi-year) march down.

How to Apply These Ideas to Trading

Just how do we apply the lifecycle of $VIX to trading? First, investors must assess the state of the market. Each stage of the cycle provides investors with different set of risk rewards and calls for different approaches. Once the stage is determined, $VIX investors should execute the optimal plan for the stage. At the same time, they must continuously reassess the market state. The process is summarized in the diagram at the end of this section.

Caution Stage: High volatility risk premium regimes like these present a dilemma for option traders. $VIX is low (sub 20) but not low enough (below 14). Meanwhile, historical volatility will be very low in comparison (ranging from 8 to 12) at this stage. Therefore, there is not enough conviction that buying implied volatility when $VIX is, say, 16, will pay off.

In fact, these regimes may be better suited for short volatility positions. Low realized volatility tends to persist during early to middle stages of bull markets. This gives enough time for short options positions to accrue enough P&L cushion to weather out potential volatility spikes. The high positive VPR provides a 'margin of safety' to selling volatility. The main risk is the possibility of unexpected market pullback.

Complacency Stage: This is the best time to buy hedges, be contrarian, and purchase downside puts – either for speculation or hedging. Both historical and implied volatilities will be near the lows at this point. VPR will be low, given the complacent market sentiment. Option premiums are cheap enough that even a little pick-up in volatility can make buying options profitable. Since volatility is mean reverting, these times make for a great contrarian entry point. These factors all contribute to creating a very good opportunity for longing $VIX. The main risk is historical volatility staying anemic longer than expected.

Panic Stage: This is the best time to avoid doing much, if you can afford to stay flat. Unless you have a strong view, these are the worst times to build large options positions. Liquidity will be terrible and bid ask spreads will be wide. Wait for the market to develop a tradable bottom. Given the lack of visibility, the noise to information ratio in the market will be extremely high. Those who were short volatility coming into panic stage should consider covering their positions. Similarly, those fortunate enough to have hedged should consider monetizing hedges.

Relief Stage: This tends to be the best time to short volatility (via options, VIX futures, and VIX ETPs). $VIX will be high, so there should be plenty of P&L in shorting volatility. At this stage, VPR is not an important consideration, because mean reversion forces will continue to pressure $VIX downwards. As discussed earlier in the chapter, high levels of $VIX (>40) have almost always been followed by lower levels within a few months.

Unfortunately, $VIX is Not Tradable

Why can't one buy or sell the VIX? Neither $VIX nor $SPX are not tradable securities; they are indices. However, there is a big difference between $VIX and $SPX. $SPX could theoretically be replicated if one bought all five hundred stocks included in the index. Therefore, $SPX is an index that can be re-created with its constituents. ETFs such as SPDRs effectively do this for investors, as do mutual funds. On the other hand, $VIX cannot be replicated at all. Not only is $VIX not tradable, it is not indirectly investible either like $SPX.

Here's why. $VIX a constant maturity indicator, which means it always tracks implied volatility of options with average maturity of 30 days. Let us consider this simplified example, which illustrates the infeasibility of replicating a constant maturity indicator. Suppose one were to purchase 30 day options in order to replicate $VIX. The next day, the options will have a 29 day maturity. Within just one day, the maturities of the options basket and $VIX will diverge. The next day, the options basket will expire in 28 days, while the $VIX still tracks the 30 day point. Recall that $VIX interpolates the 30 day volatility point from near-term and far-term options, <u>every time it is re-calculated.</u> Thus, $VIX never 'matures', since it never tracked a fixed set of options in the first place. Eventually, the options basket will expire, while $VIX lives on, still tracking 30 day maturity implied volatility.

There are a few practical hurdles as well. First, options expiring in exactly 30 days do not exist all the time. Think about it this way. For that to happen, there has to be an options expiry every day of the year. Second, $VIX has a minute-to-minute convention, which means that the weights of VIN and VIF (near and far term expiries) change every minute. Therefore, even after someone, somehow, managed to purchase all near and far term expiry options, he would still need to rebalance that basket every minute. Given that this process would entail at least 300-400 option trades every minute, it is infeasible on many levels.

The Drawbacks of Options

There are three main ways to gain exposure (long or short) implied volatility; $SPX options, VIX futures, and

VIX ETPs (ETNs and ETFs). While each product is related to one another, there are many significant differences as well as usages. However, not every product is suited for trading pure implied volatility. Here, we will first discuss $SPX options and why they are not the ideal vehicles for gaining exposure to implied volatility.

The first reason is that implied volatility is just one of many factors that determine option payoffs. When option has time remaining until expiry, its value can change when its implied volatility changes. How? Recall the analogy of an option contract being akin to an insurance contract. If an insurance company assigns a higher probability of an accident occurring in a certain neighborhood, its housing insurance premiums will increase. At the same time, implied volatility is not the only factor that drives option premiums. The other factors include stock (futures) price, interest rates, time decay, and the strike price. Therefore, every options trade represents a sum of individual bets on each of these factors, just one of which is implied volatility.

Secondly, implied volatility only affects the mark-to-market P&L of options; it is a complete non-factor for their final payoffs. Many people forget that option payoff, ultimately, *SOLELY* depends on the difference between the final underlier price and the strike price. After an option expires, it does not matter if $VIX is at 100 or 10. *The only thing that matters is whether the stock (or futures) settled profitably through the strike price, minus the upfront premium paid.* Implied volatility only matters for options with remaining time value, because the market's estimate of future volatility means something only if an option is still in play. The general rule is the following: an option contract's sensitivity to implied volatility (the market's anticipation of volatility – or called vega) decreases as options mature. If an option has 10 years of life remaining, then it is extremely sensitive to changes in implied volatility. For an option expiring in less than an hour, not so much.

Neither is implied volatility important for an option contract whose strike is extremely far out of the money. Suppose you owned an option on AMZN that expires in one month struck at $1,000 – with the AMZN stock trading at $270 (at the time of writing). It would not mean much if the market priced in 10% higher implied volatility for that option; it would still be worthless. Effectively, there is almost no chance that the option will be in the money, and hence it will receive a very little boost from increases in implied volatility. The general rule is that options with low vega's are not good instruments for gaining exposure to $VIX.

Key: Options' vega is small if they expire sooner than later, and if their strike is further away than closer.

Don't pick these options if your goal is to 'trade $VIX'

Consider the following real-life example. Suppose on May 17th, 2013, an investor bought June 28th, 2013 expiry 1600-strike puts to bet on a pullback in the market. $SPX ended up *dropping from 1670 to 1560 over a month*, and the puts became in the money briefly. However, $SPX rallied back to 1606 just days before option settlement, and the puts ended up expiring worthless! Within that timeframe, however, $VIX rallied almost 25% (13 -> 16.3), and every VIX futures contract saw gains as well. This illustrates that $SPX options may not make money depending on strike, <u>even if $VIX rises and $SPX sells off.</u> The chance of losing money due to unfortunate strike picking is called strike risk.

Thirdly, $SPX options have inconsistent implied volatility exposure. The fact that an option's vega changes 1) over time, and 2) with underlier movements suggests that options provide inconsistent implied volatility exposure. This creates two problems: unpredictability and need for maintenance. First, unpredictable exposure is a problem for volatility investors who require that their portfolios are precisely hedged. If one cannot tolerate variable hedge exposures, options are clearly not the way to go. Secondly, unpredictability creates the onus of constant maintenance. For example, investors would need to manually intervene when their positions' vega drops or increases significantly from their desired range. This creates a need for rebalancing, which unfortunately is time consuming and costly.

Fourthly, $SPX options are unsuitable for 'trading $VIX', because individual options have little to do with $VIX. Recall that $VIX tracks hundreds of different options at any given moment. Not only that, it tracks two expiries, near-term and far-term. Therefore, it does not make much sense to purchase just one or two options and expect close tracking to $VIX. This line of reasoning is similar to expecting a single stock in S&P 500 to perform the same as S&P 500.The change in implied volatility of one option contract does not equate to the change in the aggregate level of S&P 500 implied volatility, namely $VIX.

There are other reasons why vanilla options are poorly suited for trading pure implied volatility, which we will skip for the sake of brevity. The important take-away, however, is the following:

- option prices depend on many factors other than implied volatility,
- option prices are not affected by changes in implied volatility by a constant amount, and
- option contracts do not necessarily make money when volatility rises, because other factors like underlier price and passage of time can easily dominate

In the next chapter, we will discuss how VIX futures solve many of these issues and simplifies trading $VIX.

Summary of Chapter 2

- Implied Volatility ($VIX) fluctuates around historical volatility
- $VIX tends to be higher than historical volatility when markets are stable
- $VIX tends to be lower than historical volatility when historical volatility reaches extremely high levels (+40)
- Often, high readings of $VIX signaled great buying opportunities for $SPX.
- $VIX tends to mean revert. This suggests that option investors need to be contrarian in order to be successful.
- Option investors need to recognize that $VIX rises and falls in cycles, and assess the market state based on the lifecycle model.
- $VIX itself is not tradable, be-

cause it is a price index.

- $SPX options are not the ideal instruments for trading $VIX.

Part Two: VIX Futures

We have mentioned that one cannot actually buy or sell $VIX. $VIX is not a security; it is an index. As of now, one can gain exposure to $VIX through three main channels: $SPX options (including SPDR options), VIX futures, and VIX ETNs. Prior to 2004, $SPX options were the main exchange-traded products for trading implied volatility. S&P 500 options, unfortunately, are poorly suited for trading implied volatility, if that were the goal. In contrast, $VIX futures and $VIX ETNs are easier to understand, simpler to manage, and provide cleaner exposure to implied volatility.

In 'Part Two: VIX Futures', we will introduce the basic features of VIX futures. Then, we will move on to discussing the most important properties of VIX futures; how they behave in relation to other asset classes and under different market conditions. Finally, two practical uses of VIX futures will be introduced: as a hedge, and as an alpha generator.

Chapter Three: The Creation of VIX Futures

Enter VIX Futures

Introduced in 2004, VIX futures have seen tremendous growth in the past nine years to become the most dominant instrument for buying and selling volatility. The growth has been helped by innovations such as VIX ETNs and rising public interest in portfolio hedging after the financial crisis of 2008. The average daily volume of VIX futures has grown steadily about 15% annually to 50 thousand contracts a day, which represents 50 million vega notional. That would make VIX futures the most actively traded equity derivative product globally, surpassing $SPX options.

VIX futures have many features that make them perhaps the best product for trading volatility. They inherit all the benefits of trading normal futures, including their transparency, versatility, and simplicity. This allows VIX futures to overcome many of the weaknesses of options, such their unpredictability and inconsistency.

VIX Futures are not complicated. They work just like any other futures contracts. There are a set of specifications such as multiplier, minimum tick size, and number of expiries listed at any given moment. Many readers may be familiar with $SPX futures (ES or SP). They are used for making directional bets on $SPX, which is the cash index. Similarly, we use VIX futures to take directional views on $VIX, either for speculative or hedging purposes.

How to Interpret VIX Futures

VIX futures are the markets' expectations of $VIX in the future. For example, if the September 2013 VIX futures contract (VXU13) is trading at 19, this indicates that the market expects $VIX to open at 19 on the day that September VIX futures contracts expire. Why? That is because VIX futures are guaranteed to converge to $VIX at their settlement. If VIX futures were allowed to expire at levels different from where $VIX is, then we would not be able to say that VIX futures are expectations of $VIX in the future. Thus, this guarantee of convergence binds VIX futures and $VIX together.

Main Features of VIX Futures

VIX futures are traded electronically on a single exchange called Chicago Futures Exchange (CFE), which is a subsidiary of CBOE. They are designed to be the simplest ways to gain exposure to implied volatility. In general, futures are widely traded financial instruments that simplify both hedging and speculation. Futures have existed for hundreds of years (dating back to 18th Century

Japan) for the purpose of providing investors with the means to hedge price uncertainty of commodities to be delivered in the future. Their popularity lead to development of financial futures such as T-Note futures and $SPX futures in the 20th Century. VIX futures are the latest innovation to come to the futures market.

The following is a list of the most important features of VIX futures.

Linear Payoff to Volatility: All futures contracts provide simple, linear exposure to the spot market. There is no concept of strike price, which is the main reason why option payoffs are non-linear. In other words, there is no 'contingencies' embedded in the payoff of futures contracts. It is simple to understand and manage, since the only unknown variable is the spot price in the future. Likewise, the final payoff of VIX futures depends solely on the opening price of $VIX at settlement.

Electronically Traded on Just One

Exchange: VIX futures are only traded on CFE (Chicago Futures Exchange), through electronic sessions. This contrasts with options or other futures contracts, which may be traded on multiple electronic and non-electronic exchanges. For example, SPDR ETF options trade on CBOE, AMEX, PSE, PHLX exchanges. Also, $SPX options are traded mainly inside the CBOE options pit.

$1,000 Multiplier: $1,000 multiplier means that each one point move in the VIX future price will equate to $1,000 in profit or loss, per single contract. VIX mini futures with a $100 multiplier exist, but they are much less actively traded.

$0.05 minimum tick-size: One tick represents $50 of P&L per contract. 'Tick' refers to the minimum increment that a price can move.

→ $0.05 * $1,000 multiplier = $50

$0.05 tick-size is large compared to all other U.S. options, which trade in $0.01 (penny) increments. For example, SPDR ETF options have $0.01 minimum tick size.

Listed Expiries to 9 Consecutive Months: The exchange lists up to nine different expiries of VIX futures at any given moment. Each expiry is separated from each other by a month. This number is small compared to other commodity futures like crude oil, which has contracts listed out to nine years forward.

Trading Hours: Up until May 30th, 2013, VIX futures trading hours were between 8:00 am – 16:15 pm EST. Afterwards, the hours have been extended to include another session from 4:30 pm to 5:15 pm, and the market open was moved earlier to 2:00 am, in order to attract flow from European markets. To summarize,

Session1: M – F 2:00 am to 4:15 pm EST

Session2: M – Th: 4:30 pm to 5:15 pm EST

Cash Settlement at 9:30 EST: VIX futures are cash settled, meaning that there is no physical product to be delivered. This contrasts with commodities futures, which are usually settled by physical delivery of underlying commodity. One still hears horror stories of negligent corn futures traders taking delivery of corn bushels to his house!

Auction Based Settlement Process: Due to the cash settlement feature, the exchange must publish a price that can be used for the final P&L calculation. That final price is called Special Opening Quotation (SOQ), which is determined through opening prices of S&P 500 options on the morning of the VIX expiry day. The official settlement price can sometimes take hours to compute, even though the whole process should theoretically take just seconds.

VIX Futures Make Trading Volatility Easier and Cheaper

VIX futures are characterized by clarity and simplicity. Their risks are easy to manage and visualize without the aid of complex tools. There is no burden of choosing among thousands of different strike/maturity combinations like $SPX options. In addition, VIX futures provide many additional benefits such as high liquidity and low transaction costs. The full list of benefits are summarized below.

Clear Relationship to $VIX: Recall that $SPX options have numerous factors that affect their payoffs other than implied volatility. In addition, the vega of options constantly fluctuate based on market data. Essentially, these two reasons make options poor vehicles for betting purely on implied volatility. Instead, VIX futures provide traders and investors with linear exposure to $VIX, and are guaranteed to converge to $VIX at settlement. Thus, it is much easier to understand how VIX futures relate to

$VIX.

Pure Implied Volatility Exposure: A corollary benefit of VIX futures' linear relationship to $VIX at settlement is that they provide investors with pure implied volatility exposure. The only variable, again, is $VIX opening price on the settlement day. This allows investors to directly bet on whether $VIX in certain number of months will be above or below the current price of a VIX futures contract.

There is, however, an important caveat. Prior to settlement, VIX futures and $VIX will not track each other perfectly on a day to day basis. The two will be highly correlated, but the magnitude of their fluctuations can be significantly different. As we have mentioned already, the two track different types of volatility before they converge. The key here is to recognize that the daily changes in VIX futures will not exactly match that of $VIX.

Constant Vega: VIX futures have

constant P&L sensitivity to movements in implied volatility, which is effectively the futures contract multiplier. The multiplier makes it easy to calculate how much P&L changes per movement in $VIX. In other words, the vega of VIX futures is equal to the futures multiplier, which is $1,000 per contract (for every $1 change in price). And since the multiplier is constant, it follows that the vega of VIX futures is constant as well.

Less Micro-Management: Constant vega exposure greatly simplifies maintenance of VIX futures positions, since there is less need for position rebalancing. On the other hand, $SPX options positions need frequent rebalancing, since their option vegas change all the time.

No Strike Risk: VIX futures do not have strike risk. The only thing that matters is the direction of implied volatility.

Liquidity: VIX futures are traded on

a single exchange, and only nine expiries are listed at any given moment. Among those expiries, the first two represent about 80% of total VIX futures trading volume. In essence, all trading activity for VIX futures happens in a single venue over just a few expiries, which makes them highly liquid and inexpensive to trade (in terms of bid-ask spread).

In contrast, options achieve the opposite effect by dispersing liquidity among a greater number of strikes and expiries. Just the first two months of S&P 500 options alone have over four hundred options listed. With these many tradable strikes, options essentially spread liquidity and volume thinly. While S&P 500 options, as a whole, are very liquid, liquidity shrinks dramatically at the individual strike level. A side-effect is that bid offer spreads for the vast majority of S&P 500 options tend to be wide. Only a few strikes will achieve the critical volume threshold that to the point where bid offer spreads are compressed.

Commissions: VIX Futures are extremely cheap to trade, especially considering the risk exposure that each VIX futures contract provides. At many brokerages, for example, VIX futures are charged regular futures commissions. Round-trip cost tends to be about $6 on average, which is half a basis point in terms of volatility points per contract. Considering the multiplier of a standard VIX futures contract is $1,000, the $6 round-trip commissions are extremely reasonable.

Especially, VIX futures are a bargain to trade compared to S&P 500 or SPY options, which cost similar commissions to trade per contract. When the commissions are adjusted for risk exposure, VIX futures can be <u>more than ten times cheaper to trade</u>. This is because most options contracts have smaller risk exposures than VIX futures contracts. Far out of the money

$SPX options are especially expensive to trade, because they do not have much vega or other market exposures.

VIX Futures Settlement Explained

VIX futures are designed to reflect the level of $VIX at settlement. Hence, it is only natural that the settlement price for VIX futures are calculated with the $VIX methodology, down to every detail. Each month, CBOE holds an auction of 30 day maturity S&P 500 options at the market open. VIX expiry dates are deliberately set to the dates when 30 day maturity options are available. The auction itself is run through a systematic, electronic process, although manual intervention is allowed (for example, market makers are allowed to offset imbalances). After the auction is finished, the clearing prices of the 30 day maturity options are used to calculate $VIX. The result of this calculation is the settlement price of that month's expiring VIX futures contract.

As we can see, there are two special aspects about the VIX expiry process.

First, while regular $VIX is calculated with screen mid-market prices of $SPX options, the settlement price for VIX futures is calculated with actual trade prices of $SPX options. The trade prices are determined through the auction. By using only trade prices, CBOE ensures that the settlement price truthfully reflects the supply demand for options. Mid-market prices computed from electronic screens are just indications of where $SPX options trade, and hence inappropriate for determining SOQ. Many other futures contracts use auction processes to determine the settlement prices. For example, S&P 500 futures are settled using a similar auction process (MOO- market on open). The difference is that opening auctions happen every day for S&P 500, instead of once a month like $VIX.

Second, the VIX futures settlement price is calculated from options with the same expiry date, whereas regular $VIX calculation involves two expiries, near and farm term. The expiry used for $VIX settlement calculation is exactly thirty days long in maturity. In reality, VIX expiry dates are set specifically such that they are exactly thirty days prior to $SPX option expiry days. Thus, by design, 30 day maturity options are listed on every VIX expiry date.

Example: How do we find out when the July 2013 VIX futures expire? First, take the third Friday of the month of August, 2013, which is August 16th, 2013. Second, subtract 30 days from it, where we get July 17th, 2013. That's it.

Many people are baffled by why VIX expiry days happen on Wednesdays. There is no mysterious reason for this, other than that subtracting thirty days from a Friday will always be a Wednesday.

Available Auction Data

On every VIX expiry day, CBOE (http://cfe.cboe.com/data/EOSpage.aspx) provides live updates from the opening auction, including the quantity and direction of imbalances, as well as the number of contracts paired. The paired amount indicates the number of contracts that are matched at the moment. Imbalance quantities indicate how many buy or sell orders are not fulfilled due to the lack of offsetting orders. Essentially, the direction of imbalances tells us which side (demand or supply) is stronger. This information is very beneficial for market makers, since it indicates which options need more sellers or buyers.

In addition, the aggregate direction of imbalance across all strikes tends to accurately predict whether the settlement of VIX futures will be rich or cheap. Large buy imbalances typically lead to a high settlement prints. All outstanding buy imbalances must be offset by market makers in order for the opening auction to end. To entice the market makers to offset the imbalances, the opening price of the auction must be high enough to compensate them for the risk. Thus, the actual settlement level and the direction of imbalance prior to the open are closely correlated. The reverse happens when there are large outstanding sell imbalances as well. As of now, only market makers registered with the exchange are currently allowed to offset imbalance orders.

After the auction is complete, CBOE releases the clearing levels for all strikes included in $VIX settlement auction. The actual release of this data usually falls after the market close at 4:15 pm Eastern time. This information allows people to calculate settlement prices for themselves. These disclosures are necessary, because the settlement price affects tremendous amount of P&L for the market given the enormous amount of open interest of VIX futures.

To summarize, the important data feeds published by CBOE on VIX expiry days are:

- Imbalance direction for each strike (NEED BUYERS, NEED SELLERS, or nothing)
- Paired amount for each strike
- Indicative opening levels for each strike
- The list of every strike to be included in settlement

When Not to Trade VIX Futures

So far, we have discussed the reasons why VIX futures are the best instruments for trading implied volatility. However, VIX futures are not applicable to every volatility trading goals. Here, we discuss the situations that $SPX options are better suited for than VIX futures.

In the preface, we have discussed the meaning of the term 'volatility trading', and highlighted that one can take two different approaches; to trade actual volatility or implied volatility. Again, the distinction between the two is the following. When one trades the latter, one only cares about how the market will price options going forward. When one trades the former, however, he cares mostly about how much the underlier will actually move. In general, options are used to bet on the former (actual, or historical volatility), and VIX futures are used for the latter (implied volatility). Because these instruments are used to accomplish different goals, their performances can greatly even under the same market scenario.

For example, suppose one decided to go long volatility via purchasing both VIX futures and S&P 500 straddles. If the market fails to move at all, the straddles will expire worthless. VIX futures, on the other hand, will not lose all their value. In fact, it is not 100%

certain whether VIX futures would depreciate at all, even if historical volatility dropped to zero. We only know empirically that implied volatility tends to track historical volatility. However, the two are not perfectly correlated, as there is no hard rule that requires the two to move together.

Therefore, trading VIX futures to directly bet on historical volatility runs into the problem of unpredictability, i.e. one does not know whether or how much money he would make given an estimate of historical volatility. For example, if one purchases the September 2013 VIX futures contracts at 19 in July, and the historical volatility turns out to be 12% from July to September, how much money would the person make? The answer is that there is no exact answer. All we know is that the September 2013 contracts will converge to $VIX on the September expiry date. So the real question is where $VIX will be at the settlement, and whether it will be higher or lower than 19. This question can be answered through statistical means, i.e. estimating how much VPR should be over historical volatility, etc. However, the answer will be subject to estimation errors.

In essence, using VIX futures to bet on historical volatility can be problematic, because historical volatility and implied volatility do not have an exact, formulaic relationship. The two are never the same, because the market always prices in a different future from the past. Below are the most three common scenarios where $SPX options are clearly preferred over VIX futures.

The goal is to receive time premium: If receiving time decay is the goal, $SPX options are the way to go. Sellers of options are compensated each day for wearing the risk of market volatility, in the form of time decay. These are real, hard cash-flows. The amount may be small initially for the trader or investor to notice, but it adds up eventually to eat away at the entirety of the time premium of options.

On the other hand, VIX futures do not explicitly compensate short volatility positions with time decay. Even if the market does not move for the entire duration of the position, it is possible that short VIX futures positions do not make a single penny.

More generally, to bet on volatility (but unsure of direction): The short options is a special case of betting on actual (historical) volatility. Effectively, one is making a bet that the market will be less volatile than what the options are pricing in. The same goes for long volatility positions. If one suspects a violent move in the market, but is unsure of the direction, then options are the perfect way to play that. In this case, one could purchase a straddle (a put option + a call option) to monetize that view. If the market moves either direction with more velocity than what the market implied, then the position will make money. The directionality of the underlier's move, i.e. up or down, does not matter at the end (in the case of straddle).

On the other hand, buying VIX futures to play this scenario does not make much sense. Clearly, VIX futures will make more money when the market sells off, because $VIX (implied volatility) is negatively correlated to $SPX. Hence, the P&L profile will be biased towards a downside move in the market.

To Hedge a Specific Level in $SPX: This may perhaps be the most obvious use of $SPX options. Suppose $SPX is at 1,600, and 3% out of the money put is offered at 2%. Then, a portfolio manager can buy the put option and guarantee that he won't lose more than 5%.

Buying VIX futures, however, does not provide such a stop-out. The VIX futures hedge could work out better or worse than the $SPX option hedge. It all depends on how much implied volatility spikes when the market sells off. While unlikely, it cannot be ruled out that VIX futures do not appreciate when $SPX sells off. The negative relationship between VIX futures and $SPX is not perfect, and the breakdown of the relationship is a significant risk for hedging with VIX futures.

Summary

- VIX futures are the best for making pure implied volatility bets
- Compared to S&P 500 options, VIX futures are simple to trade, easy to manage, and are liquid.
- VIX futures and $VIX converge to each other when the futures expire
- VIX futures are the most liquid volatility trading vehicles in the market
- The settlement price for VIX futures are determined through an auction of S&P 500 options. Thus, we can see that VIX futures, $VIX, and S&P 500 options are all related.
- VIX futures are not suitable ve-

hicles for betting on actual volatility

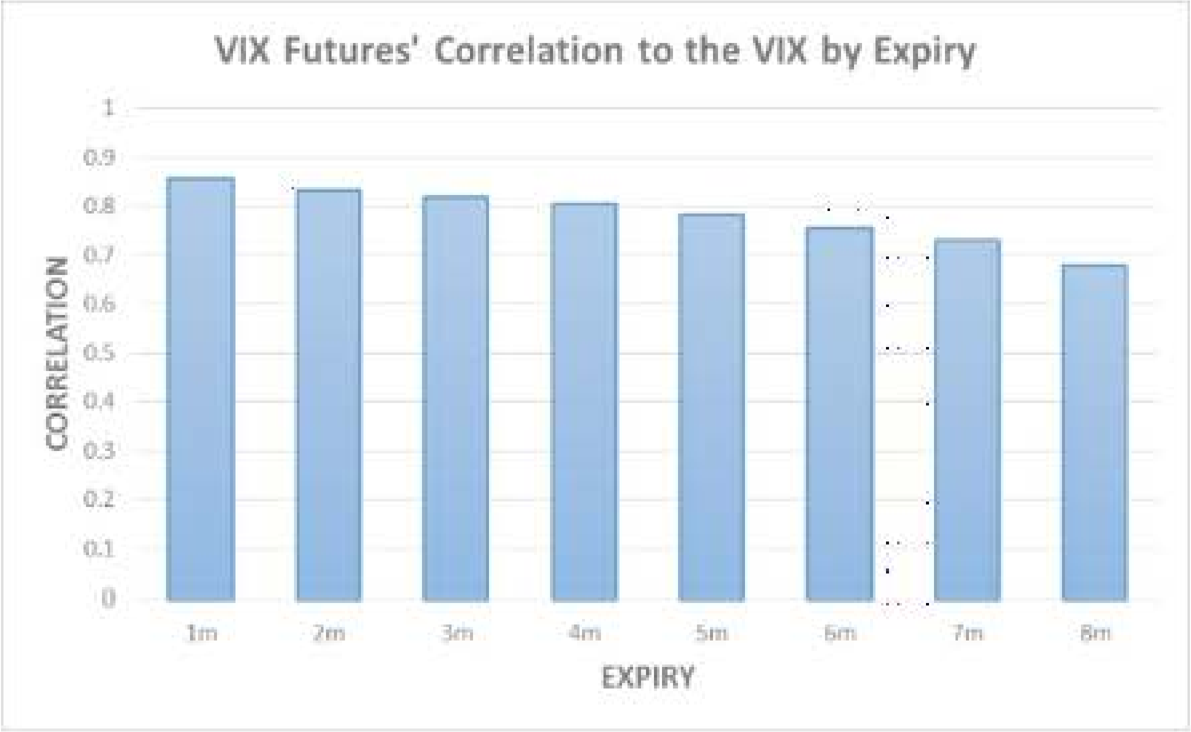
Chapter Four: Understanding VIX Futures

VIX futures are more complicated than $VIX, because there are simply more of them to analyze. The good news is that most properties of VIX futures fall into just a few categories that we will study in study in this chapter. There are currently nine different expiries listed for VIX futures, and they share some common properties as well as differences. Analyzing the differences is more interesting, because they reveal how implied volatilities behave differently across time. For example, how do sixth month VIX futures act differently from second month futures? When should investors trade short dated maturities instead of long dated ones? Answering these types of questions involves studying the term structure of VIX futures. In the rest of this book, we will repeatedly see how term structure can significantly impact implied volatility.

In chapter four, we will mainly study three aspects of VIX futures. First, we will learn about some general properties of VIX futures. These are the VIX futures' unique characteristics that separate them from traditional investments such as stocks and bonds. Second, we will study how VIX futures behave differently across maturities. Lastly, we will study the important properties of term structure spreads, which are simultaneous long and short positions of VIX futures. Spreads are the most common way to take views on the slope of the VIX futures term structure, and they have several properties that can be used as trading signals. As always, we will be defining key terms along the way in order to help the reader.

VIX Futures Tend to Move Together

Oil company stocks move together. Internet company stocks move together. Similarly, VIX futures contracts tend to move together as well. The reason for this is that all VIX futures are highly correlated to $VIX. This makes sense, because the contracts are estimations of $VIX in the future. If $VIX moved a certain amount, then one would expect the futures contracts to match the movement at least partially. As the chart below shows, since 2004, every expiry of VIX futures has had at least 75% correlation to $VIX. The implication is that future estimates of $VIX are closely related to the daily changes in $VIX. The practical implication is that VIX futures tend to either parallel shift up or down. The term 'parallel shift' refers to the pattern of VIX futures moving together in the same direction. The opposite of 'parallel shift' would be the term ‘twist’, which refers to the pattern in which some VIX futures move down while some move up. In practice, ‘twists’ are extremely rare.



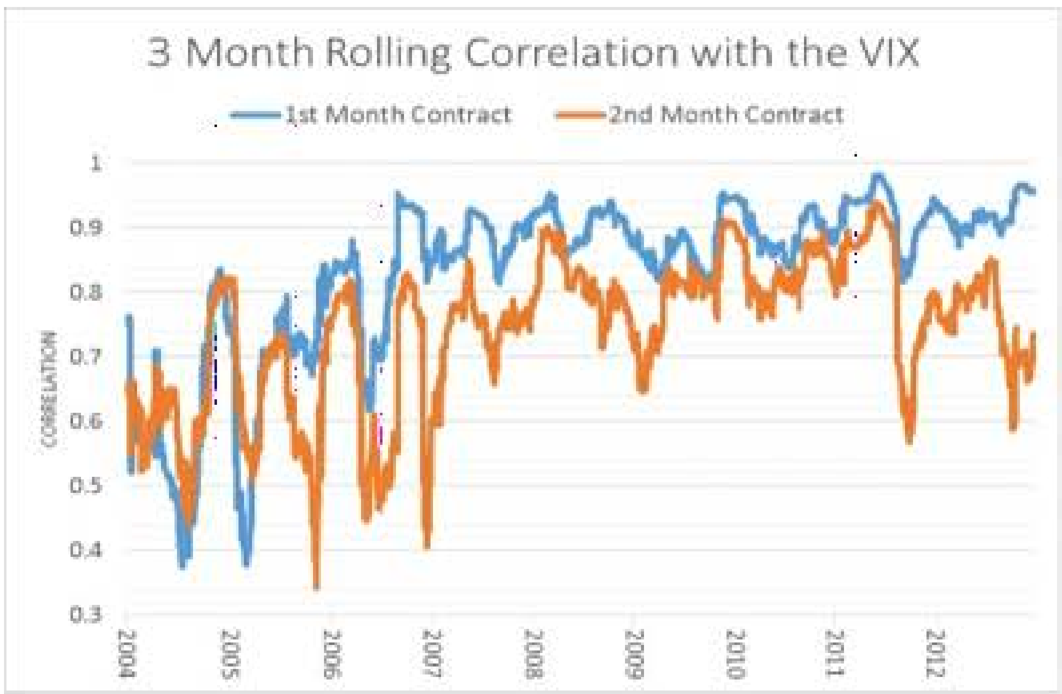
Below is a correlation matrix of 1m to 8m VIX futures contracts since their inception. Correlation between any two contracts has ranged from 72% (between 1m and 8m contracts) to as high as 92% (between 1m and 2m contracts). This also shows that that futures contracts that are closer together in terms of time also display higher correlation. Every pair of successive contracts (back to back expiries, such as 3m and 4m futures) have displayed higher than 0.92 correlation (the highest being 0.97 between 3^{rd} and 4^{th} month futures). Meanwhile, contracts that are more than six months apart (such as 1m and 7m, 1m and 8m, and so on) have displayed less than 0.8 correlation.

	1m	2m	3m	4m	5m	6m	7m	8m
1m	1.00							
2m	0.92	1.00						
3m	0.89	0.96	1.00					
4m	0.86	0.93	0.97	1.00				
5m	0.83	0.90	0.94	0.97	1.00			
6m	0.80	0.87	0.91	0.94	0.96	1.00		
7m	0.78	0.84	0.89	0.91	0.93	0.94	1.00	
8m	0.72	0.79	0.83	0.85	0.87	0.89	0.93	1.00

Key: All VIX futures contracts tend to move in the same direction on a daily basis. Contracts that are closer to each other tend to display higher correlation than the ones that are further apart from each other.

However, one must be careful not to assume that the correlation between $VIX and VIX futures is static. In reality, correlations between securities or asset classes change all the time, which makes constructing portfolios difficult and imprecise. The relationship between $VIX and VIX futures is no exception. Below is a chart of 3m correlations between $VIX and various expiries of

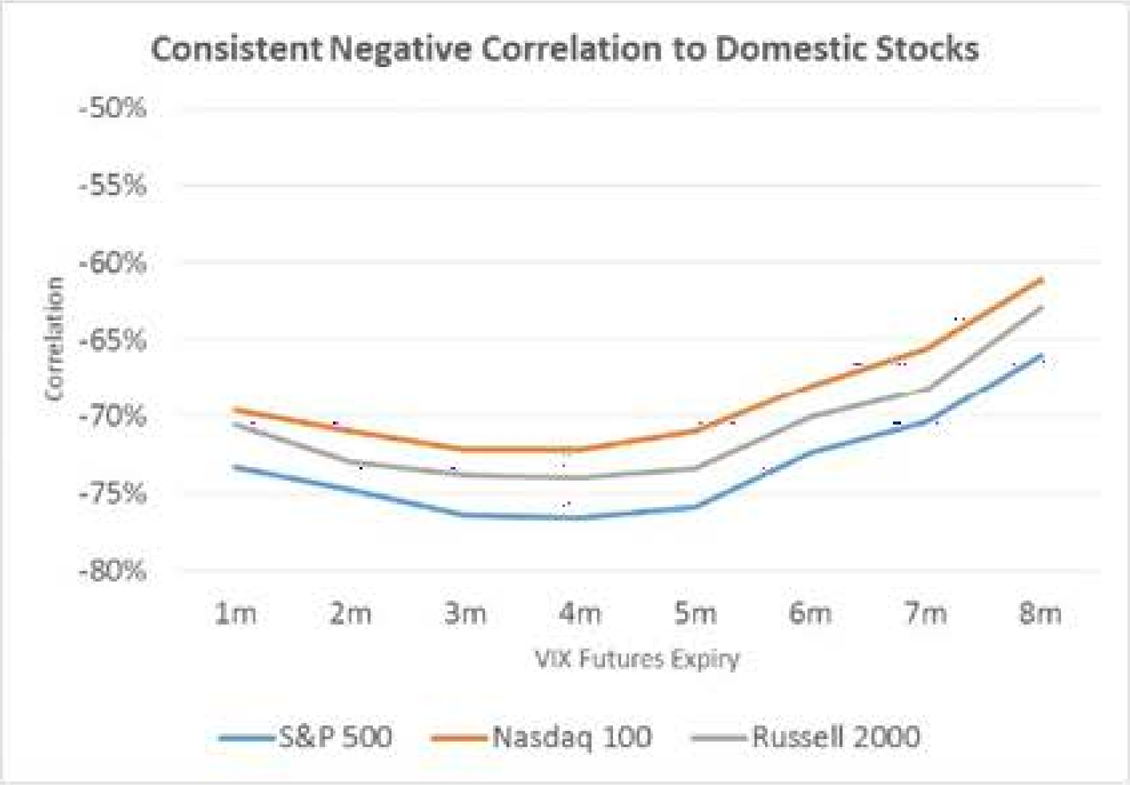
VIX futures contracts. The purpose of the chart is to show that the relationship between VIX futures and $VIX is hardly stable. Since 2004, the correlation figures between $VIX and 1m and 6m VIX futures have ranged from high 0.3's to high 0.9's, which is an incredibly wide range. The practical implication is that when one purchases VIX futures in the hopes of gaining exposure to $VIX, he or she must remember that the correlation is variable as well as imperfect. This is especially true when one purchases VIX futures after a period of high correlation. In the chart below, we note that correlations have tended to mean revert from extreme levels. In another words, high correlation regimes (0.9+ correlation) tend to be succeeded by lower correlation regimes. Similarly, low correlation regimes (0.5- correlation) tend to be met with snapbacks.



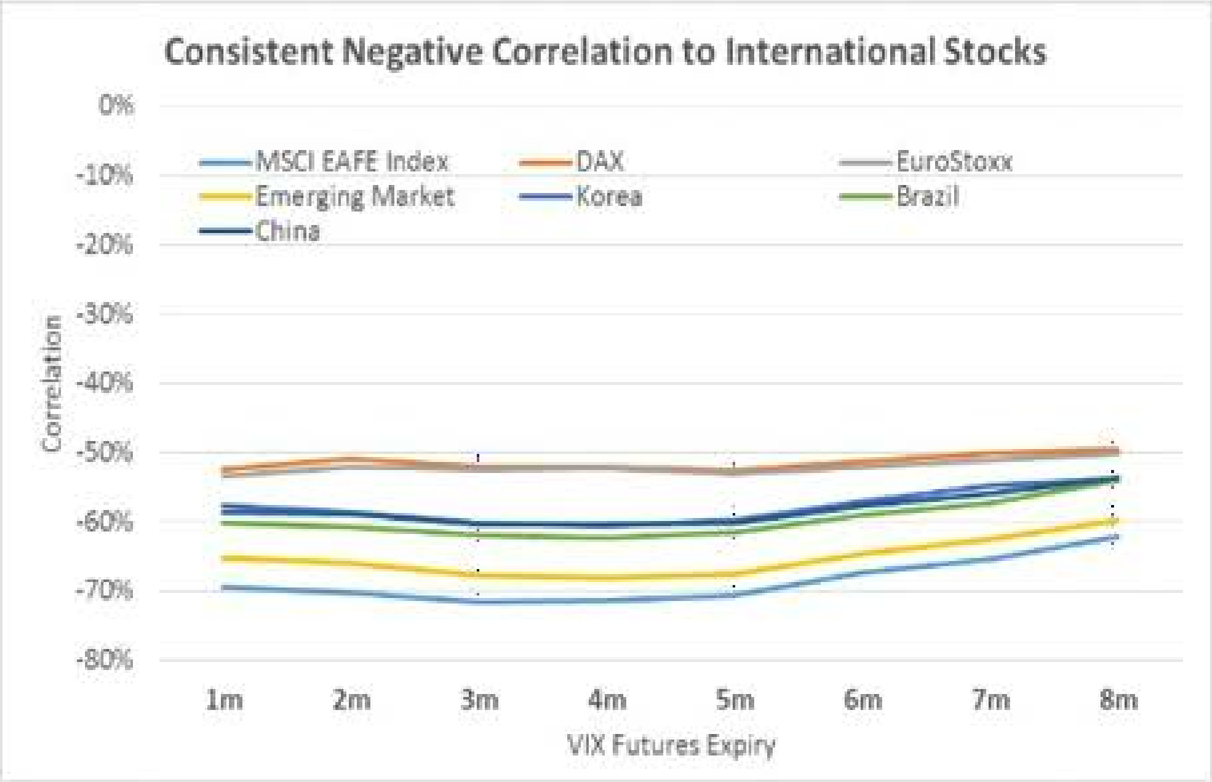
The Relationship Between VIX Futures and Risky Assets

Another commonality shared by VIX futures is their high negative correlation to traditional risky assets like equities, high yield bonds, and cyclical commodities such as crude. One would expect this to be the case, since all VIX futures are highly correlated to $VIX. $VIX, however, is not tradable, and VIX futures are the main vehicles for expressing views on $VIX. Therefore, it is worthwhile to reconfirm whether VIX futures are consistently negatively correlated to risky assets across different market segments.

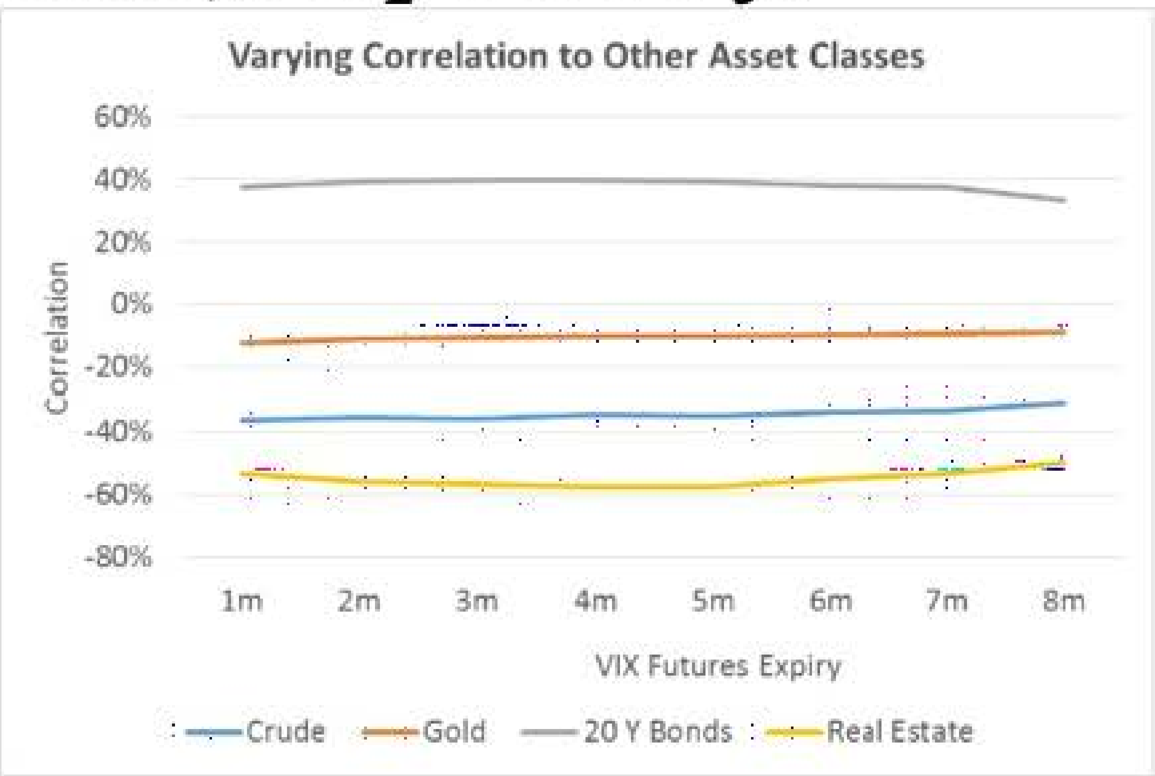
Across Domestic Stock Indices: Since inception, VIX futures have been proven to be negatively correlated to the three major equity indices in the U.S. (S&P 500, Nasdaq 100, Russell 2000). The chart below shows that the correlation between different expiries of VIX futures contracts and the three indices has ranged from mid-70%'s to low -60%'s. This shows us that VIX futures can be potentially used for hedging Russell 2000 and Nasdaq 100 as well. Since neither Nasdaq 100 nor Russell 2000 has active volatility futures markets in operation (for VXN and RVX indices), VIX futures should be considered for investors looking to hedge these two indices.



Across Globally: Emerging and developed markets alike have also shown negative correlation to VIX futures of all expiries. The following chart shows the correlation figures between VIX futures of different terms and the major international equity indices (all numbers are calculated with data starting in 2000). The take away is that markets nowadays are highly correlated. One market's risks are easily transferred to other markets around globally, since money travels faster and easier than ever. Therefore, a strong case can be made that global investors can benefit from using VIX futures to hedge their local portfolios. $SPX is the only index with a hyper-active volatility futures market, and it also happens to the most important equity market in the world (U.S. stocks represent about half of global stock market capitalization). Historically, U.S. business cycles have significantly impacted not just $SPX but international markets, and global trade has become more connected than ever through globalization. Therefore, it makes sense for investors in foreign stocks to consider hedging with VIX futures, and take advantage of their supreme liquidity and simplicity of implementation. Their alternative is to trade options on foreign stock market indices, which are magnitudes less liquid than either VIX futures or $SPX options markets. Thus, shifting to VIX futures hedges can lead to significant savings in transaction costs.



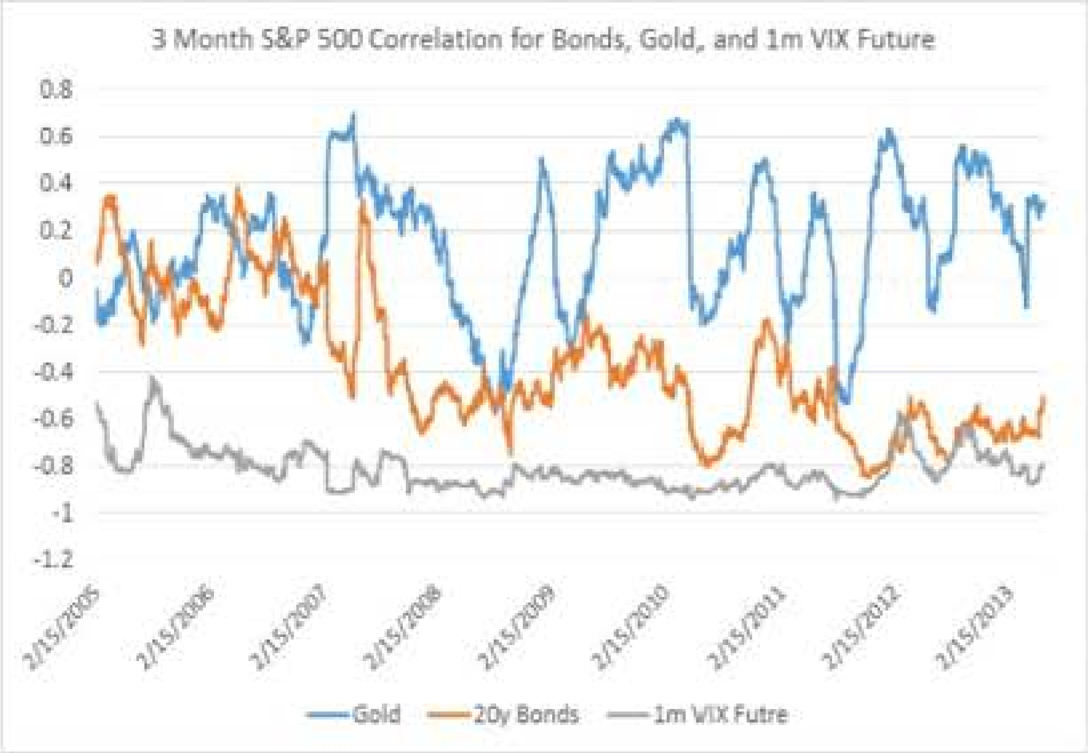
Across Other Asset Classes: Non-equity markets that are sensitive to business cycles have also been negatively correlated to VIX futures across all expiries. On the other hand, long bonds (20y Treasuries) and gold have shown positive or little correlation to VIX futures, respectively.



To summarize, VIX futures have behaved reliably different from asset classes that are tied to business cycles (domestic and international equities, as well as real estate and crude oil). Assets that move counter-cyclically, such as Treasury bonds, should behave similarly to VIX futures. Lastly, we should note that gold has had little correlation to VIX futures. This is not surprising, given that the long term correlation between the stock market and gold has been close to zero.

Comparing VIX Futures to Treasuries and Gold

Traditionally, equity investors have turned to international stocks, real estate, gold, and bonds for diversification. As of late, international stocks and real estate have become too correlated with the U.S. market to offer much diversification. Therefore, the roles of gold and bonds as diversifiers became very important in the past decade. The assumption is that bonds and gold help diversify equity portfolios, because they are not correlated to the stock market. In reality, their correlations to stocks in the past decade have been anything but stable. As the chart below shows, gold recently became correlated to S&P 500, and have gone through many periods of +0.4 correlation. Similarly, bonds went through a spell of positive correlation with the stock market between 2005 and 2007. Essentially, this shows that gold and bond are not perpetual safe havens, since they are capable of becoming positively correlated to the stock market.



The implication is that VIX futures deserve a place in traditional asset allocation. Bonds and gold have traditionally served the role of diversifiers well. However, their relationship to risky assets is not as predictable as that of VIX futures. If the bonds and gold start moving together with stocks, investors cannot rule out the scenario where all three asset classes depreciate. In fact, this is happening, as we have seen in June 2013. Given the low level of interest rates that we are facing, it has especially become problematic to rely on bonds for effectively protecting equity portfolios. This calls for more awareness among investors of VIX futures.

How VIX Futures Differ From One Another

We have so far discussed some common properties shared by all VIX futures, namely their tendency to move together as well as their negative correlation to risky assets. Let us now move on to discuss how VIX futures contracts differ from one another. This will also kickoff our discussion of the VIX futures term structure.

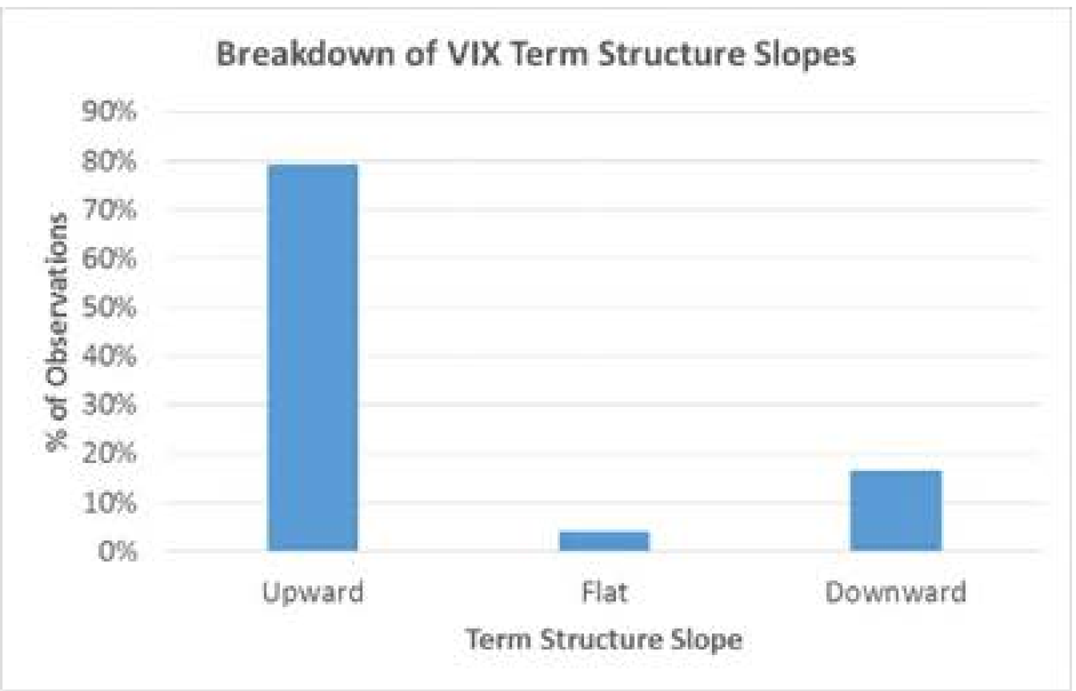
First, what do we exactly mean by 'VIX futures term structure'? It refers to the relationship between the price of a VIX futures contract and its expiry. Essentially, it involves studying how the prices of VIX futures vary as a function of time to expiry. Consider the following snapshot of VIX futures prices on June 3rd, 2013. A typical term structure chart like this shows how the levels of VIX futures contracts differ across expiries. In this case, we note that the price differences between months can be quite large. For example, June 2013 contracts are 26% lower than January 2014 contracts (15.95 versus 20.15). Also, we notice that the line is steadily upward sloping, meaning each succeeding contract is higher than its preceding contracts.

The question is why the prices of VIX futures differ for every maturity, and what factors determine these differences. In addition, we want to find out what causes the slope of VIX futures term structure to change. Finding the answers to these types of questions are the foundation of term structure analysis. These inquiries will help investors discern whether the term structure is normal or abnormal based on the market conditions, and help them choose which VIX futures to trade as well.

Key: Understanding what causes the slope of VIX futures term structure to change, and how that affects the performance of VIX futures are the crux of term structure analysis

Characterizing Term Structure States

The first thing that one should know about the VIX futures term structure is that it is predominantly in an upward sloping state. The chart below shows the % of days since 2004 when the VIX futures term structure was upward, flat, or downward sloping. We characterized the term structure to be flat if the difference between the 6m and the 1m VIX futures prices was less than 0.3 points in absolute terms. If the difference was positive, the curve was upward sloping; if negative, the curve was defined to be sloping downward (inverted). As we can see, a positive slope is the predominant state (80% of days), followed by downward (16%) and flat slopes (4%). The slope was exactly zero on just five days (0.2% of occurrences). In the financial lingo, an upward sloping term structure is defined as 'contango', whereas a downward sloping term structure is referred to as 'backwardation'. Essentially, if futures contracts are more expensive than the spot price, the market is in contango, and vice versa for backwardation.



There are two main explanations for why the term structure is mostly in contango state.

Carrying Spot Volatility Costs Money: The formula for futures pricing can be expressed as [futures price = spot price + carry cost]. In the case of crude oil futures, for example, the carry component includes the cost of transporting and storing physical crude oil until the date of delivery. In addition, it incorporates the amount of interest that one could earn by selling the physical crude oil and putting the proceeds in the bank until the delivery date. Thus, carry is a sum of all the costs and proceeds that one incurs by holding onto the physical product instead of a futures contract.

Similarly, the carry component for VIX futures can be summarized as the costs and proceeds of holding onto $VIX for the lifetime of the VIX futures contract. Since $VIX is not tradable, however, the carry of VIX futures implies the costs and proceeds from holding onto S&P 500 options over that time. According to the futures pricing formula, the futures price is higher than the spot price only if the carry number is a net cost (positive number). For that to be true, holding S&P 500 options over the period must be expected to be cost money, i.e. a money losing position. Historically, holding options positions have been unprofitable, since options lose money when historical volatility is lower than implied volatility. Therefore, if the VIX term structure is in contango, where the futures prices are higher than spot, the market is implying that historical volatility is expected to be lower than implied volatility of S&P 500 options.

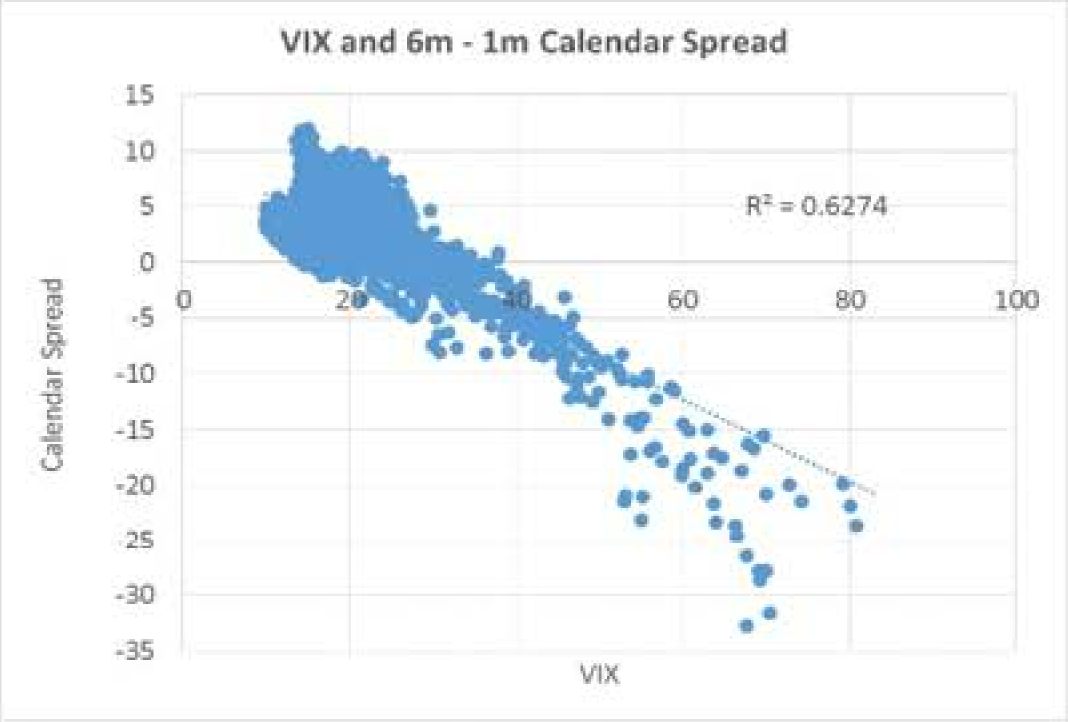
Expression of mean-reversion: When $VIX drops to low levels, it is rational for the market to price VIX futures contracts at higher premiums. For example, it is unreasonable to sell 8m VIX futures at 10 when $VIX itself is trading at 10. The reason is because the future distribution of $VIX has an upward-bias when $VIX trades at low levels, i.e. lower than 15. Essentially, contango is the mechanism through which the sellers of VIX futures demand higher premiums to spot $VIX in order to account for the mean reversion effect. In other words, contango reflects the majority-market view that $VIX is likely to be higher in the future.

The opposite is true for backwardation. For example, when $VIX is trading at 80, it is unreasonable to purchase 8m VIX futures at a higher level than 80. That will essentially equate to a view that a peak-state in chaos will persist for eight months with no resolution. While possible, such a scenario is unlikely to be sustainable for so long. Therefore, buyers of VIX futures are discouraged from paying high levels for longer dated futures when $VIX is high, which drives their prices down. In addition, historical volatility tends to spike above implied volatility during high $VIX regimes, which turns the carry component into a negative number. Thus, the formula would indicate that VIX futures will trade at a discount during high volatility regimes. Effectively, one is rewarded for holding physical S&P 500 options over VIX futures, which makes VIX futures less valuable in comparison.

Table: Summary of Contango Versus Backwardation

	Contango	Backwardation
Slope	Upward	Downward
Likely when…	Low volatility regime ($VIX is below 20)	High volatility regime ($VIX is above 30)
Implied Carry of S&P 500 Options	Cost	Proceed

These points suggest that the term structure slope may be negatively correlated to the level of $VIX. If this relationship were true, the higher the level of $VIX, the flatter the VIX term structure will become. In fact, we can confirm this in the scatterplot below, which shows a high R^2 (0.63) between the level of $VIX and the calendar spread between 6m and 1m contracts.



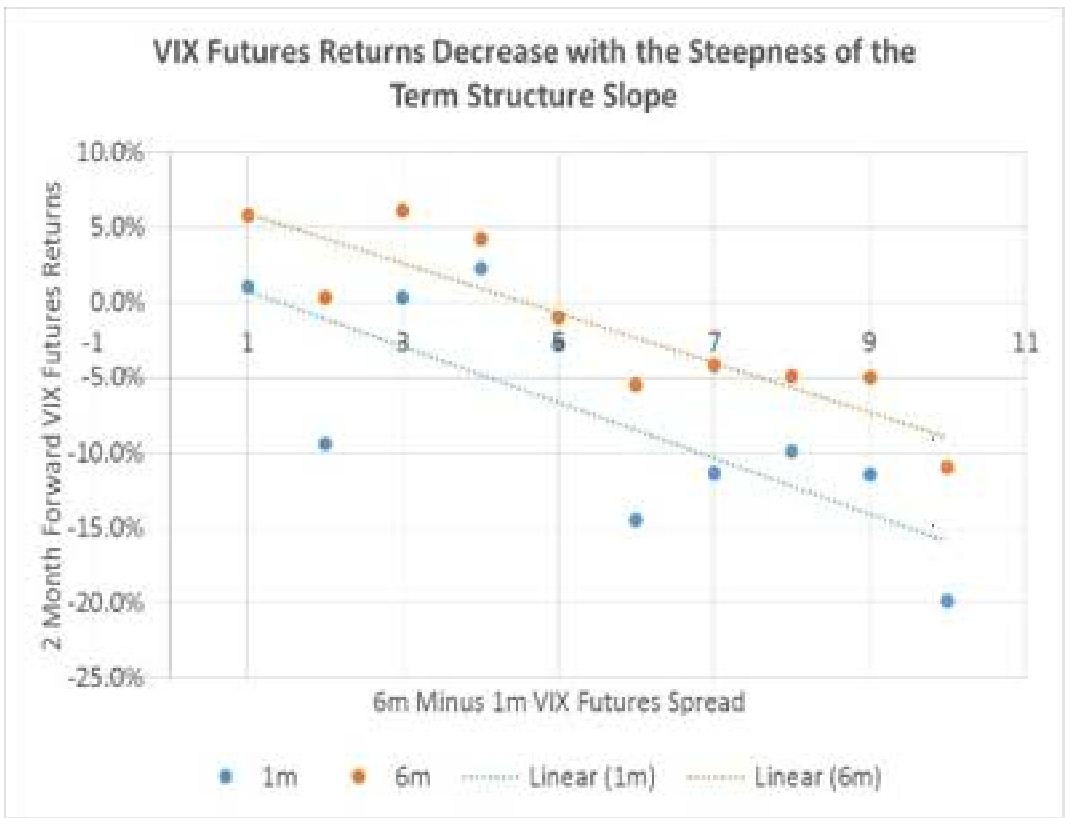
In practice, this relationship between calendar spreads and $VIX can be used to express views on volatility. The execution is done mainly in the form of calendar spread trades, which involve a long/short position in two VIX futures contracts of different maturities. A long calendar spread trade (long further dated contract, short shorter dated contract) benefits from the slope steepening, i.e. contango increasing. Conversely, a short calendar trade spread benefits from the slope flattening, i.e. contango decreasing. Thus, short calendar spread profits during bearish market scenarios (market sell-off, spike in $VIX, etc), whereas long calendar spread outperforms in bullish to neutral market scenarios.

Then, what is the most important motivation for trading VIX futures spreads instead of outright contracts? The distinct advantage of trading spreads is the reduction of vega risk. If the spread is done on a 1-for-1 basis, one can practically have zero vega exposure (no P&L sensitivity to parallel shifts in the VIX futures curve). This is beneficial if one has little conviction about the level of volatility, but wants to have an isolated exposure to the shape of the VIX futures curve.

What Contango and Backwardation Mean for VIX Futures

So far, we have seen how often the VIX term structure is in contango or backwardation states, and the factors that cause the term structure slope to change. However, we have not yet discussed why investors should care about the term structure's slope. The main reason is that the slope of the VIX futures curve is a powerful predictor of future performance of VIX futures. In general, VIX futures tend to appreciate when the term structure is in contango. When in backwardation, VIX futures tend to appreciate. This phenomenon has been extensively documented not just for VIX futures, but for other actively traded commodities futures markets like crude oil and natural gas as well.

Below is a chart of the average two month performances of 1m and 6m VIX futures across various levels of 1m6m term structure spread, defined as 6m VIX futures price minus 1m VIX futures price. The data implies that higher levels of the spread imply lower forward returns for both 1m and 6m VIX futures. For example, when the 1m 6m VIX futures spread reached 6 or above, both blue and the orange dots are below zero. Conversely, when the spread was below 5, the returns for 6m VIX futures were generally positive, and the 1m futures also performed significantly better compared to when the spread was wider. This implies that the two month returns for both 1m and 6m VIX futures individually were negative in these scenarios. In addition, performing linear regressions against this dataset produces two linear equations with statistically-significant negative slopes. We can see that the blue line rests below the orange line, which implies that the average two month returns for 1m VIX futures have historically been about 5% lower than 6m VIX futures.



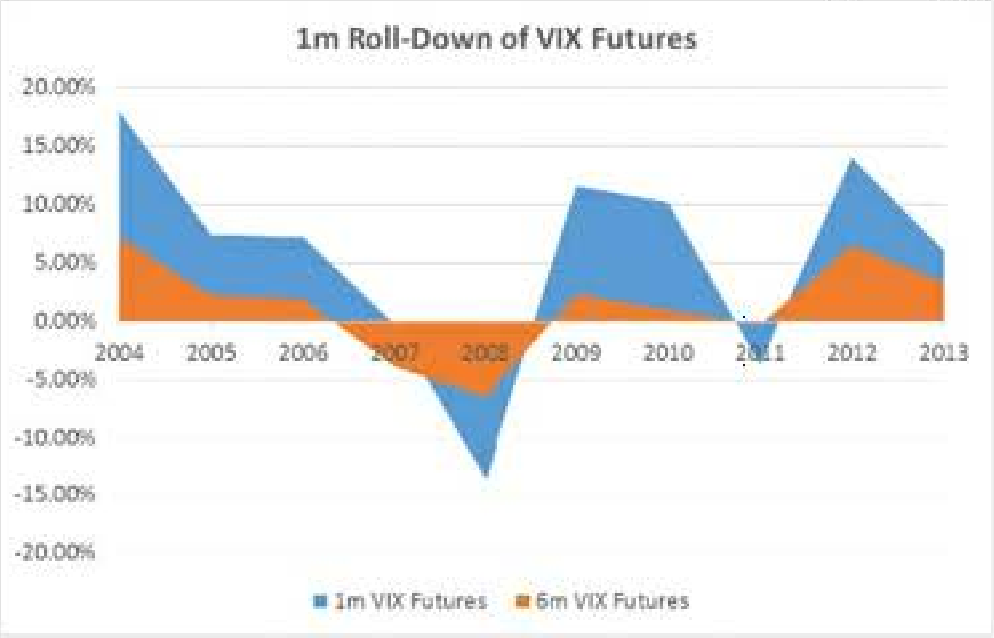
The main reason for this is that during contango regimes, long futures positions suffer from negative roll-down. 1m roll-down is defined as how many points (in $) a VIX futures contract is expected to appreciate/depreciate if the shape of the term structure stays constant over the next expiry cycle (roughly one month). The formula is approximated as:

$$\frac{P_{i+1} - P_i}{P_i} \times \frac{30}{N_{i+1} - N_i}$$

, where P_i equals the price of i-th month VIX futures contract, and N_i equals the number of days from now to the i-th month VIX expiry. If the term structure is in contango, 1m roll-down for every VIX futures contract will be positive. Conversely, it will be negative if the term structure is in backwardation. For example, if the 3m VIX future's 1m roll-down is 5%, it implies that purchasing the contract will result in a 5% loss in 30 days. Conversely, if the figure is -5%, it implies a 5% profit.

Roll-down during contango regimes is the primary drag on strategy performance, which negates much of the risk reduction benefits that they also provide. Below table summarizes the average roll-down of VIX futures by year since 2004. On average, 1m and 6m VIX futures contracts suffered 5% and 1.5% losses due to negative roll-down from contango, per month. Generally, the term structure flattens along far dated expiries, which explains why longer dated contracts tend to hold better over long periods.

Chart: 1m Roll-Down of 1m and 6m VIX Futures Since 2004, By Year.

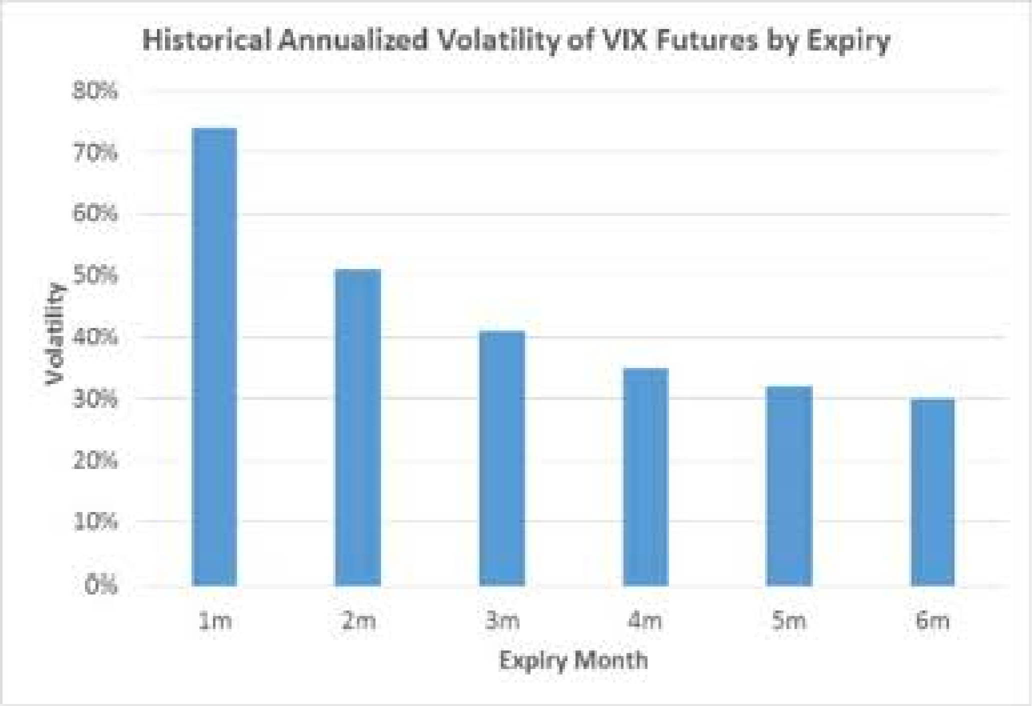


Due to this relationship, short VIX futures strategies generally work the best during the highest contango regimes, whereas long VIX futures strategies work the best during the highest backwardation regimes (most inverted). In the later chapters, we will find that we can exploit this relationship between term structure and VIX futures' returns to make significant improvements to both long and short VIX futures strategies.

Volatility and Beta of VIX Futures

There is nothing complicated about the term 'volatility of VIX futures'. It simply refers to how volatile each VIX futures contract is. Just like any other futures contracts, the number is calculated as the annualized standard deviation of the daily price changes of VIX futures contracts. The rule that we will highlight here is that shorter dated futures are more volatile than longer dated ones. The chart below shows how the historical volatilities of VIX futures differ across time to expiry. We note that each contract is less volatile than its preceding contracts, and that the differences in volatility can be quite large. For example, it shows that

1m contracts are twice as volatile as 6m contracts (72% versus 30%). It is also obvious that VIX futures, on average, are much, much more volatile than the S&P 500 index, which has had 18% volatility in the past decade.



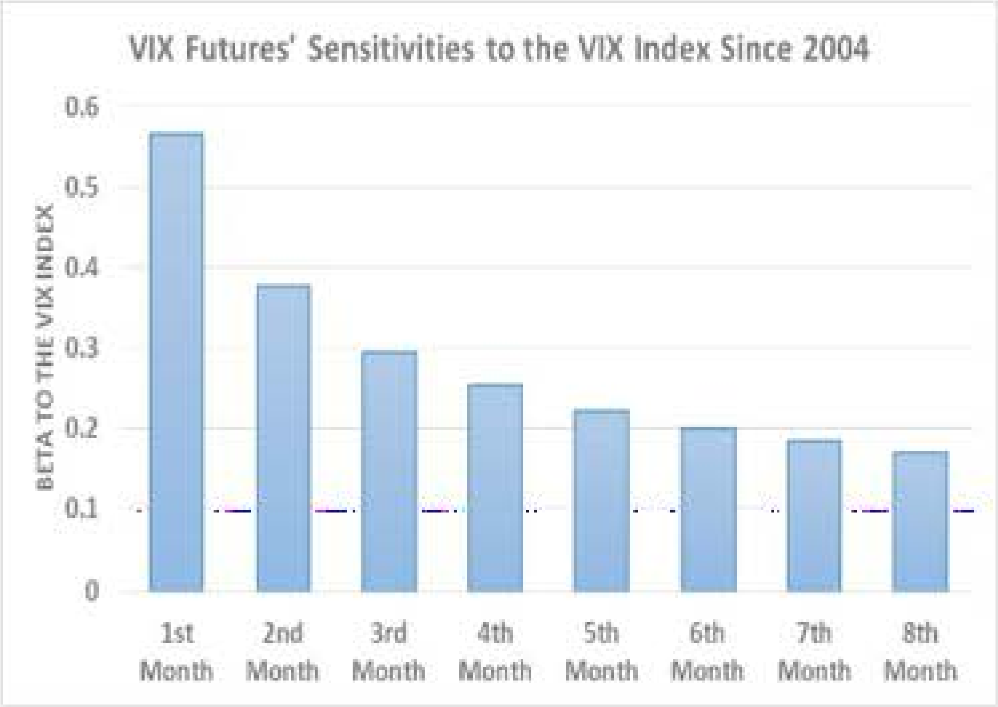
In addition, we note that the difference in volatility between successive pairs of contracts decreases with time to expiry. For example, there is a large difference in volatility between 1m and 2m contracts (75% versus 50%), whereas that between 5m and 6m month contracts is tiny (31.5% versus 30%). Thus, the volatility of VIX futures contract decreases with time only up to a certain point. Past that point, VIX futures start moving very similarly to each other in both direction and magnitude.

So, why are long dated VIX futures contracts less volatile? The reason is because short term volatility estimates are more sensitive to the daily changes in the market than long term volatility estimates. For example, it is not as clear how one day of market sell-off will affect market volatility in one year's time. However, it is easier to see how the market volatility over a shorter timeframe can be affected. To see why, suppose CBOE listed VIX futures contracts out to one hundred years (for illustrative purposes). A 100 year VIX futures contract should theoretically have close to zero volatility, because the daily movements in the market will add almost no information to one's estimate of $VIX in a hundred years. Similarly, a 99 year contract should have nearly zero volatility, since a year's difference in 99 years does not mean much. Thus, 100 year VIX futures should be trading at a similar level to the 99 year contracts. Essentially, the information value of daily market movements exponentially decays to zero as we lengthen the timeframe of estimate. This is the fundamental reason why volatility of VIX futures decreases with time in an increasingly slow manner (of course, the volatility of one hundred year VIX futures will not exactly be zero, but a small positive number).

This has important consequences for picking which VIX futures to trade.

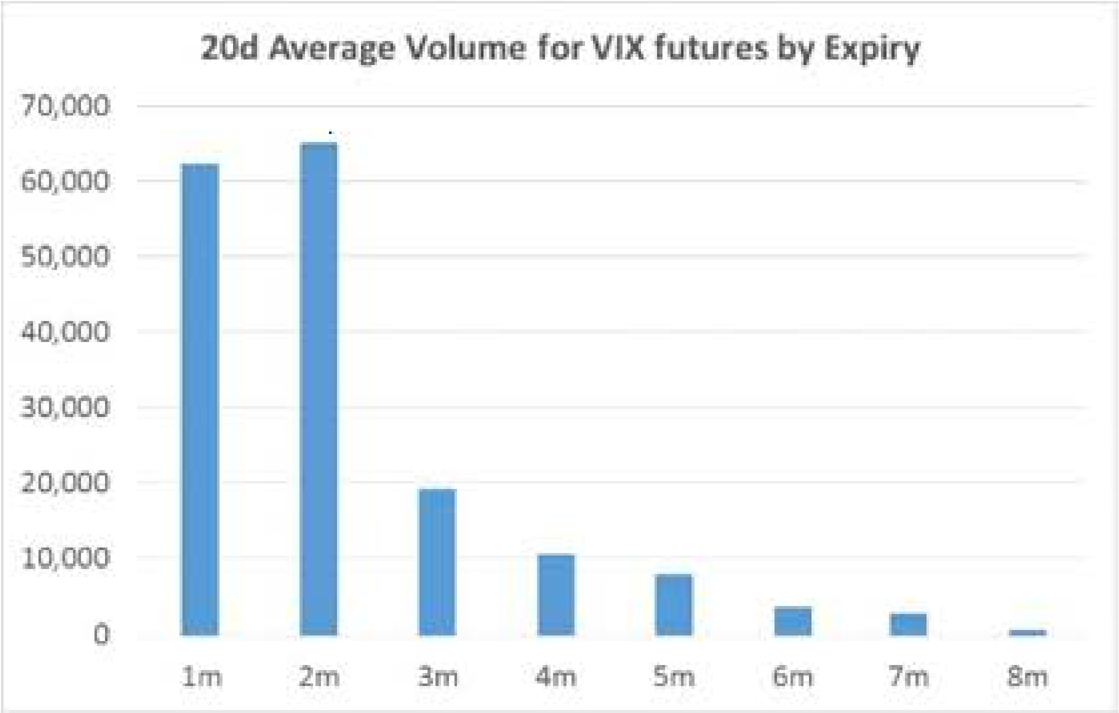
Example: If one's goal was to hedge short term pull backs of $SPX, long dated VIX futures are not appropriate. Imagine one were to buy 100 year VIX futures to hedge a six month correction in the market. It is unreasonable to think that the 100 year VIX futures contracts would even budge for market corrections over a six month horizon. Beyond a certain expiry, VIX futures will become so insensitive to daily market changes that they would become useless. Thus, when deciding between VIX futures, investors need to consider which contract duration fits one's hedging timeframe the best. Generally, pick a VIX futures contract that expires on or before the end of the period that one desires to hedge. For example, if one is hedging over a six month horizon, it is reasonable to trade any contract from 1m to 6m.

Finally, every VIX futures contract has different betas to $VIX. The beta of X to Y tells us how much X is expected to move in percentage terms for every 1% move in Y. For example, if Amazon has a beta of 2 to $SPX, it indicates that Amazon stock moves 2% for every 1% move in $SPX on average. Thus, beta quantifies how sensitive an instrument is to daily changes in the benchmark, whether it be $VIX or something else. The chart below shows that all VIX futures contracts have beta to $VIX that is smaller than 1, which indicates that 1% move in $VIX tends to coincide with less than 1% move in VIX futures. In addition, it shows that shorter dated contracts have a higher beta to $VIX than longer dated contracts. This simply reflects the fact that shorter dated contracts are more volatile than longer dated contracts, and that they are more correlated to $VIX as well. As each contract nears expiry, it will become more highly correlated to $VIX, and hence its beta will increase as well.



VIX Futures Are Not All Liquid

For VIX futures, liquidity tends to decrease with maturity. The chart below shows average daily volume of VIX futures by maturity. 1m and 2m VIX futures tend to five to six times as active as 5m and 6m futures. Liquidity falls off dramatically after seventh month. This may be surprising when one considers that short dated VIX futures are more volatile than longer dated VIX futures. Normally, at least in the case of the stock market, high volatility stocks (such as penny stocks, small cap stocks) tend to have lower liquidity than more stable, large cap stocks. The reason is because high volatility discourages investors and hence reduces liquidity. Then, what explains the phenomenon that short term VIX futures are more liquid than the long term ones?



The answer is best explained by the old adage: "liquidity breeds liquidity". 1m and 2m VIX futures are held by VXX, which is the most liquid volatility ETN in the market (we will cover VIX ETNs in greater detail in later chapters). VXX is significantly more actively traded than VXZ, which is an ETN that holds the 4m, 5m, 6m, and 7m VIX futures contracts (by a factor of 40). Therefore, 1m and 2m VIX futures benefit significantly from having an affiliated ETN that is hyper liquid.

In addition, short term VIX futures may be considered more useful for hedgers than the longer term contracts, because they track $VIX more closely. For example, trading 7m or 8m futures to hedge against immediate market sell-offs is unreasonable, given that their relationship to daily market changes is weak. In contrast, 1m VIX futures are very sensitive to daily market changes, and hence more useful for hedging short term market disruptions. Thus, short term VIX futures have a stronger use case, which could explain why their trading volumes are larger than the longer term contracts. As we pointed out, extremely long dated contracts will not be suitable for hedging, since they have very little sensitivity to short term market disruptions.

Chapter Five: Hedging with VIX Futures

In this chapter, we will highlight the specific components of implementing a hedging strategy with VIX futures, such as hedge selection, hedge sizing, and risk management. In addition, we will explain the difference between discretionary and systematic VIX futures hedging programs, as well as their pros and cons. Finally, we will overview some of the common (read: rookie) mistakes in trading VIX futures.

Hedge Implementation

Successful hedging with VIX futures starts with the right sizing. The most commonly asked question by first time traders of VIX futures is the following:

If I have X dollars invested in the stock market, how many VIX futures do I need to buy to hedge myself?

In this chapter, we will try to answer this question using an easy step by step methodology. But first, we must understand that the above question is actually a two-part question. Notice that the question assumes that one already knows which VIX futures to buy. Picking the right VIX future is just as important as determining position sizing. Therefore, we will tackle this question in two stages: hedge selection (which VIX futures contract to buy) and hedge sizing (how many contracts to buy).

Hedge Selection: Picking the Right VIX Futures Contract

Deciding which VIX futures to buy can be overwhelming, especially these days when there are nine listed expiries. However, picking the right VIX futures contract is easy once the trader/investor knows what he wants out of hedging. For example, how sure is he about the timing and magnitude of the market selloff? How much capital is he willing to commit to purchasing VIX futures? Based on one's answers to these questions, the hedging strategy will be different, and it will dictate which contract expiries are required.

In the previous chapter, we discussed several key aspects of VIX futures, such as their tracking to $VIX and sensitivity to the market. Due to the disparities in their properties, each VIX futures contract is suited for hedging different market scenarios. The following are three main factors to consider before choosing an expiry to buy: the length of hedging window, one's level of bearishness, and the slope of the VIX futures term structure.

Length of Hedging Window: If one believes that a market sell-off is imminent, he should purchase first or second month contracts. Recall that short dated contracts track $VIX the best, and have the highest negative sensitivity to the stock market. These properties make them better hedges for short term pull backs than longer term contracts, which are not as sensitive to daily market changes.

Conversely, if one is uncertain about the timing of the sell-off (but believes that there will be one in X number of months), then he should consider purchasing a contract that expires in X months or longer. For example, if one believes that there will be a sell-off within four months but is unsure when, then buying 3m or 4m contracts is a good compromise. In this case, purchasing a 1m or 2m contract is problematic for two reasons. First, short dated contracts tend to suffer most from the contango. Therefore, if nothing happens (and usually, nothing ends up happening that roils the market), short dated contracts lose money faster than long dated contracts. Second, short dated contracts will need to be rolled more often within the hedging window. Rolling futures contracts will increase the total transaction costs, not to mention that it demands trader's attention.

Degree of Bearishness: If one has strong conviction in a large sell-off in the market, then he should purchase 1m or 2m contracts. These short dated contracts will spike much higher than 6m or 7m futures in the event of a market sell-off, often two to three times as much. Short dated VIX futures contracts tend to have the most negative betas to $SPX, which can range anywhere from -3 to -7. In comparison, 6m to 7m VIX futures have negative betas that range anywhere from -1 to -4. Thus, the longer term contracts will provide 'less juice' if one's goal is to capitalize on a market crash.

However, there is a caveat. In return for higher negative sensitivity to

$SPX, short dated VIX futures suffer from high negative roll-down and high volatility. If the bearish scenario does not pan out, then owning 1m VIX futures will cost almost twice as much as owning 6m VIX futures. Thus, one should always balance the strength of his conviction with the risks of being long short dated VIX futures.

The Slope of Term Structure: One can further optimize his selection of VIX futures by calculating the 1m roll-down metric for the VIX futures curve. Generally, one's goal is to pick the shortest dated VIX futures with the lowest 1m roll-down. Alternatively, one should pick the expiry that provides the most negative beta to S&P 500 divided by its 1m roll-down. The idea behind is to maximize the hedging power of a VIX futures contract per unit of roll-down.

Hedge Sizing

Once it is decided which VIX future will be used as the hedge, one can follow the three steps below to determine the number contracts to purchase.

Step one, determine the notional value of S&P 500 exposure that needs to be hedged

Step two, figure out the beta of the VIX future to the S&P 500, which will be the hedge ratio

Step three, solve for the number of VIX futures contracts in the following equation

# of VIX futures * (beta of the VIX future to S&P 500) * 1000 = Notional to be Hedged

The first step is purely up to each individual's discretion. The decision will be influenced by one's market view, risk tolerance, and desire to monetize or cut losses. The number of contracts increase linearly with the desired hedge exposure. If one wants to protect his entire equity portfolio as opposed to only 50%, then he must buy twice as many VIX futures. One must remember, however, that hedges do not provide one with free lunch. One cannot protect the portfolio and expect the same amount of upside as one would have if he did not hedge. A VIX future hedge will most likely lose money if risky assets continue to rally.

The second step involves determining the beta of the VIX future to the S&P 500. In order to calculate the beta, we need to first decide how many days to use as the parameter for beta calculation. We have previously discussed that VIX futures maintain negative betas under most timeframes. However, the number of contracts to purchase can vary significantly depending on which beta metric one decides to use. For example, as of May 2013, one month beta is about 30% larger than the six month beta, meaning one would purchase almost 30% more VIX futures as hedge if he were to use six month betas as the hedge ratio.

In order to bring consistency to the

hedging methodology, one must stick to a particular rolling period for beta calculation. Ideal hedge ratios must satisfy two properties. A good hedge ratio will balance responsiveness and stability. Responsiveness means that the hedge ratio adapts to the regime shifts in correlation regimes. Stability, on the other hand, means that the hedge ratio is not too volatile for practical use. Typically, three to six month betas of VIX futures to S&P 500 are used as hedge ratios. One year beta can be too slow to react to fast changing conditions. In contrast, one month beta will adapt too quickly to the latest correlation regime changes, and hence lead to numerous false alarms.

In general, shorter term futures have higher negative betas to S&P 500 than longer term futures; therefore, less of them are need to hedge the same amount of exposure. For example, suppose 1m and 6m futures had betas of -6 and -3 to S&P 500, respectively. Based on the formula presented above, one theoretically needs just half the number of contracts to gain the same amount of hedge exposure. This, however, is not to say that purchasing one of 1m contracts and two of 6m contracts are the same trades. For example, the vegas of the two positions are different. If the VIX futures term structure parallel-shifted up one point, then the latter position will lose twice the money. One must remember that beta is just a statistical estimate. There is no hard rule that says that two positions with the same betas to S&P 500 will move the same amount. Here, we are merely pointing out that one could potentially purchase less vega to gain potentially the same amount of exposure to S&P 500.

Key: If you want to minimize vega exposure, buy 1m VIX futures. If you want to maximize vega exposure, buy 9m VIX futures, or whatever that is furthest dated.

Hedge Execution

Once a hedge is chosen and the number of contracts to be purchased are determined, the remaining step is execution. The important guidelines are to hedge periodically at regular intervals, while avoiding initiating hedges at extremely stretched levels in $VIX. The following are a few rules of thumb.

Hedge When You Can Afford to: Sometimes it is tempting to 'let it ride' and not put on hedges when implied volatility is cheap, i.e. when $VIX is at 16 or lower. However, by the time something happens that causes the market to drop, it typically becomes 'too late' to buy options or VIX futures. Recall that $VIX always mean reverts. Every time one pays up for options or VIX futures, he or she is increasing the chances of future losses. The only time when mean reversion of $VIX favors implied volatility buyers is when $VIX is low. Therefore, those inclined to periodically book profits should consider hedging every time $VIX is oversold.

Always Monetize Hedges: Again, because VIX futures mean revert, it is important to monetize hedges when they do pay off. Recall that $VIX has reversed back down with almost 100% probability in three months every time it spiked above 40. This suggests that one does not get rewarded for holding on to VIX futures for long periods of time. Therefore, it is important that investors begin monetizing VIX futures after $VIX spikes above a critical level. In this way, one may not be able to sell the absolute high of VIX futures, but at least he will avoid letting all his P&L melt away when $VIX crashes back down.

Hedge Periodically, If Levels Make Sense: One needs to hedge periodically when the levels are low in order to remove the burden of timing. Due to the strong mean-reversion forces, the risk reward becomes terrible to the late entrants of the hedging game, once $VIX hits 30's or higher. When one hedges regularly during the times when $VIX is low and the term structure is flat, one significantly improves his chances of making money with VIX hedges. This also helps one cultivate a positive attitude toward trading/investing. One knows that he has actively prepared for adverse situations in the market. Therefore, when the markets sell off and provide him with better investing opportunities, he will not be panicking.

Why Sizing Hedges This Way Is Appropriate

Instead of sizing every hedge, why not simply buy equal number of contracts per every hedge? This approach has some merits, but its cons far outweigh the pros. The main con is that purchasing equal number of contracts periodically deludes one into thinking that his risk exposure is kept constant. Risk, however, should always be thought of in terms of dollar notional. To see why, consider that ten contracts of 1m VIX futures priced at 16 equates a notional exposure of 16 * 1000 (the multiplier) * 10 = $160,000. When the level is at 32, however, the same number of contracts gives one $320,000 of hedge exposure. Essentially, the method inherently ramps up hedges when volatility is expensive, and buys little when volatility is low; therefore, it goes directly against the mantra of "buy-low, sell-high".

This mistake is compounded by the fact that volatility-of-volatility is higher when implied volatilities are high. In other words, VIX futures tend to be more volatile themselves when their prices are high. Therefore, if one purchased the same number of contracts regardless of their price, he will not only suffer from higher dollar notional exposure to VIX futures, but also higher volatility of the position itself. This shows that <u>managing VIX futures positions in terms of contracts or 'vega' is a terrible practice in risk management.</u> With this approach, one is guaranteed to have the worst P&L swings at the worst times as well, and can create significant emotional distress.

Systematic Hedging

So far, we have discussed mostly how to make better decisions picking VIX futures, sizing positions, as well as taking profits. These decisions, to varying degrees, involve one's discretion. At some point, the trader needs to make a judgment call based on his view of the market. For example, how does one decide how much of his portfolio he wants to protect? Should one allocate 5% or 15% of his portfolio to VIX futures for the best risk adjusted performance? If one decides to make all these decisions with his 'gut', the trader will need to personally make these decisions all the time. Some traders enjoy making these market calls because it gives them a greater sense of control over their positions. For those who are averse to discretionary trading, developing a systematic approach to trading VIX futures is necessary.

Systematic VIX futures hedging program can be separated broadly in two categories: static and dynamic. In this book, we define a static hedging strategy as one that requires maintenance of a fixed percentage allocation to VIX futures. Dynamic hedging, on the other hand, imposes no fixed allocation to VIX futures. The strategy will incorporate a trading signal that tells the trader to either ramp up or decrease allocation to VIX futures based on the signal's assessment of the market. Either case, systematic hedging programs reduces the burden of human trader to personally make decisions all the time. The major benefit of this is that it eliminates avoidable human error, i.e. impulsive trades. In addition, a systematic approach programmatically enforces discipline a priori, such as profit taking and risk management.

Static Hedging

A static VIX futures hedging program typically look likes the following: 'every month, allocate X% of the portfolio notional to front month VIX futures contracts, and keep the rest in $SPX'. This approach is simple to implement, easy to understand, and can be effective as well under certain scenarios. In addition, there are two other benefits of using a static/target allocation strategy for VIX futures.

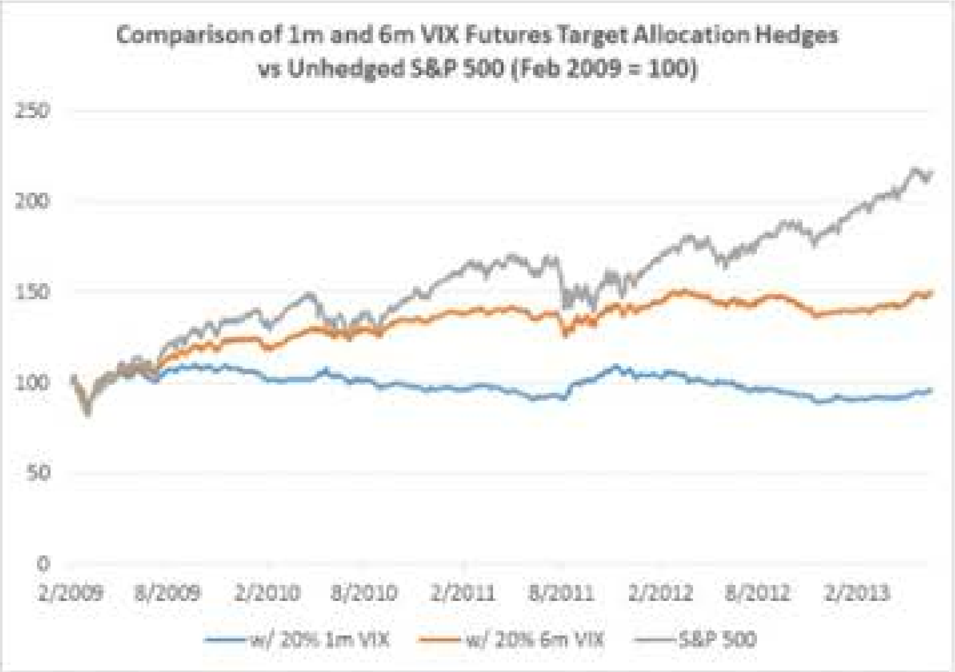
First, a static allocation to VIX futures provides consistent portfolio protection. In other words, one can always rest assured that the portfolio is protected to some degree at all times. This is particularly useful in case something happens that disrupts the market in an unforeseen manner (terrorist attacks, surprise fed hikes, currency devaluations without warning, etc). If protection against black swan events is one's primary goal, then one can't do much better than a static program.

Second, a static program enforces 'buy low, sell high' to VIX futures in an automated fashion. Two things happen when one rebalances VIX futures periodically (every month, every quarter, etc). When VIX futures sell off relative to the market, the program will accumulate more VIX futures at a lower price at the next rebalance date. Conversely, when VIX futures spike, the program will reduce VIX futures position at higher (read: profitable) levels. Essentially, targeting a fixed allocation enforces investors to buy more when futures are cheap and sell more when futures are rich. Given that VIX futures are mean reverting instruments, this approach is well-suited for trading VIX futures. Automated monetization such as this is the key benefit of periodic portfolio rebalancing.

However, most static allocation strategies suffer from poor performance, especially over long timeframes.

The primary reason is that VIX futures are poor products for long term buy and hold. Long term holding periods are not beneficial for VIX futures because the term structure of VIX is predominantly in the state of contango. Historically, the slope of the VIX futures term structure has cost 1m and 6m VIX futures about 5.5% and 1.5% each month, respectively. When annualized, these amounts add to about 60% and 18% of losses for the futures, which are sizeable both in absolute and relative terms compared to the S&P 500. This implies that the hedges can become so expensive to the point where the costs offset the risk reduction benefits that the futures provide.

Consider the chart below, which shows the performances of a pure S&P 500 portfolio, one hedged with 20% allocation to 1m futures, and another hedged with 20% allocation to 6m futures since 2009. All three portfolios are rebalanced on a quarterly basis, and all trades are assumed to be frictionless for illustrative purposes. We confirm the maximum drawdown and volatility of hedged portfolios to be small, but we also note that portfolios hedged with 1m and 6m futures underperformed the regular S&P 500 by 120% and 60%, respectively. These are clearly unacceptable, which prompts us to think of ways to do better. A good start will be to incorporate our knowledge of how VIX behaves (mean-reversion, volatility risk premium) and how the term structure affects VIX futures into our strategies.



Of course, from 2009 to 2013 represents one of the worst periods for hedging, given the enormous rally in the market, excessive volatility risk premium, and persistent contango. Thus, the point here is to emphasize that static hedging is not the same as permanent allocation to VIX futures, which is shown to have significant performance issues. Rather, it refers to the practice of maintaining a target allocation to VIX futures over a period of time. In this framework, hedges are rebalanced periodically at a fixed percentage of the total portfolio. One still has the freedom to stop the hedging program whenever he desires based on his risk appetite and investment goals. Typically, institutional investors 'commit' to static hedging programs for periods ranging from a few months to more than five years. These time frames are not unique to VIX futures based hedging programs, and apply to $SPX options or futures based hedging programs as well.

Key: VIX Futures are not for buy and hold. Hence, perpetual static allocation programs are not prac-

tical.

Implementing Static Hedging

The barebones static allocation strategy has three parameters; choice of VIX futures, target allocation, and rebalance frequency.

Choice of VIX futures: We have previously discussed the factors to consider in picking VIX futures contracts to buy or sell. The same rules apply whether one is trading with a discretionary or systematic approach. However, when one needs to commit to a hedge position for several months, long term performance considerations start dominating one-off considerations. For example, if one were to hedge for three months, he should consider the historical ranges of three month holding period returns of various expiries of VIX futures. Such analysis will reveal which month contracts tend to hold value the best, provide the best risk adjusted hedging return, etc. In general, hedging periods lasting longer than 6 months is best accomplished with 5m to 6m VIX futures. Short dated futures (1m, 2m) are best suited for tactical, short term hedges only, because these futures suffer greatly from negative roll-down (since 1m and 2m expiries tend to have the highest 1m roll-down figures), which makes them terrible for long term buy and hold.

How Much to Allocate to VIX Futures: Typically, risk reduction and improvement of risk/reward profile are the two main goals for implementing hedges. Meanwhile, some investors may be hedging in order to increase the absolute performance for the portfolio. Thus, there are different reasons for implementing hedges, and one needs to take these reasons into account when determining % allocation to VIX futures. Using historical data, one can solve for an allocation that provided the highest risk reduction or performance increase, or whichever metric that he is optimizing for.

Obviously, the more one allocates to VIX futures, the more bearish the overall portfolio will become. After a certain point, the portfolio will actually start doing *better* if the market sells off. For such high allocations, we are moving outside the realm of hedging strategies, and venturing into the topic of how to make money from market crashes (which is an art of its own). On the other hand, allocating too little to VIX futures will cause too small an impact on the overall portfolio performance. The hedged performance will be too similar to unhedged performance (based on CAGR%, maximum drawdown, Sharpe ratio, etc) to justify the hedging program's existence.

Rebalancing: In general, VIX futures positions are best rebalanced every month. The reason for this is to allow for more frequent monetization opportunities compared to quarterly rebalance schedules. In addition, frequent rebalancing is needed to prevent VIX futures from deviating significantly from target allocations. Since VIX futures are extremely volatile relative to the stock market, it is very easy for allocations to be wildly off target even on a monthly basis.

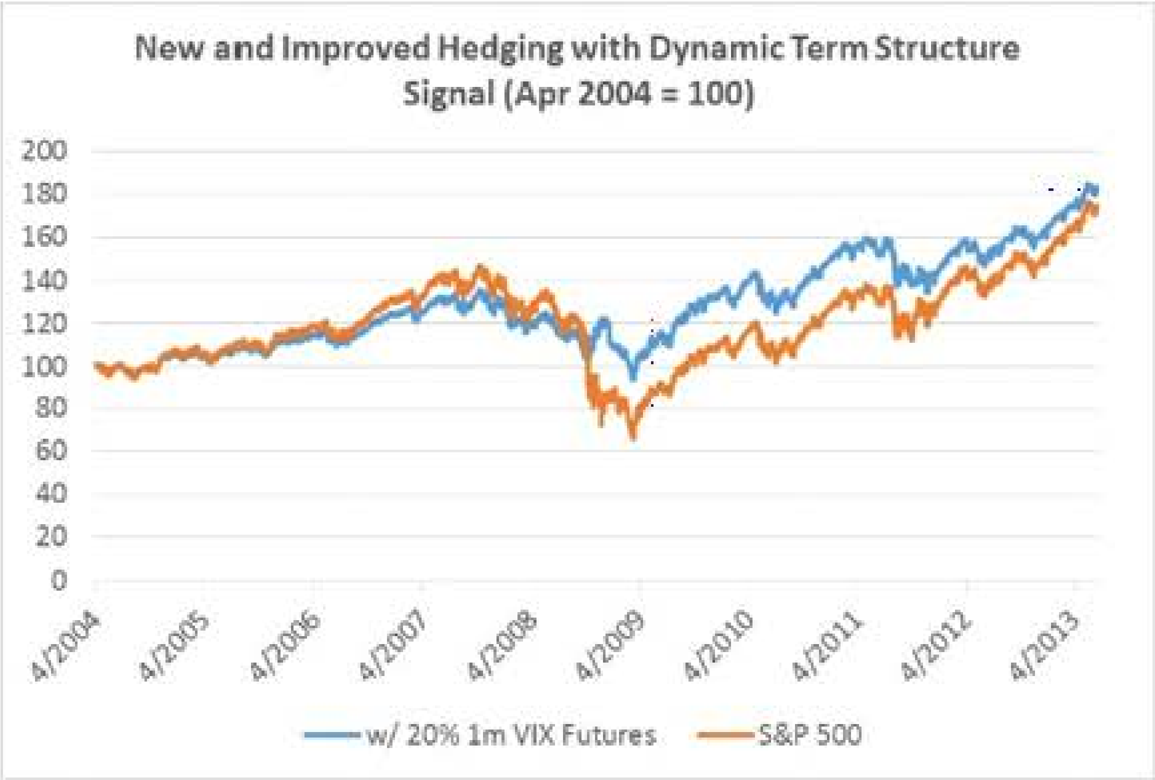
Dynamic Hedging

A dynamic hedging program is different from a static hedging program in that it does not require a fixed capital allocation to VIX futures. Instead, allocation to VIX futures will vary based on the output from a market timing signal. For example, if the strategy deems the market to be very bullish, it has the flexibility of not allocating any capital to purchasing VIX futures. Conversely, if the strategy determines that the market is heading south, it may aggressively allocate to the shortest dated VIX futures possible. In essence, dynamic hedging programs utilize quantitative market timing signals to determine when and how to scale capital allocations to VIX futures.

This implies that the success of a dynamic hedging program depends on the quality of its market (or volatility) timing signal. For example, if the signal incorrectly forecasts that hedging is not required, the strategy will fail to protect the equity portfolio when the stock market sells off. On the other hand, a good market timing indicator will purchase VIX futures just at the right times. In essence, dynamic strategies exchange flexibility and fine-tuning for timing risk.

The primary motivation behind trading a dynamic hedging program is the performance gain over static hedging programs. Think of all the properties of $VIX and VIX futures that we have covered up to this point. We know by now that the factors such as mean reversion and term structure are critical determinants for the movements in implied volatility. If so, why not incorporate them directly into hedging strategies? These insights will help improve every component of the hedging strategy: hedge selection, hedge sizing, and execution.

For example, what if we optimized the static hedging program in just one aspect, namely the hedge selection and timing? We know that contango is a headwind for the performance of VIX futures, whereas backwardation tends to be a tailwind. Incorporating this insight into hedge selection can be as simple as choosing not to allocate to VIX futures when the term structure is in contango. This would effectively allow the strategy to avoid suffering from negative roll-yield, while allowing for the flexibility of re-initiating hedges when the term structure turns into backwardation. We simulate such a strategy using 1m VIX futures at 20% allocation, and find that it outperformed the unhedged S&P 500 strategy by about 1.6% per annum. Meanwhile, the hedged strategy experienced just 19% peak to trough drawdown, which is much less than the 55% loss that the S&P 500 sustained over the same time frame. Sharpe ratio doubled as well (0.82 versus 0.4), indicating significant improvements in risk adjusted performance.



There are, however, many areas to be careful about when developing a dynamic allocation strategy for VIX futures. When developing a systematic strategy, one needs to avoid over-fitting strategy parameters to historical data. With enough parameters, one can always develop a timing model that calls every move in the past with 100% accuracy. Unfortunately, such over-fitted trading systems tend to be too fragile to be used in live trading, because history never repeats itself in the exact same manner. When one trades such a system, even minute differences between the future and the past can create massive differences in the investment outcomes.

Finally, investors must realize that dynamic hedging programs may not protect investors from unexpected shocks to the market. Most market timing signals (trend or reversion) are wired to stick to a market assessment until something happens that changes the parameters. For example, most trend following signals are bullish until the next big sell off flips the trend, and stays bearish until the next big rally. Here, we are not arguing about the benefits of using trend following signals; we are simply highlighting the reactionary nature of commonly used market timing signals, which makes dynamic hedging strategies vulnerable to quick, unforeseen shocks to the market.

Table: Recap of Static Versus Dynamic Hedging

	Static Hedgings	Dynamic Hedging
Pros	Simple to understand and implement.	Potential Performance improvement over static allocation
	No burden of timing	Takes latest market developments into account
	Constant notional exposure to volatility	Variable exposure to volatility
Cons	Hold long volatility without taking market environment, such as volatility levels, into account	Adds complexity to execution and understanding
	Poorest performance relative to dynamic hedging strategy	Potential for over-fitting parameters to historical data
		Model could lead to very little volatility allocation, which means less protection from truly unexpected shock events.

Other Risk Factors to Consider When Hedging with VIX Futures

Following are some points to heed when hedging equity portfolios with VIX futures. Some risk factors are controllable while the others are not. Unfortunately, the best that investors can do is to be aware of all the risks and to adjust their hedging plans to their goals and financial capabilities accordingly.

Drop-off in inverse correlation between VIX futures and S&P 500: While

VIX futures are negatively correlated with the equity market in a consistent manner, the relationship is not perfect. Therefore, there will be days when both the VIX futures and the S&P 500 will be down.

Need to roll hedges: One must remember to close out existing hedge positions and to purchase a further dated futures contract when expiration nears. If one forgets to roll the contracts before they expire, portfolio will be unhedged until the hedge is re-initiated. If one is unlucky, the market may sell off during that timeframe, and lead to unnecessary losses. Of course, one may also get lucky and make money by serendipitously forgetting to roll. Either case, forgetting to roll can introduce extra elements of uncertainty that may be undesirable.

Lack of Granularity: VIX futures trade with a $1,000 multiplier, which makes precise allocations difficult for small portfolios (sub $250,000). For example, a single VIX futures contract priced at 16 represents a $16,000 allocation (16 times $1,000). This represents a 16% allocation for a $100,000 portfolio. If one decides to add merely one contract, then he'd be increasing his VIX futures allocation to 32% of the portfolio. Because of the large multiplier, VIX futures do not provide much granularity, and hence are not suitable for small portfolios. VIX futures may be more suitable for portfolios larger than $500,000, since one contract (priced at 16) represents just a 3.2% allocation relative to total portfolio.

Bid-Ask Spread: Another reason why VIX futures may be unsuitable for small portfolios is their bid-ask spread. For a single contract, the spread is worth $50 (5 cents times the $1,000 multiplier). Assuming the hedge is rebalanced monthly, bid ask spread alone adds up to about $600 dollars of cost (5 cents times 12 times $1,000), which is about 0.6% of a $100,000 portfolio.

Over time, 0.6% per year will become a significant drag to the portfolio. Of course, the above math assumes that investors constantly pay the bid ask spread whenever they roll VIX futures hedges. Our experience tells us that it is possible to get filled on the bid around half the times. Even still, all transaction costs, including the bid ask spread, need to be accounted for. In any case, active day trading of VIX futures can lead to prohibitive transaction costs.

Summary

- Pick the right VIX futures that suits your hedging goals.
- Short dated VIX futures allow one to capitalize on the most bearish views, because they track $VIX better than longer dated VIX futures
- On the flip side, short dated contracts can suffer from heavy losses from contango
- Long dated contracts suffer less from contango, and may be suitable for

hedging longer horizons

- Either case, VIX futures tend to be poor buy and hold instruments
- Static allocation to VIX futures is simple and easy to implement, but suffers from poor performance
- Dynamic allocation strategies to VIX futures perform significantly better, but they may fail to provide protection against unforeseen, black swan events
- Rebalancing is crucial for monetization
- VIX futures are not suitable for small portfolios, due to their high multiplier

Chapter Six: Shorting VIX Futures for Alpha Generation

In this chapter, we will discuss how VIX futures can used to generate alpha. We will discuss why shorting VIX futures can add value, how the strategy has performed in the past, its risks, and how to manage them properly. We will also cover the philosophical aspects behind the short VIX futures trade. VIX futures have traditionally been perceived as hedging vehicles, but they can be used to generate alpha as well. When one shorts VIX futures, he is making a neutral to moderately bullish bet on the market. If the market sells off in a volatile fashion, the trade will most likely lose money. In cases of large $VIX spikes, the trade could lose enough money to wipe out entire accounts. On the other hand, if the market is range-bound or trending slow, short volatility tends to generate excess returns over the S&P 500. As usual, the key is to properly manage the risks.

The majority of P&L for short VIX futures trades comes from the contraction of VIX futures basis. VIX futures basis simply refers to the difference between the price of a VIX futures contract and the spot $VIX. When the term structure is in contango, VIX futures basis is said to be positive based on the futures pricing formula [futures – spot = basis]. When in backwardation, the basis is negative. Essentially, the basis reflects the amount that futures sellers need to be compensated for selling futures and purchasing the spot product. It turns out that VIX future basis are systematically overpriced (in other words, too positive), which can be proven by showing that one can make above-market returns by shorting VIX futures.

In addition, the fact that one can generate above-average returns selling VIX futures implies that VIX futures are generally inaccurate predictors of $VIX. Recall that VIX futures are the market's expectation of the future levels of $VIX. If these 'expectations' accurate predictors of $VIX overall, there would no systematic opportunity to make money from buying and selling VIX futures.

The Risk Reward of Shorting VIX Futures

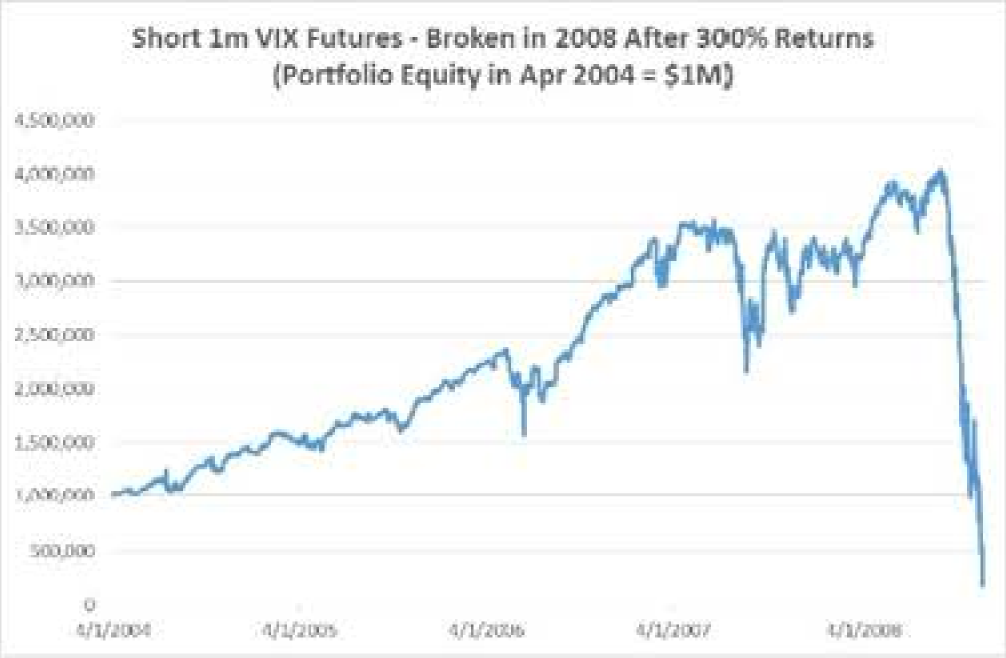
If you had a million dollars, how many VIX futures would you *short*? And which VIX futures should you go short? Most people would say that betting the entire account is probably a bad idea (not that the brokerage would allow anyone to do that, given that VIX futures require 4 to 6 times the contract amount as margin). So what would be your next best guess?

Let's pick 50% of capital as the magic number. We will simulate P&L for selling $500,000 notional of VIX futures every month, using the 1m contracts as our trading vehicle. The rest of the account is assumed to be invested in a CD account. We will see how the portfolio performed during various timeframes since 2004. The goal is to develop a sense of how the strategy behaved under different market conditions, and to highlight the risks of the strategy as well its rewards. In our back-tests, we will assume that the allocations are rebalanced quarterly, and that trades are frictionless.

Scenario 1: Strategy Initiated in 2004

Let's assume that an investor initiated a short VIX futures program soon after VIX futures were launched. The strategy would have done exceedingly well up until the summer of 2008. The annual gains averaged around 40% a year, and the initial equity of $1m dollars grew to $4m by mid-2008. The path up until that point was far from smooth; the strategy lost 30% or more during two separate volatility spikes (February 2007, when a mini-crash in the Chinese market triggered a 5% sell-off in the S&P 500, and August 2007, when the fears of slowdown triggered a 10% correction in the S&P 500).

Then came autumn of 2008. The portfolio took a 102% nose dive in mid-November. Essentially, all the equity was wiped out. How did this happen? It's simple. All it took for the strategy to go bankrupt was for the front month VIX futures to triple, which is what happened (in mid-August 2008, front month futures were trading at low 20's. It subsequently spiked to 67 three months later). More than four years of P&L was wiped out in less than one thirtieth of the time it took to build it, including principle. This shows that even shorting half the notional of the portfolio is quite risky, especially if one intends to manage the position passively.



Scenario 2: Strategy Initiated in 2009

Suppose instead the investor began shorting front month VIX futures in 2009, after the VIX index peaked. Recall that the best times to short volatility is when volatility is high. In January 2009, front month VIX futures were trading in the 50's. Essentially, the timing could not have been better to start shorting VIX futures. Indeed, the strategy made more than 60% for 2009 and 2010. However, when the European financial crisis occurred in 2011, the strategy again took a nose dive and gave back all the winnings. Reason: the strategy lost more than 90% as front month futures almost tripled from low 17's to high 40's. After the crisis subsided in late 2011, there was little equity left.

The lesson is the following. Majority allocations (larger than 50% of equity) are not appropriate for short 1m VIX futures strategies, especially if one is unwilling to frequently monitor the positions. 1m VIX futures have easily doubled or tripled in the past over extremely short time frames. The math works out such that if 50% of the portfolio loses more than 200% (triple), then the portfolio will go bankrupt even if the other 50% of the portfolio was in cash.

*50% * (1 - 200%) * equity + 50% * equity => zero, kaput, broke, go see a bankruptcy lawyer*

Thus, the risk is real, and it must be addressed before one contemplates large-scale short positions in VIX futures, options, VIX ETNs, or whatever volatility product one desires to trade. Once one starts to hemorrhage money, it only becomes harder to cut risk or stop out. Even professional traders who work under supervised conditions find it tough to lock-in the losses, due to people's natural tendency for loss aversion. Losses get only tougher to take as they grow bigger, because the psychological sunk cost becomes larger. Thus, it is extremely important to size the position appropriately such that the losses can never grow larger than one can take, both financially and psychologically. One needs to form a plan B before the situation calls for one. Dealing with losses and making rational decisions in the middle of 10%, 20%, or even 30%

losses is tough.

Deciding the right position size ultimately comes down to what type of drawdowns what is willing and capable to tolerate. If one wants to minimize the probability of a 50% drawdown, then one needs to pick an allocation that suffered smaller drawdowns during historical simulations. Studying how the strategy performed under 2008-type of conditions will yield a good estimate of 'what bad things can get'. The table below summarizes maximum drawdown and volatility figures for 10%, 20%, and 30% short front month VIX futures allocations as well as buy and hold strategy for S&P 500. We can see that 20% allocation portfolio sustained a maximum drawdown of -45.27% in 2008. To some, the figure may sound too high. To others, the figure may seem tolerable relative to other strategy options, considering S&P 500 had a drawdown of -55% in 2008.

	10% Short	20% Short	30% short	Cash	SPY
Avg DD	-0.87%	-1.91%	-2.96%	-0.19%	-2.16%
Avg DD Length (in days)	12.62	15.17	16.43	11.49	27.23
Long DD	422	489	489	132	1223
Max DD	-22.54%	-45.27%	-65.62%	-2.50%	-55.19%
Sharpe	0.77	0.59	0.50	1.48	0.39
Total Return	80.12%	136.16%	167%	24.03%	74.89%
Vol	8.76%	19.03%	31.92%	1.59%	20.96%

Sell VIX Futures in Moderation, and You'll Make Money

When done in moderation, shorting 1m VIX futures can be a good source of alpha. At 10% allocation, the strategy had a Sharpe ratio of 0.78 since 2004, which is almost double that of the S&P 500 (0.39). Most importantly, the strategy had a drawdown of 22.5% in 2008 and a nine year average annualized volatility under 9%. This figure is low enough to be in the realm of what people consider to be 'bond-like returns'. Chart below is a side by side comparison of a $100K invested in the S&P 500 (with dividends) versus a collateralized $10K short position in front-month VIX futures. Clearly, the orange line (representing 10% short 1m VIX futures) suffered smaller and faster-recovering drawdowns versus the blue (representing S&P 500 with reinvested dividends). Since 2009, S&P 500 has out-performed the short VIX futures strategy, but the latter has still out-performed the former on the end-to-end return basis.

Known Unknowns and Unknown Unknowns

At the end of the day, one can think of VIX futures term premium as insurance against the unknown unknown events in the market. The 'unknown unknown' events represent the set of unforeseen market disruption events that have the potential to significantly increase market volatility. Risks such as recessions or bad earnings surprises tend to be anticipated and prepared for by investors (not perfectly, but there will always be a segment among investors who are at least aware of these factors). However, there are some disruptive factors that are beyond all investors' imagination: disasters, terrorist attacks, political breakdowns, and others, which are the stuff of nightmares.

In some sense, hedge against known unknowns is not that valuable. Everyone knows that recessions are bad for equity markets, fed hikes for bond markets, and deflation for precious metals. The exact timing of these events are hard to predict precisely; if it was easy to figure that out, everyone would be rich. However, all these 'unknown' market variables develop over a lengthy process. Recessions take time to develop, and the early signs show in the form of negative surprises in the leading indicators. The Federal Reserve tends to signal bond markets months in advance of future rate hikes; in fact, the new monetary communication policy stresses transparent communication. Deflation itself is a length process as well. Prices do not all drop overnight; moving the CPI is a monumental and lengthy process. All these processes take more than months, or even years, to develop. Most people have plenty of time to prepare for these things.

Unknown unknown events, however, are impossible to prepare for without insurance. Examples include 2001 Terrorist attack on the U.S., 2004 Southeast Asian Tsunami, and 2011 Earthquake in Japan. When the September 2001 attacks hit the U.S., S&P 500 shedded more than 5% in one day, and the VIX spiked 20%. The 2011 Earthquake in Japan had Nikkei 225 index drop more than 20% over a span of few days, with the VNKY (the VIX index for Nikkei 225) spiking from 20 to 70 in a matter of two days. We are blessed that no larger disasters have hit the financial centers in the U.S., and most likely they won't (fingers-crossed). However, are you willing to bet your entire account that such things will never hapen?

Shorting volatility entails betting against black swan events, and that is why there is a clear bias towards long volatility losing money more frequently. Simply, most bearish calls tend to be false alarms, and life has a remarkable way of chugging along toward stable growth. By definition, black swan events do not happen often, which makes investors who bought insurance look absolutely foolish, sometimes for a very long time (just ask John Paulson). The concept of tail risk came into vogue with Nassim Taleb's book, but it is not a new concept. The debate has raged on for decades whether tail risk is worth hedging, whether it be accident and property insurance or financial derivatives.

Disruptive changes, however, are

unavoidable, and are bound to occur with 100% probability. Every once in a while, large natural disasters strike that remind us how fragile not just our ecosystem but our societies really are. Thus, shorting VIX futures is ultimately a short fat-tail strategy. It bets against the very concept of uncertainty, and the inevitability of it affecting our lives. The strategy is not for everyone. If one is not comfortable making those bets, then short volatility is not for him. The chances of success are low when one does not feel comfortable with the idea behind short volatility.

Summary of Risks of Shorting VIX Futures

The risks of shorting VIX futures can be summarized as below. Some risks such as strategy risk cannot quantified, but can be controlled. Gap risk and liquidity risk, however, are risks that are beyond one's control.

Potentially Extreme Downside: For

massive VIX spikes, short VIX futures strategy can incur losses that are several times larger than the initial capital in a short amount of time.

Strategy risk: Extreme volatility. It is easy to flinch at 5%, 7%, 10% losses and stop out and lock in severe losses.

Gap risk: Overnight up-gaps can be sizeable. Outright short VIX futures strategies are fully exposed to overnight gaps, which are un-hedgable by definition unless one uses VIX options to hedge that. Unfortunately, the costs of purchasing VIX options will significantly eat away at short volatility profits, which will lessen the financial appeal of shorting volatility.

Liquidity risk: Liquidity tends to vanish during extreme, unpredicted spikes in volatility such as the flash crash of 2010. Both bids and offers widen, making it difficult for traders to either cover shorts or sell long.

Margin call risk: If futures were shorted without sufficient margin in the account, they may be covered on behalf you, typically at the worst times (and levels) possible. This means that one likely needs to keep outsized cash in the futures account, which represents opportunity cost. The maintenance margin requirement dilutes the overall portfolio return, and hence makes short VIX futures as a strategy less attractive.

Summary

- Shorting the shorter end of the VIX futures term structure tends to be more profitable than shorting the longer end, due to the higher roll-down
- Unfortunately, shorting 1m VIX futures can fully capable of bankrupting accounts, especially for short allocations larger than 50% of total equity.
- One must size his short VIX futures positions prior to execution to prevent large losses
- When done in moderation, short 1m VIX futures positions have generated better risk-adjusted returns than

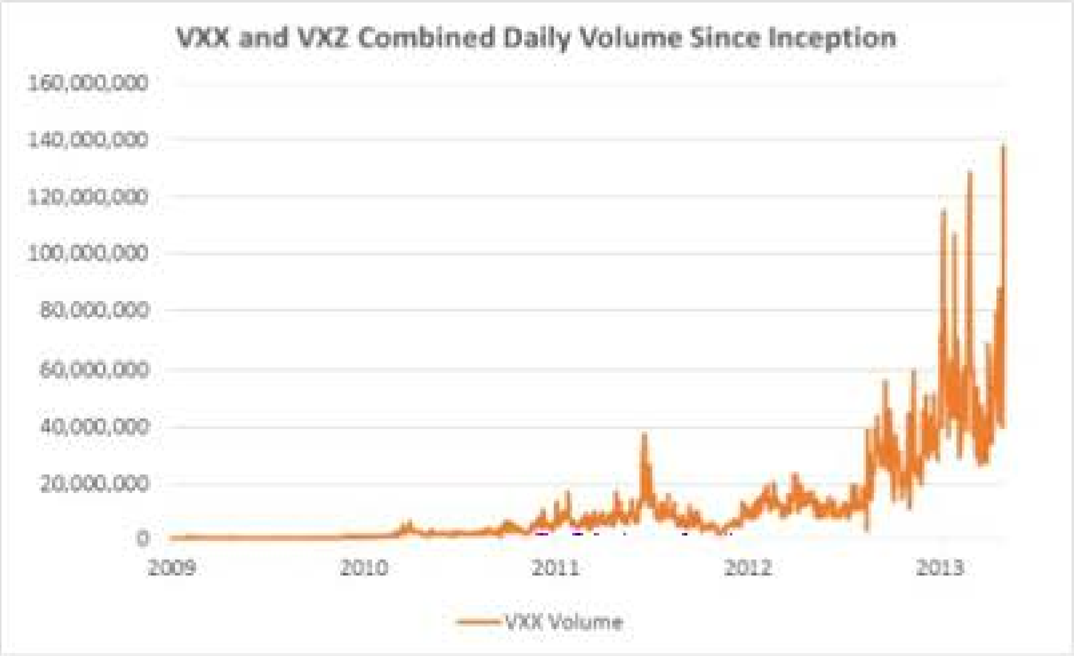
S&P 500 since 2004

- Dynamically adjusting short positions according to the slope of term structure has shown to decrease drawdowns in the past
- 'Unknown-unknown' risks cannot be hedged, and they represent the biggest risks of shorting volatility

Part Three: VIX ETNs

Chapter Seven: VXX/VXZ - The Next Step in Evolution

VXX and VXZ, launched in 2009, are one of the most important innovations in financial derivatives ever to come about. It democratized a product area that was dominated by a small clique of participants, and helped improve equity derivatives liquidity worldwide by spreading risk among more diverse group of investors and traders. In the past four years, these ETNs have evolved to become one of the most popular trading vehicles. The combined average daily volume for VXX and VXZ have quintupled each year, and it now exceeds over 80 million shares per day. In this chapter, we will discuss what these products try to accomplish, their relationships with VIX futures and the VIX index, and their behavior across various market conditions.



Launch of VIX ETNs

January of 2009 was the perfect time for VXX and VXZ to be launched. The economy was in absolute disarray. S&P 500 was trading at 830, almost 50% lower from the highs of October 2007, and fear in the market was palpable. Hedging demand skyrocketed even at astronomical levels of the VIX index, and for a while the levels seemed justified with the markets moving 4% on a daily basis.

Unfortunately, those were the times when only listed options and VIX futures were available. VIX futures liquidity were extremely poor then (average daily volumes were about 30 times less than they are now) and poorly marketed. It was only traded among a select few sophisticated volatility arbitrage hedge funds and a few investment banks such as Goldman Sachs, which was heavily involved in the development of VIX futures.

S&P 500 options were still the dominant volatility product, but they were too complicated and large for most investors to touch. Rather, the masses wanted to trade the VIX index, which was having 10% moves on a regular basis. In a time of widespread fear, the media sensationalized the index as the 'fear index'. Everyone was wondering what the best way to trade the VIX was, when no one really understood what the VIX index or VIX futures were.

In this backdrop, the launch of VXX and VXZ was met with widespread enthusiasm. Unfortunately, the masses were not equipped with sufficient knowledge to properly trade VIX ETNs. For most people, the distinction between VXX, which holds VIX futures, and the VIX index was lost. Over time, correct information spread across investor base, and the products have established a strong ecosystem of users, both at retail and institutional levels. Initially popular as a long volatility vehicle, the ETNs' multiple years of double digit losses increased their popularity as a short volatility vehicle. Regardless of usage, VXX and VXZ remain one of the most popular and easiest ways to express views on volatility.

What is VXX

VXX is an ETN that tracks S&P 500 VIX Short Term Futures Total Return Index (SPVIXSTR), which represents the performance of constant maturity front month VIX futures. This is key. VXX tracks the performance of investing in VIX futures, not the price of VIX futures. Here, we will discuss the characteristics of the VXX ETN and their applicable implications.

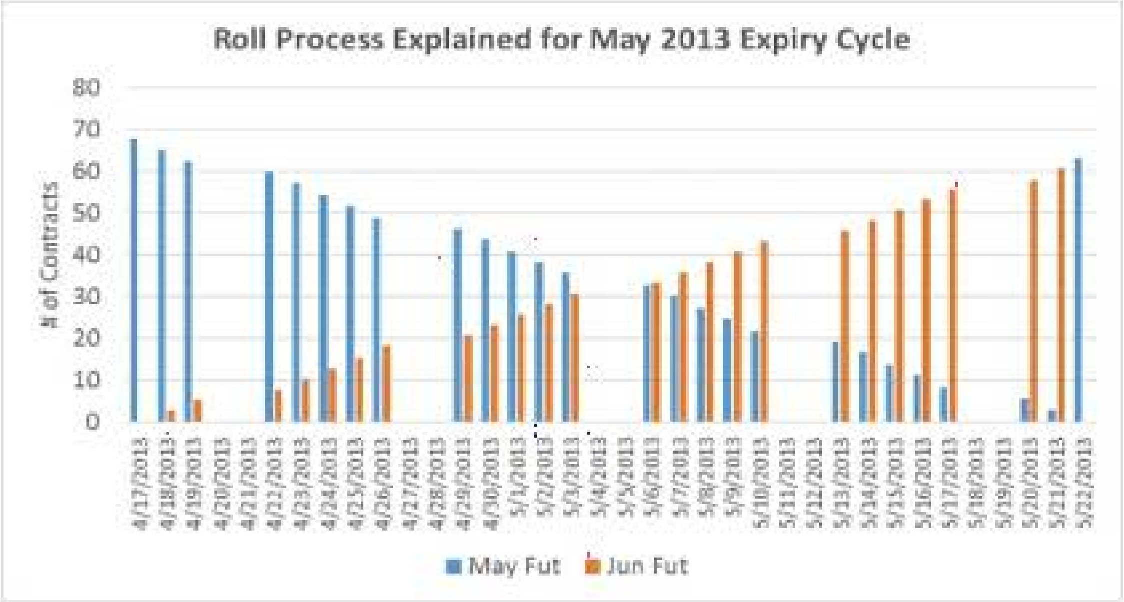
Trades Like A Stock: VXX is traded on NYSE/ARCA. Unlike VIX futures, VXX does not require a separate option or futures agreement. VXX is both shortable and optionable like most stocks. VXX options are also listed, and trades like normal stock options.

Exposure to VIX Futures: VXX tracks a combination of 1m and 2m month VIX futures, not the VIX index. The proportions of each contract are determined such that the weighted average of maturities is one month. One of the most common misconceptions among investors is that VXX tracks the VIX index. Yes, there is a statistical relationship between the VIX index and VXX. However, they are not obligated to track each other at all. At least with first month VIX futures, one knows that they will converge to the VIX index. VXX does not converge to anything.

Constant Maturity: Unlike VIX futures, whose maturity shortens over time, VXX maintains a constant maturity exposure to volatility. In another words, there's no concept of expiry for VXX. In fact, it attempts to constantly track the thirty day maturity point of the VIX futures curve. This is accomplished via by rolling a fraction of front futures each day to the second month contract. The daily roll lengthens the maturity of VIX futures held by VXX to offset the natural shortening of maturity. Think about it this way. If VXX just held onto the same set of futures, those futures will eventually expire, and VXX would be left with no volatility exposure.

Example: Suppose there are 21 business days between April and May VIX futures expiries. On the VIX expiry date for April, VXX is completely comprised of May VIX futures, which is the new front month contract. On each day, approximately 1/21th of the May VIX futures are sold, and the cash raised is used to buy the June futures. This process ensures that all May futures will be rolled to June futures by the day before the June VIX expiry.

The following is a chart that shows the numbers of May and June contracts contained in a \$1m VXX portfolio using data from April 16th, 2013 to May 23rd, 2013. As one can see, VXX slowly changes its composition from being 100% May futures to 100% June futures. The whole cycle repeats on May expiry, when the VXX is comprised purely of June VIX futures.



Term Structure Has an Impact on Number of Contracts Held by VXX: If the first and second month futures were the same price, then the daily roll would not affect the number of VIX futures contracts held by the ETN. The amount raised by selling the front month contracts will buy the same number of contracts for the second month contracts.

On the other hand, if the term structure is upward sloping, the June futures are more expensive than the May futures. This means that VXX cannot buy the same number of June futures with the money from selling May futures, which are priced lower. This results in less number of contracts bought than sold. Conversely, if the term structure is inverted, then the net number of contracts purchased will be greater than zero.

Example: Suppose May VIX futures are trading at $20 and June futures are trading at $22 (upward sloping term structure). The VXX ETN needs to sell 300 contracts of May futures at the market close. The number of June contracts to be rolled into is then ($300 * $20) divided by $22, which is 273 contracts. This will result in a loss of 27 contracts for the ETN.

The practical implication is this. <u>If the term structure stays upward sloping for a long time, the vega (the total number of contracts) held by VXX ETN will decrease over time</u> (assuming there are no new inflows). The fund will keep rolling to higher priced contracts, and buy less of them, leaving the fund with a net loss of contracts (and investors' capital).

Contango Kills VXX Returns: We know that the term structure is upward sloping more often than not. In this case, rolling futures forward every day will enforce selling lower priced futures and buying higher priced futures. If the volatility curve stays at the same levels, VXX will keep accruing realized losses by selling low and buying high.

<u>Example:</u> Suppose that the VIX index, May VIX futures, and June VIX futures are at 16, 18, and 19 respectively. Also, assume that the shape of the term structure does not change for the whole month, and that May and June

have the same number of business days.

At the start of the month, VXX ETN will be fully comprised of May futures. Each day, approximately 5% of them will be sold to buy June futures, which are trading at a $1 premium. Over the course of the month, May VIX futures will roll down from $18 to $16, and June futures from $19 to $18. At the end of the month, the average sale price for May futures will be $17, whereas our average buy price for June futures will be $18.5. This means that the ETN lost $1 on the May futures, and $0.5 on the June futures.

Who is Doing the Rolling?: Barclays Bank, the index issuer, will technically do the rolling. Barclays are incentivized to do their best to replicate the VXX performance. As the issuer, the bank is short all outstanding shares of VXX to the investor base. In order to flatten this exposure, the bank then has to buy the set of 1m and 2m VIX future that replicate VXX.

VXZ

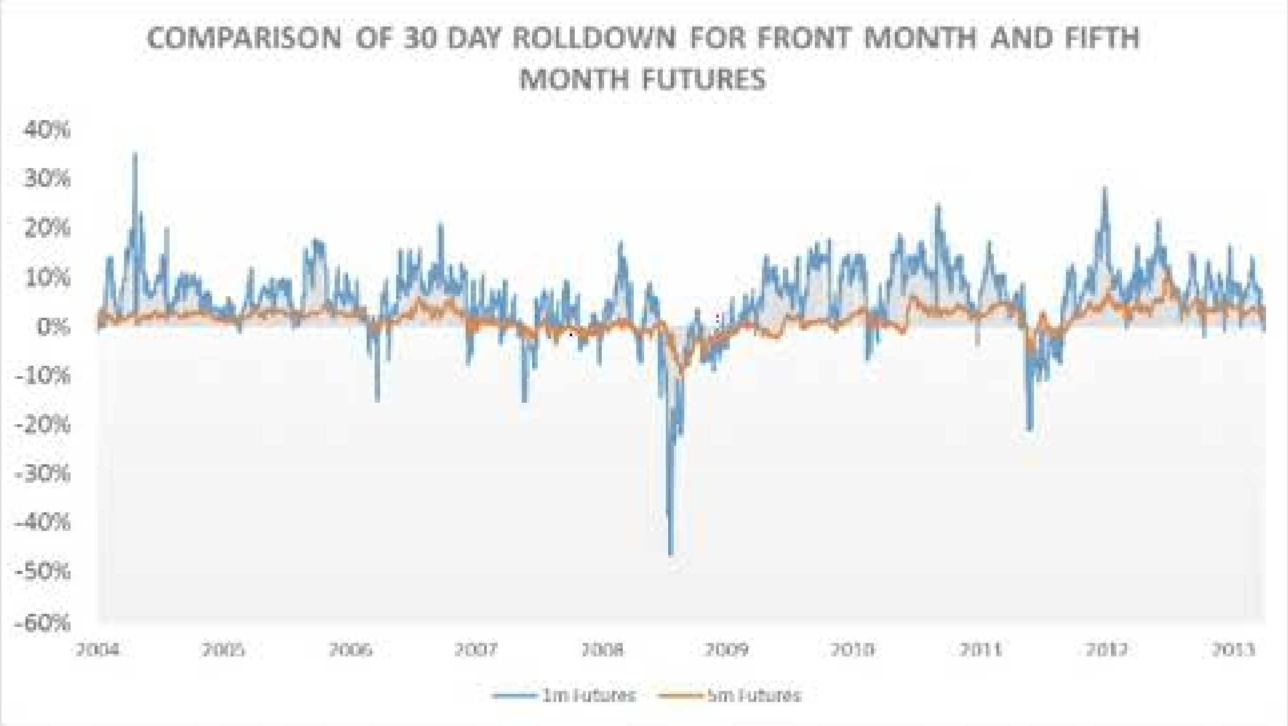
VXZ is a longer dated version of VXX with a slight twist. VXZ tracks the investment performance of roughly 5m VIX futures contracts. Instead of holding two contracts, VXZ can hold up to four different contracts at once. Officially, VXZ delivers the performance of S&P 500 VIX Mid-Term Futures Total Return Index (SPVIXMTR). As with VXX, VXZ follows a daily roll process to maintain constant maturity exposure, and trades like a stock. Their differences are summarized as below:

Exposure to VIX Futures: VXZ holds a combination of fourth, fifth, sixth, and seventh month contracts. Compared to VXX, VXZ spreads out exposure over a larger set of maturities. Also, the maturity exposure is much longer (five months versus one month). Thus, compared to VXX, VXZ has less negative sensitivity to the S&P 500 as well as less correlation to $VIX.

Roll Procedure: VXZ rolls a fraction of fourth month contracts each day to the seventh month contract, which is three expiries further out. This compares to VXX, which rolls from two consecutive expiries. By each VIX expiry date, VXZ will have sold all of the previously fourth month contract, and be comprised of new set of fourth, fifth, and sixth month futures. Recall that VXX just has single expiry exposure on VIX expiry days.

Less Turn over: VXX turns over 100% of its portfolio every single month. This is largely unavoidable because VXX targets a short maturity, but high turnover is one of the biggest weakness of VXX. Instead, VXZ turns over only one third of the portfolio every month, which mitigates the issue.

Less Roll Down: Historically, the VIX futures term structure have been much steeper in the front compared to the back. Since 2004, the difference between the 30 day and 60 day futures have been 6%, while that between the fourth and fifth month futures have been roughly 2%. This implies that VXX suffers about three times as much as VXZ from monthly futures roll down.



Less Drag: When one combines less turn over with less roll down, one gets an ETN with much lower negative drag. This is easily seen by the divergence of the two ETNs' returns since 2009. The CAGR of VXX since 2009 has been negative 63%, while that of VXZ has been negative 30%. The entire difference is explained by the extra drag that VXX suffers. This is evident from the divergence in performance between the two indices since their inceptions.

Benefits of Trading VXX and VXZ Over VIX Futures:

Compared to VIX ETNs, VIX futures have some glaring issues that undermine their mass-appeal.

Constant Need to Roll: VIX futures expire every month, and hence requires traders extra work to monitor and rebalance positions. Suppose one's strategy depended on holding sixth month futures. One needs to roll the futures on VIX expiry dates, because the position will become fifth month futures post-expiry. For all futures products, whether they be natural gas or volatility, rolling is a necessary evil and a source of pain. On the other hand, VIX ETNs don't expire. VXX and VXZ do not have expiration dates. Both ETNs hold futures, and they roll a fraction of the futures they own on a daily basis. The roll is executed by the sponsors of the ETN (Barclays) on behalf of the shareholders of the ETN, who simply receive the performance of the futures contracts. There is simply less to worry about.

Variable Maturity: VIX futures become more seasoned with each day. The maturity exposure of a contract shortens every day, and while unnoticeable over short timeframes, the changes in its behavior will be noticeable over months or even weeks. For example, suppose a person purchased 6m contracts, and did not roll them for three months. The contracts will then become 3m contracts, which have drastically different characteristics from 6m contracts.

Rolling contracts mitigates, not eliminates, the problem, since it resets the maturity every month. If one were to roll less frequently, however, his strategy is under more risk of having inconsistent exposures. Instead, VIX ETNs maintain a constant maturity. VXX maintains a one month expiry exposure to the VIX futures term structure, and VXZ maintains a five month exposure. One does not need to worry about their volatility exposures changing with the pass of time. Maturity exposure is reset daily through the daily roll features of the products.

Nickel Pricing: Nickel pricing is a feature that makes VIX futures impractical for small accounts (sub $100,000 dollars). The value of one tick is $50 per contract, meaning $100 for a round trip. If one were to trade a round trip on a monthly basis with a $100,000 portfolio, it will cost 1.2% of capital each year just on transaction costs (12 months * $100 ~ 1.2% of $100K). Over the years, this can represent a huge drag on the portfolio. On the other hand, VIX ETNs are priced in pennies like any other stocks. The benefits of penny pricing trickled down to volatility products with VXX and VXZ, which trade on NYSE/ARCA. Tighter spreads mean more profits to investors and traders, not market makers.

High Multiplier: We have previously mentioned that lack of granularity is a problem for VIX futures due to their large multiplier. This is especially a problem during high volatility regimes such as 2008, when the notional value of a single contract surged as high as $63,000 (when front month VIX futures traded up to 63). This makes it infeasible for small accounts to hold any VIX futures positions. Instead, VIX ETNs are better suited for small accounts, since they are traded with a penny multiplier. Both VXX and VXZ, as of writing, are trading around twenty dollars. Thus, the minimum investment in VXX or VXZ is small. When compared to VIX futures, this represents more than eight hundred times finer granularity. Combined with penny pricing, finer granularity makes VXX and VXZ much more suitable for smaller portfolios. With more flexibility of sizing, one can be extremely precise with allocations.

Finally, VXX and VXZ have the benefit of being tradable in regular stock accounts. VIX futures, on the other hand, need a separate futures account and a margin agreement. This is a benefit for investors who are restricted only to regular stock accounts, who previously had no way to deploy tactical volatility hedges.

The Drawbacks of VXX and VXZ

The common theme in the list of benefits of VXX and VXZ is their usability and retail-friendliness. For serious investors and traders, however, the convenience comes at a non-trivial cost to flexibility and customizability.

VXX and VXZ represent just two

points in the VIX futures curve: VIX futures have nine listed expiry points to choose from, and are the building blocks of both VXX and VXZ ETNs. By definition, VIX futures have more variety and are amenable for more diverse set of strategies that suit different market conditions. In addition, VIX futures allow for term structure optimization. If one does not want exposure to a particular expiry, one simply can avoid purchasing it. For example, one may not want to purchase 2m VIX futures, because 1m roll-down is high relative to the 1m futures. When one trades VIX futures, he can simply opt not to purchase them. This is impossible with VXX and VXZ, which are packaged strategies that deliver the performance of specific set of futures.

VIX ETNs do not have the highest betas to $VIX: While convenient to put on as trades, VXX and VXZ are not the best vehicles to gain exposure to $VIX, if that's the objective. VXX does not track the VIX index as well as 1m VIX futures, because the ETN combines both 1m and 2m month futures contracts. Since inception, VXX has had just 70% of the beta of 1m VIX futures to $VIX. Thus, if one prioritizes maximizing VIX exposure for a tactical trade, then both VXX and VXZ are a sub-optimal vehicle.

The Cons of ETNs

Unlike VIX futures, VIX ETNs generally charge management fees. In the case of VXX and VXZ, the management fee is 89 bps. Considering most mutual funds these days charge less than 50 bps of management fee, 89 bps is steep. In general, fees are not the biggest concern for VIX ETN traders since the fee is very small relative to the ETNs' volatility. In addition, if one day trades VIX ETNs or holds them for tactical trades lasting less than months, then fees are too trivial to be considered a factor. Otherwise, fees can accrue over time to a sizeable amount.

VXX and VXZ also cost money to short. As with any stocks, one must pay additional fees in order to locate and borrow VIX ETNs to short. The borrow rate (for shorting VIX ETNs) will depend on the brokerage. Again, the rate pales in comparison to the ETNs' volatility, but it still subtracts from the bottom line. For VIX futures, there is no such explicit cost that affects the shorts. Instead, they require adherence to the margin requirement. In this age of 0% CD rates, however, the cost of margin is negligible.

In addition, VXX and VXZ can deviate significantly from their net asset values. Historically, 1% or 2% discounts or premiums have often been observed for both ETNs. Some of these deviations are mostly a byproduct of the fact that NAV is calculated based on 4:15 pm EST close for VIX futures, while VXX and VXZ market close is computed at 4:00 pm EST. A lot can happen within these fifteen minutes, and VIX futures can easily move several percentage points given their high volatility. However, divergences do not always correct within short timeframes. For example, VXX and VXZ tend to deviate significantly from NAV around market open. One must, therefore, track NAV regularly when trading VIX futures in order to avoid selling at discount or buying at premium.

Finally, one must remember that VXX and VXZ are notes issued by Barclays. Thus, there is a small credit risk component with VXX and VXZ positions. With ETNs, the investors ultimately rely on the issuer to make good on the performance of the ETN. No ETN in the market has turned out to be a problem from a credit risk standpoint to this date; however, sharp declines in credit quality of the issuer can theoretically lead to a default on these notes.

The Common Misconceptions about VIX ETNs

While they may trade like normal stocks, VIX ETNs should not be analyzed the same way as one analyzes stocks. Forgetting that these ETNs hold VIX futures will cause one to lose sight of the risks and make avoidable mistakes.

The Prices of VIX ETNs Mean Little: The prices of VIX ETNs are simply reflections of the performance of rolling VIX futures contracts since January 2009. If VXX is down 50% in a given year, it means that purchasing and rolling 1m and 2m VIX futures for the entire year resulted in 50% loss in capital. The statistic, however, does not mean that implied volatility is down 50% on the year. In other words, the performance of VXX or VXZ is not equal to the change in $VIX or VIX futures over a certain period. The point is that the prices of VIX ETNs should be interpreted as the performance of purchasing volatility, and not as the level of volatility. The price of VIX ETNs do not contain any information about the value of volatility. For normal stocks, a drop in price signals better value. For VIX ETNs, it does not signal anything about the value of implied volatility. $VIX and VIX futures, on the other hand, are price indicators. Their numeric values reflect actual implied volatility levels. One can analyze the levels and make assessments on whether they are rich or cheap, high or low. If $VIX or VIX futures drops 50% over three months, it really means that implied volatility is 50% cheaper.

This distinction between VIX ETNs and the VIX index can be made to other ETNs as well. USO and UNG, for example, are ETNs that purportedly track the performance of oil and natural gas. However, one must not confuse tracking performance with tracking price. USO and UNG, similarly to VXX and VXZ, roll crude and natural gas futures to make investing in these commodities easier. Similarly, their current levels do not reflect the prices of spot crude oil or spot natural gas. Instead, these spot prices are tracked by WTI index or AMEX Natural Gas Index. One can look at the WTI index to say whether cash crude oil is high or low compared to the past. USO will not tell you anything about crude oil's valuation.

When to Take the Prices of Performance Indicators Seriously: One cannot use WTI index to determine how crude oil has performed in the past. WTI index tracks the cash spot market like the VIX index. However, spot market does not reflect the cost of carrying physical product, nor indicate the performance of carrying oil futures. For asset classes such as commodities and volatility that are divided between cash and investible futures, one must use different indices to answer different questions. To summarize, one must use performance indicator data to answer questions like these:

"How has investing in XYZ performed since ABC"

"How can investing in XYZ improve the performance of my portfolio?"

"What are the risks of investing in XYZ, and how big are the drawdowns?"

They should not be used to answer questions like these:

"How cheap or rich is XYZ compared to a year ago?"

"Is this a good time to go long in XYZ?"

"What is XYZ pricing in right now?"

The Dangers of Using VIX ETN Prices to Time Volatility: Since VIX ETN prices incorporate zero information about the valuation of volatility, they should not be used to time trades. This means that one should not use traditional technical analysis on VIX ETNs. There is a logical lapse in using technical indicators, which are used to gauge price patterns and supply demand, with performance indicators

How to Properly Analyze VIX ETNs

In general, it helps to break down VIX ETNs into their component VIX futures. One benefit is that when the constituent futures are known, performing scenario analysis of VIX ETNs becomes very easy. For VIX futures, the P&L change per one volatility point movement is given by the contract multiplier, which is $1,000. For VIX ETNs, since the price does not have any relationship to volatility, it is not immediately obvious what the P&L would be if volatility spikes a certain number of volatility points. If one knew how many contract his VIX ETN position holds, he can instead multiply the number of each contract by its change and aggregate.

Example: A $35,000 position in VXX on Apr 15th contains 0.7 contracts of April and 1.2 contracts of May futures. April and May futures are trading at 15.5 and 16.5 respectively. One wants to see how much his VXX position will move when the term structure parallel shifts down by 50 cents.

For parallel shifts in the VIX futures term structure, the P&L sensitivity for VIX ETN is simply the number of contracts it holds in total. The $35,000 position holds 1.9 contracts, and hence the P&L for this scenario will be -$0.5 * 1000 * 1.9.

<u>Example2:</u> Suppose one wanted to simulate how much one were to make if the term structure became flat at 18. For this to happen, term structure must flatten and rise at the same time. April futures must move 2.5 volatility points (from 15.5 to 18) and May futures must move 1.5 volatility points (from 16.5 to 18) for the term structure to be flat at 18. The P&L then is simply a sum-product of number contracts for each expiry <u>times</u> the change in the contract.

For April futures, P&L will go up by $2.5 * $1,000 * 0.7 = $1,750

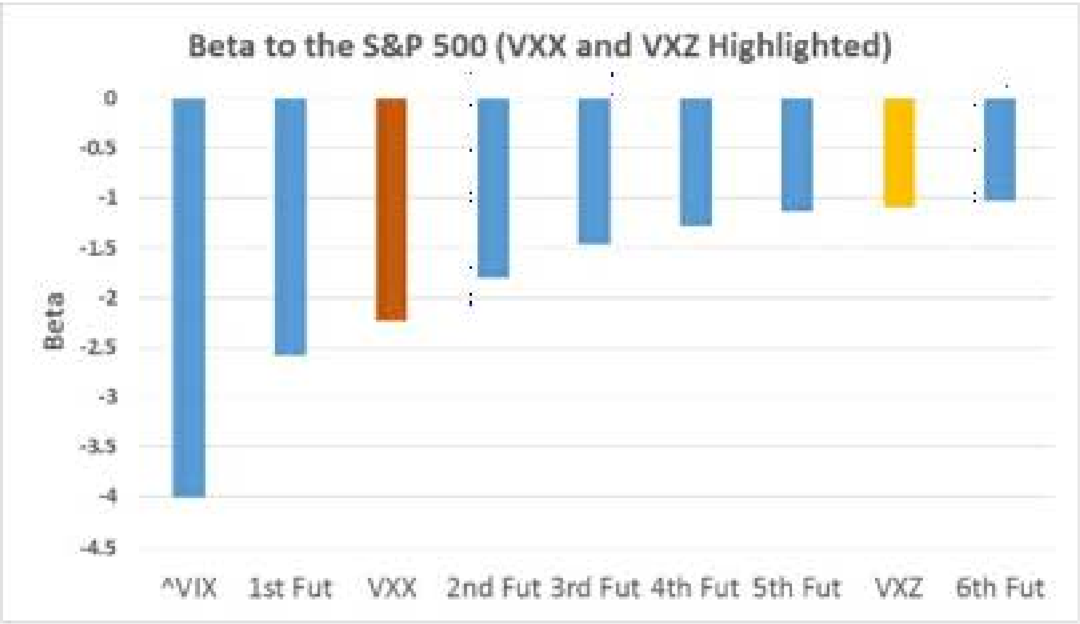
For May futures, P&L will go up by $1.5 * $1,000 * 1.2 = $1,800

The total P&L will be the sum, 3,550

Example3: On VIX expiry days, VXX is entirely composed of front month futures. Therefore, change in the front month VIX futures contracts should theoretically equal change in VXX, assuming that VXX closed at NAV the day before. This makes estimating VIX ETN P&L on VIX expiry days easy. Suppose on the day before May expiry, the June contracts (the new first month contracts) closed at 20. Then, one volatility point move either way will be 5% (1/20), which is also the amount VXX will move.

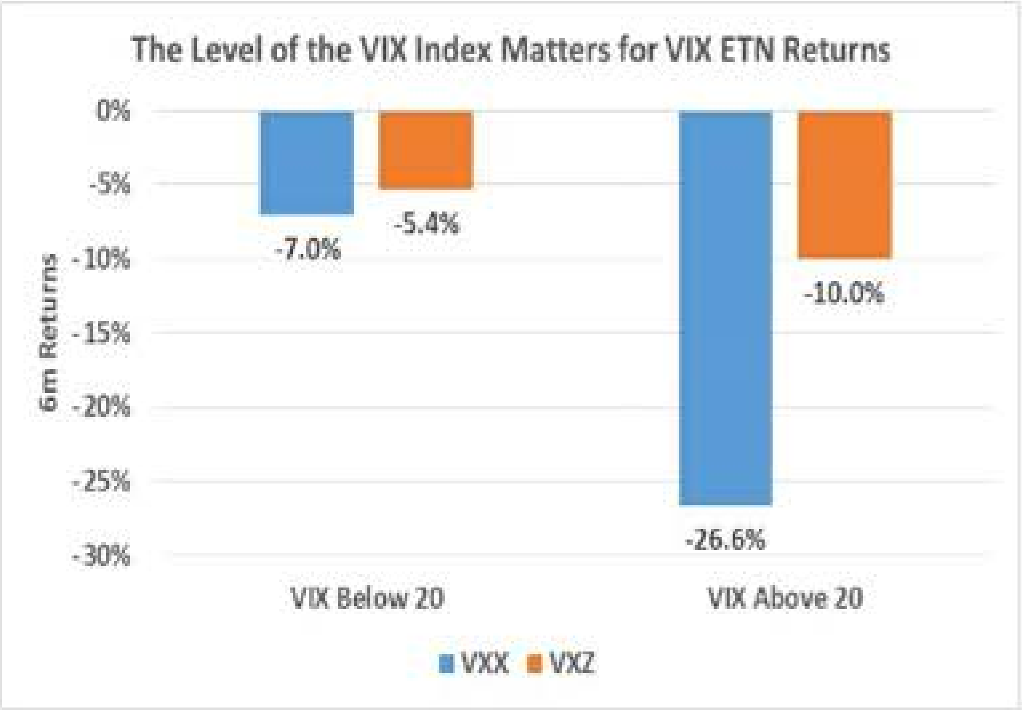
Relationship to Risky Classes

Just like VIX futures and $VIX, VXX and VXZ also have strong negative sensitivity to the stock market. Again, the absolute level of sensitivity decreases with time to expiry for the reasons that we extensively covered. The following chart summarizes the beta of all volatility instruments that we covered so far ($VIX, VIX futures, VXX, and VXZ) to the S&P 500. Each ETN should in theory be as sensitive as the average of its component futures. As expected, VXX's sensitivity falls between 1m and 2m contracts, whereas VXZ's sensitivity falls near the 5m contract.



<u>Mean Reversion</u>

At the end of the day, VIX ETNs are volatility products; they cannot escape the forces of mean reversion that affect the VIX index and VIX futures. VIX ETNs perform differently based on the volatility regime. High levels of the VIX portend poor future performances for the ETNs. Low readings of the VIX have also been followed by losses for VIX ETNs, but in much smaller magnitudes. The chart below summarizes this relationship. Since inception, VXX has lost over 26% on average over three months following VIX index level readings of 20 and higher. When VIX index was below 20, VXX has lost just one third of that amount. For VXZ, the differential between the regimes was not as stark but present nonetheless (10% loss when VIX over 20 versus 5% loss otherwise). The lesson is simple. Buy VIX ETNs when $VIX is low, sell them when $VIX is high. This has applied to all volatility products we have covered in this book.



Summary

- VIX ETNs are the most actively traded volatility instruments in the market
- Both VXX and VXZ provide investors with exposure to VIX futures
- VXX roughly has maturity of one month, whereas VXZ has maturity of five months
- VXX and VXZ undergo daily roll process
- The number of contracts that each ETN holds varies each day
- VXX has lost about 5.5% per month due to contango, while VXZ has lost about 1.5%
- VXX and VXZ are better suited for smaller accounts, since they can be

traded in small units

- VXX and VXZ both provide constant maturity exposure to volatility

Chapter Eight: Strategies for VIX ETNs

In this section, we will go over the strategies for buying VIX ETNs for hedging as well as shorting them for alpha generation. Risk management, again, is crucial for volatility strategies, since they are inherently more volatile than stock strategies.

TIPs for Executing VIX ETN Strategies

The principles that apply to VIX futures strategies also apply to VIX ETNs.

Always Be Monetizing: One needs to periodically monetize VIX ETN positions regardless of whether one is long or short. Mean reversion is a fundamental characteristic of volatility that needs to be accounted for through regular rebalancing. Remember that volatility spikes rarely last more than three months. Unlike normal investing, excessive patience can cost money.

Be Aware of Term Structure: Remember that the slope of VIX futures term structure significantly impacts VIX ETN returns in terms of both direction and magnitude. On average, upward sloping term structure means negative returns for VIX ETNs, and the opposite holds true for downward sloping term structure.

Be Tactical: All volatility products, whether they be options, futures, or ETNs, are not meant for long holding periods. Contrary to the common wisdom of investing, readiness and willingness to adjust and micromanage positions is the key to success with VIX ETNs. Since volatility trading is not traditional investing, and traditional methodologies do not apply.

Be Mindful of ETN NAVs: Bear in mind that VIX ETNs can and will diverge from their intrinsic values. When considering executing, take a second to see where the NAV is relative to the current market. It is not hard to do, and one can potentially save multiple percentage points.

VXX and VXZ Are Not Designed for Buy and Hold

Like VIX futures, VXX and VXZ are not buy and hold instruments. Unlike equities or bonds, all volatility products, including VIX ETNs, do not reward longer holding periods. The chance of making money on the long side actually decreases with time if the markets remain stable as they have been during 2009 – 2012. During quiet regimes, contango will provide a significant performance drag to VIX ETNs in the form of roll down.

To illustrate how buy and hold is a terrible idea for VIX ETNs, we simulate one hundred different random entries for VXX and VXZ since their inception, and measure the holding period returns ranging from 30 to 120 business days.

Table: VIX ETN Returns by Different Lengths of Holding Period

Ticker	# Days Held	Best	Average	Worst	Std. Dev
VXX	30days	84.32%	-11.69%	-41.46%	19.97%
	60days	131.50%	-16.26%	-51.80%	32.80%
	90days	123.89%	-17.93%	-65.03%	50.26%
	120days	121.40%	-33.82%	-72.92%	40.41%
VXZ	30days	38.75%	-2.65%	-19.86%	10.09%
	60days	45.54%	-5.88%	-26.05%	15.10%
	90days	41.36%	-6.35%	-36.43%	19.95%
	120days	32.20%	-11.87%	-44.26%	21.30%

We can confirm mainly two things from the table above:

First, longer holding periods yield worse returns. For VXX, average returns worsened about 30% if one held the stock for 120 days compared to 30 days. Returns for VXZ worsened similarly by about 25% if one held for 120 days instead of 30 days.

Second, the best returns were much larger than the worst returns. For VXX, the best 60 day return in the simulation period was 131%, which is more than two times larger than the worst 60 day return. Similar results applied to VXZ.

The statistics above indicate that both VIX ETNs are distributed with a negative mean and a positive skew. The positive returns last for short periods of times, but their magnitudes are larger than that of the negative returns. Thus, VIX ETNs give investors a chance to make outsized returns quickly if timed properly. The negative average returns also imply that holding VIX ETNs for long periods is probably a bad idea. Conversely, holding short VIX ETN positions have tended to pay off. In our study of random entries, over 90% of 120 day holding periods were negative. This implies that short VIX ETN positions make money over 120 day periods most of the time.

If that is the case, are VIX ETNs a no-brainer short and hold? Again, the answer depends on the intended holding period and relative size of the VIX ETN position to one's total equity. First, one's probability of making money on the short side increases with holding period, as we have seen in the table before. Second, one must ensure that the losses from potential volatility spikes will not exceed one's stop out level. Even the most aggressive investor should not short more VIX ETNs than it takes to wipe out his entire account. We have seen before that volatility spikes can easily lead to larger than 100% losses in 60 trading days or less, which will wipe out the entire account and leave one with no second chance. Therefore, it is important not to be fooled by the charts of VXX or VXZ; shorting them is not guaranteed to make money, and could potentially become very dangerous if one over-allocates. A chart that seemingly decays exponentially to zero masks many micro-spikes that caused legitimate scares.

Charts Can Be Deceiving. The above chart shows the return of VXX since 2009, which is down 99%. The magnitude of this loss masks two separate three month stretches where VXX spiked more than 50%. During the European Financial Crisis of 2011, VXX spiked more than 179%.

Static and Dynamic Hedging Programs

Like VIX futures, there are broadly two ways of approaching hedging with VIX ETNs: static and dynamic. To summarize, static programs are easier to understand, implement, and maintain. VXX and VXZ roll futures on behalf of investors, so there is generally less work involved. The downside of static hedging is that it does not incorporate new information from the market. By design, it will not adapt to changes in market conditions and shifts in risk reward. It comes as no surprise that static hedging programs have underperformed most dynamic hedging programs in the past.

The benefit of dynamic programs is that they incorporate new information to adjust positions according to changing risk/rewards. The sources of new information are many, such as the level of implied volatility and VIX futures term structure. The downside is that aggressively attempting to time volatility may result in unnecessary complexity, over-fitting, and proliferation of model parameters. Also, the strategy may sometimes recommend not to allocate to VIX ETNs at all. Therefore, it provides extra windows where the model can get 'unlucky'; for example, an unexpected volatility shock can come right after the model recommends reducing volatility hedges. Ultimately, trading a dynamic model requires a complete trust upon the model to do the job in the future.

Static Hedging

Previously, we have surmised that the pros of a static hedging program with VIX futures are its simplicity of implementation and lack of timing burden. As for its cons, we have cited poor performance, especially when it purchases shorter dated contracts. Similar concepts apply to hedging programs with VIX ETNs as well. The main additional benefits of using VIX ETNs are their constant maturity feature and smaller multipliers, which make finer granularity hedging possible for retail portfolios. Rebalancing is still crucial for a target allocation strategy such as this, since it prevents the proportion of VIX ETNs in one's portfolio from fluctuating significantly over time. Unfortunately, static hedging with VIX ETNs have turned out to be extremely costly over the years, especially since 2009. As we have seen before, the term structure of VIX futures has been in contango for the vast majority of time since 2009. This hurt VIX futures and VIX ETNs alike, and made it impossible for static allocation strategies to deliver positive value.

Below is a comparison of performances of VXX-hedged S&P 500 portfolios with various degrees of allocation to VXX. The portfolio is rebalanced quarterly, and transaction costs are ignored for simplicity. The table shows how metrics such as performance, maximum drawdown, and volatility change as one varies allocation target from 0% to 20%. Essentially, adding VIX ETNs were helpful in reducing the maximum drawdown for stock portfolios, but the benefits came at such a steep cost that hedging has been counter-productive.

	0%	5%	10%	15%	20%
Max Drawdown%	-55.18	-48.6	-41.39	-34.06	-31.57
Sharpe Ratio	0.40	0.37	0.30	0.17	(0.04)
Total Return%	74.79	54.14	33.27	12.05	-7.68
Hist. Volatility%	20.99	16.69	13.13	10.63	9.56

We can observe the following from the data presented above.

- Maximum drawdown decreased with any allocation to VIX ETN. For example, 20% allocation to VXX reduced maximum drawdown figure to -31%, as opposed to -55% if the portfolio had 0% allocation to VXX.
- Volatility was significantly reduced. Every 5% increase in allocation reduced portfolio volatility by about 2-3%. This is expected behavior since VXX is negatively correlated to S&P 500.
- However, all this came at a significant cost to the total return. Every 5% increase in allocation to VXX cost the total portfolio almost 3% a year. This is because VXX lost on average 60% each year in the sample period (minus 60% times 5% increase equates to 3% additional loss). At 20% target allocation, the strategy ended up losing money from 2004 to 2013.

At the end of the day, the efficiency of a hedging program should be measured based on how much it can reduce volatility and drawdown of one's portfolio without excessively hurting returns. The best way to measure this is by looking at how the Sharpe Ratio (returns divided by risk) changed with each allocation change. Unfortunately, increasing allocation to VXX uniformly led to decreases in the Sharpe Ratio, indicating that a long-term commitment to hedging with VXX is probably a bad idea.

That is not to say that VXX-hedged S&P 500 position never outperformed regular S&P 500 since 2008. On a short term basis, S&P 500 can be much better off hedged with VIX ETNs, even on a static basis with no rebalancing or timing. Consider the chart below which shows the performance of S&P 500 portfolio with 10% allocation to VXX in 2011, which was a year when $VIX spiked above 40 during the peak of the European Financial Crisis. In 2011, the VXX-hedged S&P 500 portfolio outperformed the unhedged version by almost

8%. In addition, the hedged portfolio experienced 50% less volatility and drawdown.

The lesson is that it is okay to implement a static hedging program with VXX as long as one does not make a blind long-term, i.e. multi-year, commitment. Volatility is an asset-class that does not reward buy and hold. We have confirmed this with our holding period simulation of VIX ETNs as well. This effectively means that target allocation strategies for the long run is probably a losing proposition. Rather, all volatility trading should be approached tactically with short term commitments to positions. Volatility trading is tactical by nature, because the duration of volatility spikes tend to be very short. Therefore, VIX ETN positions should be reassessed constantly based on numerous factors such as the level of volatility, the slope of term structure, and the macro-regime.

Static Hedging With VXZ

The primary culprit behind the terrible performance of VXX is its devastating negative roll-yield. We have seen that VXX has cost, on average, more than 5% per month to hold (annual burn of 60%), whereas VXZ costs about one-third of that amount (~1.5%, annual burn of 18%). This implies that switching from VXX to VXZ can save more than 40% per year! In return for less drag from negative roll yield, one also gets less hedging power and reduced tracking to $VIX by switching to VXZ. Therefore, there are two tradeoffs to consider: minimizing negative roll-yield versus maintaining enough hedging power for the market sell-offs. Considering this, the question is whether VXZ is better suited for static hedging programs than VXX? The answer is yes.

Below is another summary of performance statistics for VXZ hedging program with S&P 500 since 2004 (using replicated VXZ data) using different degrees of allocation to VXZ. Assume the rest of the portfolio is invested in reinvested S&P 500, rebalanced quarterly, and traded without transaction costs.

Statistic	0%	5%	10%	15%	20%
Max Drawdown%	-55.18	-50.32	-45.3	-40.02	-34.87
Sharpe Ratio	0.40	0.41	0.42	0.43	0.43
Total Return%	74.79	70.42	64.34	57.87	50.77
Volatility%	20.99	18.47	16.15	13.99	12.08

The data presented in the above table implies the following:

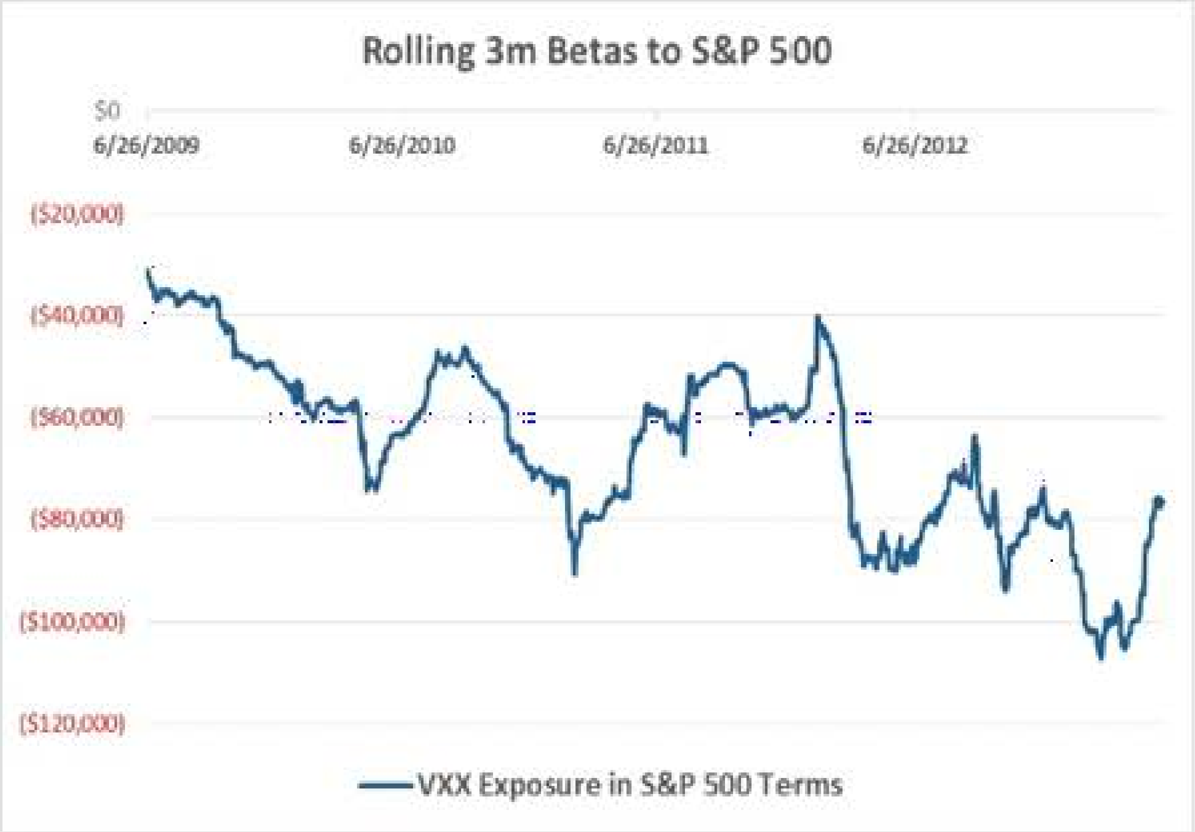
- Same as with VXX, volatility and drawdown was reduced with increasing allocation to VXZ.
- However, the total returns did not suffer as much. Notice that 20% allocation to VXZ knocked off *only* 24% from total returns since 2004, compared to pure S&P 500. That's less than 2% a year in the past nine years, which is impressive.
- Sharpe Ratio actually increased with higher allocation. Adding VXZ improved S&P 500's risk reward, unlike VXX.

Last Word on Static Hedging: Static Hedges Are Not So Static

Volatility has time varying sensitivities to the S&P 500. For example, if VXX has a beta of -4 to S&P 500, it implies that VXX tends to move 4% up for every 1% drop in the S&P 500. If the beta is -1, then VXX tends to move just 1% higher for every 1% drop in the market. The point is that same $1 of VXX can hedge different amounts of S&P 500 at different times.

Like VIX futures, VIX ETNs do not have a constant beta to the S&P 500. For example, on a three month basis, the beta of VXX to S&P 500 has ranged between -1.5 and -5.0 since 2009. This implies that static allocation to VIX ETNs is not so static after all. It is very different to hold VXX when it is moving five to one versus the S&P 500 versus when it is moving just one for one. Therefore, it makes sense to track the 'true exposure' of VXX, i.e. the VXX notional multiplied its beta to the S&P 500.

Below chart shows how the 'true exposure' of $20,000 invested in VXX has changed over time. True exposure is a good indication over the short run of how much S&P 500 exposure VIX ETN is really hedging. During low beta regimes, the same amount of a VIX ETN position will feel too small. Conversely, the position will feel overpowering during high beta regimes. At the end of the day, the size of a position is felt by its dollar volatility contribution to the entire portfolio. Dollar volatility is calculated as [average daily move in % × # of shares × $ price of the stock]. Even if the $ price of a stock is small, if volatility is big (daily move in %), the two variables will offset each other. This simply shows that one cannot expect a constant hedging exposure even if one religiously maintains the $ notional of the position at the same level.



As a corrective measure, one can instead attempt to maintain a constant position of VIX ETNs measured in terms of $ notional exposure to the S&P 500 index. This exposure is also called the 'delta', and is essentially $ notional of the VIX ETN position multiplied by the ETN's beta to the S&P 500. The variability in the true hedge exposure comes from changing betas, which can be smoothened by purchasing less VIX ETNs when their betas to the S&P 500 are high, and more when the betas are low.

Dynamically Adjusting Hedges

The main drawback of static allocation is that it fails to account for changes in volatility regimes. We have already surveyed several factors that drive volatility returns, mainly the slope of term structure and the level of volatility. Incorporating these factors can help improve risk reward profile of VIX ETN hedging strategies as well.

- Level of Volatility: In the previous chapter, we saw that VXX, on average, lost 20% more over 6 months when purchased with the VIX index above 20 versus below. Clearly, the level of volatility is a strong *negative* indicator of future performance of VIX ETNs.

- Slope of Term Structure: We have also seen that VXX tends to perform better when the term structure is flatter (less positive with time to expiry). One can use incorporate this fact to improve hedging performance as well.

Shorting VXX and VXZ for Alpha

Compared to VIX futures, VXX and VXZ are potentially better vehicles to express short volatility views. Here are some of the reasons.

- Easy to Maintain: One does not have to worry about rolling futures or rebalancing maturities with VIX ETNs.
- Accrues Positive Carry from Roll-Down: Due to their daily roll feature, long VXX and VXZ positions constantly accrue negative carry as long as the term structure is upward sloping.

When shorted, the negative carry of VIX ETNs turns positive for the investor, and is realized every day. For example, VXX sells a small proportion of its 1m VIX futures holding each day, and purchases the 2m futures. In this process, VXX partially locks in a loss (during contango) or a profit (during backwardation). No matter what happens in the market from then on, all realized profits remain with the ETN.

In contrast, when one trades a VIX futures contract, the investor does not realize any positive P&L during the holding period. All P&L is unrealized until the contract expires or is monetized; thus, all P&L associated with VIX futures depend 100% on what happens in the market going forward. In some sense, this is a lot riskier. For example, suppose one directly shorted 1m VIX futures instead of VXX, and both drop 15% over the next month. The day before the expiry, VXX will have sold

100% of the 1m VIX futures position, and all the remaining risk will be with the 2m futures. Also in the process, VXX will have locked in one half of the change in the 1m VIX futures. On the other hand, the short 1m VIX futures position will be sitting with P&L equating to the entire change in the 1m VIX futures over the period. This represents more P&L than what the person would have achieved through shorting VXX. However, all this P&L can be wiped out completely if 1m VIX futures were to spike back to the original level overnight. And meanwhile, VXX will be less hurt by this scenario because it has zero exposure to 1m VIX futures. This is one of the reasons why it is even more important to take profits periodically even with short VIX futures positions.

Same with VIX futures, the key to being successful shorting VIX ETNs boils down to two rules.

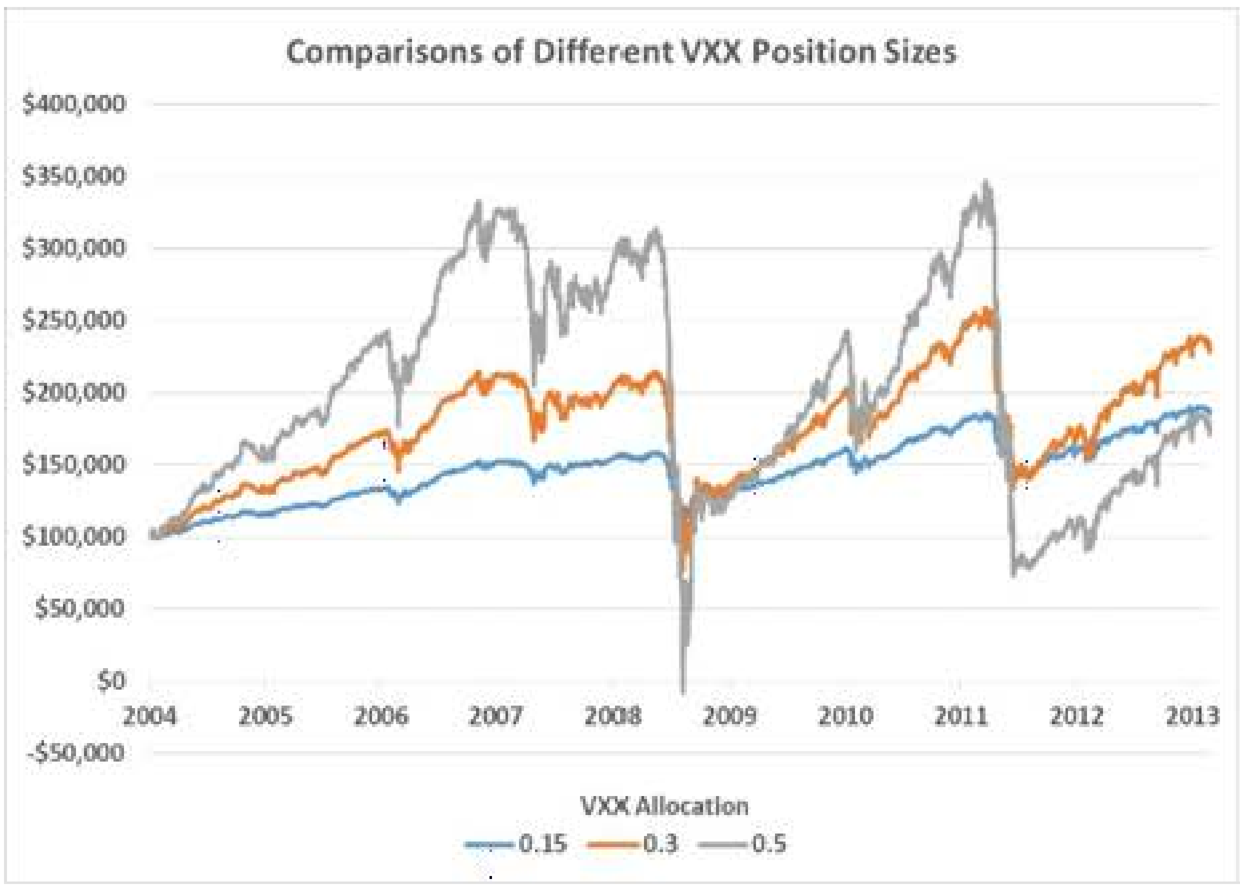
- Refrain from excessive allocation. Do not allocate more than 30% of your capital to being short VIX ETNs. Allocate even less than that if you plant to own other risky assets at the same time.

- Be selective. Use the power of mean reversion and term structure to your advantage to fine-tune entries. For example, avoid making mistakes like shorting VIX futures during backwardation, or purchasing large amounts of VIX futures when $VIX is above 70.

Done in moderation, short VIX ETN trades have generated higher returns with lower volatility and drawdown than the equity market. Unfortunately, too many investors pile onto short volatility/VIX ETN trades without preparation, and often get out of these trades at the worst times.

Taking the right amount of risk in the first place is the key to avoid bankrupting a trading account. Intuitively, 30% is around the maximum amount that one should risk for shorting VXX. At that level of risk, there is enough buffer in equity to ride out an instantaneous 100% spike in VXX. The caveat is that one could still be margin called depending on the brokerage margin requirements. In addition, we are assuming that the other 70% of the portfolio is in a cash-like asset. For example, one cannot cheat by putting the other 70% in a risky asset as well, and expect the overall position to behave the same. Therefore, when shorting VXX, one needs to keep plenty of 'ammo' – marketable securities or cash – in the account to prevent forced liquidation. By definition, margin calls come at the worst possible times, and brokerages tend to be indiscriminate about selling positions to protect their interests. Ultimately, it is the trader/investor's responsibility to ensure the account has enough liquidity to accommodate the short VIX futures strategy.

To illustrate the importance of position sizing, we see the following chart of three different equity curves with varying allocations to the short VXX position. The rest of the portfolio is assumed to be invested in cash. Again, the portfolio is assumed to be frictionless, does not suffer from brokerage margin requirements, and is rebalanced quarterly.



Essentially, the chart implies the following:

- 50% allocation went bankrupt once in 2008, and almost once more in 2011.
- he maximum drawdown of 50% allocation to short VXX was exactly -102% (bankrupt). And it happened in less than three months. Volatility can

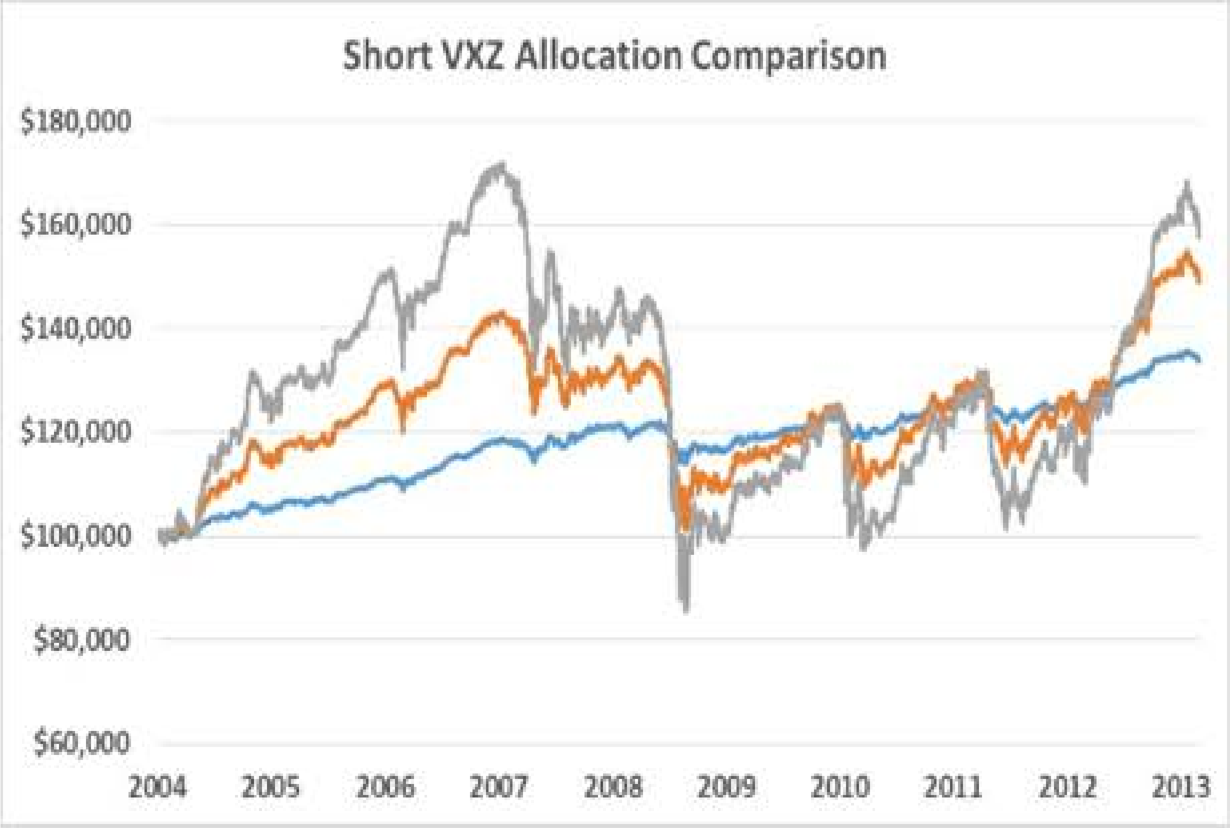
double over such short timeframes, leaving investors with very little time to digest the situation.

- 30% allocation had a significant drawdown in 2008, with portfolio equity dropping from $200,000 to $80,000. However, this drawdown was comparable to that of the S&P 500 index, which had a similar peak to trough drawdown of nearly 60%. In addition, the total return of the allocation was almost 25% higher than the S&P 500 over the nine year historical period.
- 15% allocation had a relatively mild drawdown and returned favorably. Over the historical period, 15% allocation returned more than the S&P 500 (87% versus 76%) with a smaller drawdown and lower volatility.

Again, it is important to remember that these allocations are made of cash and short VXX. If any other asset class were to be added, then the allocation to short VXX should most likely be lowered. If one's short allocation to VXX equates to 30% of capital, he cannot be long equities in the other 70%. Lastly, the simulations were run with the assumption that the account does not have margin or capital maintenance requirements.

Systematic Short of VXZ

Compared to VXX, VXZ is an arguably 'safer' volatility product to short. VXZ, being a longer term volatility instrument, is inherently less volatile than VXX, sometimes by as much as half. Since inception, the largest 3 month price increase for VXZ has 'only' been around 50%. While this is a large figure, it is by no means unheard of. Think of all the small cap/penny stocks that move around 25% or more in a single day around earnings. Even the S&P 500, for example, dropped nearly 60% from the top in 2008. In comparison, the volatility of VXZ does not seem out of this world.



The catch, however, is that it is theoretically not as profitable to short VXZ as it is to short VXX. Recall that VXZ earns significantly less roll-down P&L relative to VXX (1.5% vs 5.5% per month). Over the course of a year, historical data shows one can make 40% more money shorting VXX than VXZ. This makes VXZ a significantly less attractive short compared to VXZ, especially when the markets are stable. The chart above compares the performances of targeting 10%, 30%, and 50% short allocations to VXZ (initiated with a $100,000 portfolio in 2004). We note that all three performances are lackluster, since none of them were able to outperform the S&P 500, which returned over $80,000 over the same period. In comparison, the best performing short VXZ allocation, the 50% target short (grey line), made about $60,000. Lower short allocations did not help either. 30% (orange) and 10% (blue) allocations to short VXZ returned $49,000 and $34,000, respectively, since 2004.

Why Staying Short VIX ETNs Is Harder Than It Looks

It is tempting to look at the ETNs' horrendous performance since 2009 and decide that staying short is an automatic winning strategy. Surely, term structure generally stays upward sloping which provides negative drag on the ETNs returns. However, one must remember that term structure is a headwind only until the VIX remains low. Term structure can invert, turning itself into a tailwind to the ETNs. Most importantly, many people overlook the fact that shorting VIX futures suffers from the same downside with shorting in general. Longs can only lose the invested capital, but shorts can owe multiples of that.

The fact that upward sloping term structure is a drag on volatility investments has been known to professional traders long before either VIX futures or VXX was invented. One could have always made an argument that consistent roll down returns would be enough to cushion short term fluctuations in the VIX, which is the same argument used to justify staying short VIX ETNs. Had VXX traded in 2008, however, the ETN would have lost almost 300% in just a few short months in from September to November. The losses would have wiped out all the profits one would have made from 2004 to 2007 ten times over. The key is to remember that the VIX ETN returns from 2009 are probably an anomaly produced by extreme high starting point in the VIX index at the time of launch, persistence of record steepness in term structure throughout 2010 to 2012, and a historic 140% rally in the S&P 500.

Summary

- Most rules for trading VIX futures apply to VIX ETNs as well.
- VXX has lost 99% of its value since inception, while VXZ has lost about 80%. The main culprit is the roll-down from contango
- VIX ETNs are terrible buy-and-hold products
- Because VXX has lost about 5.5% each month due to contango, it has been the best vehicle for expressing short volatility view
- VXZ has lost just about 1.5% per month due to contango, and shorting VXZ has not produced sizeable alpha in the past

Final Words

‘History Never Repeats Itself but It Rhymes’ – Mark Twain

Although the stock market has been in existence for centuries, we are constantly reminded of how little we know about it. We have accumulated enough knowledge and statistics about the stock market to fill thousands of books. Yet still, the field is deep and rich enough to accommodate millions of different opinions and approaches, even after all these years. This provides us with a deeper perspective about VIX futures, or volatility trading in general for that matter. In the U.S., vanilla options have been trading for almost four decades. While that may seem like a long time, it is quite short compared to the history of the stock market. This also prompts us to question how much we really know about VIX futures and ETNs, which have existed for less than a decade.

The truth is that we do know a lot about the VIX index and its derivatives despite their short history. The computational resources of the modern age have made it easy for traders and investors to learn about the product faster than ever before. The fact that we went through two of the wildest economic cycles of the modern area in the past decade also gives us a rich dataset to analyze. However, much of our 'knowledge' of $VIX will most likely morph in small and large ways in the future, since the markets are always in flux. The principles, properties, and 'facts' that have been true up to now are not guaranteed to hold in the exact same way. In fact, the patterns of the past are likely to be taken advantage of in the future by new crops of arbitrageurs. Thus, we must learn to anticipate the changes in the VIX derivatives market, and even embrace them. With this mindset, there is no doubt that VIX futures and ETNs will continue to be a growth area that will provide investors with tremendous amount of opportunities in the future.

Then, how will the VIX index, VIX futures, and VIX ETNs perform going forward? As of writing (July 2013), the S&P 500 index rallied almost 140% since 2009. The chart below shows the four year rolling returns of the S&P 500 for the past sixty three years. We see that the rally of the past four years represents the second biggest four-year rally since 1950.

What the chart also tell us, however, is that the pace of these out-sized returns are not sustainable. For the last three times that the market reached these levels of returns, it cooled off substantially over the following four years, usually through a large correction. For example, the rally from 1994 to 2000 was followed by the dot-com crash. The rally from 1984 to 1987 was followed by the 1987 crash ('Black Monday'). Thus, given that we have rallied a lot, it is likely that the next four years will not be as profitable as the previous four.

The timing of the next big sell-off, however, is arguably unclear; in fact, it is more likely that the market will rally some more until it reaches a true bubble stage. Only then would the stage be set for a much larger correction to occur. Some may argue that we are already in a bubble; I disagree. The stock market has been rallying in a stable fashion, which has frustrated many investors hoping for a 'buying opportunity'. Euphoria has not quite set in either, since there are enough bears that are still in denial about the rally, which will fuel further gains in the market. These are not the symptoms of a typical bubble. The peaks of most stock market bubbles are characterized with higher volatility and tighter monetary conditions, i.e. higher short term interest rates. Prior to the 1987 or 2008 crashes, the markets experienced multi-month periods of heightened volatility. Also to be noted that both crashes were triggered by monetary tightening, albeit from a much higher level. Currently, we are in a zero-interest rate environment; raising the rate from 0% to 0.5% will not move the needle, at least in a visible manner. Thus, the market still needs to develop these bubble-like characteristics in order to setup a true correction.

In this type of a regime, the name of the game is to be protected when the time finally comes for the market correction. The question is not about whether there will be a large scale sell off in the future; it is about the timing of it. Since the timing is uncertain, one must make sure the hedging is done efficiently, and ensure there is enough financial and psychological to sustain a hedging program long enough to benefit from it. One must accept that it may take a long time for fear to set in the market. Volatility can stay low, and the curve steep, for many months ahead.

Thus, the right approach that we want to communicate is that one must respect the general rules of term structure/volatility trading. In addition, these rules must be flexibly applied, since the market rarely throws the same exact set of conditions to traders and investors. It is critical for a trading or hedging strategy not to depend too much on assumptions about variable market parameters. For example, we know that contango and backwardation are the two forces that have large effects on VIX futures with mathematical certainty. There is no doubt that the slope of the term structure hurts or benefits VIX futures. The real unknown, however, is regarding how steep or how flat the term structure will be in the future. This unknown will effectively drive how profitable VIX futures and VIX ETNs will be in the future. Herein lies the danger of developing a trading/hedging strategy that assumes some fixed degree of term structure slope for the future. The strategy needs to be flexible such that it does not rely on broad assumptions about such variables.

They say that the fortune favors the prepared mind. This adage applies to trading VIX. It is an instrument designed to help us prepare for the uncertainties of the future. We wish you the utmost success in your trading.

P.S. We would love to keep an open channel of communication with our readers. For any questions, please feel free to reach out at oceanspray@gmail.com

Putting All the Lessons Together

Top 20 Lessons

- The VIX index is a weighted average of 30 day maturity S&P 500 options
- The VIX index is negatively correlated to risky assets in a consistent manner
- All volatility instruments (S&P 500 options, $VIX, VIX futures, VIX ETNs) display mean-reversion
- Volatility spikes much faster than it falls. Historically, it spiked more than three times faster (than it fell)
- The VIX index is not tradable. It is simply a price indicator
- Things that one can trade to get exposure to the VIX index are S&P 500 options, VIX futures, and VIX ETNs
- S&P 500 options are unsuitable for trading pure implied volatility
- The VIX index is unsuitable for

betting on pure historical volatility

- Shorter dated VIX futures are more volatile than longer dated VIX futures
- The slope of the term structure significantly influences VIX futures returns
- Avoid buying VIX futures with the term structure is in steep contango.
- Similarly, avoid selling VIX futures when the term structure is in backwardation.
- VXX and VXZ are composed of VIX futures
- VXX and VXZ are not designed for buy and hold strategy
- VXX and VXZ don't expire and give you constant maturity exposure to volatility
- Avoid buying either VXX or VXZ when the VIX futures curve is in steep contango
- VXX is a great instrument for shorting volatility, as it generates roll-yield

- Filtering by term structure signal can greatly improve the performance of VIX futures strategies
- Understand that short VIX futures or VIX ETN positions are bets against black swan events
- VIX spikes have been great opportunities to buy stocks.