QUANTITATIVE AND DERIVATIVE STRATEGIES

Morgan Stanley

QDS Vega Times

MARCH 28, 2011

A Guide to VIX Futures and Options

Interest in trading VIX derivatives has grown substantially, particularly after the 2008 volatility shock. In this note, we provide an in-depth guide to VIX products and their characteristics, and review use cases for these products.

VIX derivatives behavior is very different from that of regular equity derivatives

- VIX index is **not directly tradable**
- **Term structure, skew** and **volatility of volatility** characteristics
- VIX futures and options are now **one of the most liquid ways to trade short-dated volatility.**

VIX derivatives have broad use cases

- **Tail-risk hedging with VIX contracts,** particularly for short-term trades
- **Alpha strategies with VIX contracts**

Equity hedging strategies using VIX derivatives have historically worked better than S&P500 options

- **Historical outperformance over SPX puts**, at significantly lower cost
- **1x2 VIX call spreads** and structures that trade **SPX puts vs VIX calls** are often attractive
- **Correct sizing and management** of VIX derivatives positions is critical

Listed VIX contracts allow for new systematic alpha sources from the options market

- **Steepness of term structure** and **richness of SPX implied vol of vol** as alpha drivers
- **Limit downside risk** through listed option configuration
- **Historic profitability** of systematic strategies

Diverse offering of VIX futures-linked ETPs

- **ETFs and ETNs** tracking VIX futures-based indices
- **Varying performance and use cases**, depending on the product

QUANTITATIVE AND DERIVATIVE STRATEGIES

UNITED STATES

Daniel Cheeseman
+1 212-761-5832
daniel.cheeseman@morganstanley.com

Simon Emrich
+1 212-761-8254
simon.emrich@morganstanley.com

Boris Lerner
+1 212-761-0759
boris.lerner@morganstanley.com

RELEVANT QDS ARTICLES

"Start Your Hedges: Managing Downside Risk in an Equity Rally", *Vega Times, Feb 2011.*

"Inverse & Leveraged ETF Primer", *Vega Times, Oct 2010.*

"Capital Markets Solutions for Hedging 'Structural Beta' Risk", *Global Equity and Derivative Markets, Aug 2010.*

"Volatility Exposure in Hedge Fund Returns- a Guided Tour", *Vega Times, Jun 2010.*

"Tailor-Made Variance Swaps – The Next Frontier", *Global Equity and Derivative Markets , Winter 2007*

"Strategic and Tactical Use of Variance and Volatility", *Global Equity and Derivative Markets, Dec 2005.*

I. A Roadmap for this Paper

Since its introduction in 1993, the VIX has moved from a seldom-used, exotic measure of equity risk to the forefront of investors' minds as an important indicator of sentiment. The growth in the popularity of this index has led to it being rebuilt from the ground up into a new index with derivatives linked to it.

Investors' increasing concern for volatility risk and their desire to control it has led to an explosion of liquidity in VIX futures and options despite their short trading history. VIX contracts are now the most liquid way globally to trade short-term implied volatility.

Since the VIX itself is not investable, the product itself has many important intricacies that may not be obvious for the first-time user. Moreover for current users of VIX derivatives, knowing how to best leverage this product's dynamics is crucial.

We therefore provide this paper as a how-to guide on using this product for all users of VIX contracts, current and potential. Below is an outline of the content to follow:

Section II. An Introduction to the VIX

Starting on page 4, we give a broad overview of the VIX and what the index truly represents. The VIX has many properties that make it unlike any other equity index. The points we discuss in this section include:

- What the VIX is and an overview of how it is priced
- A history of the index and the growth of global VIX look-alikes
- An analysis of the key properties of the VIX: (1) mean reversion, (2) persistent negative correlation, and (3) the convexity of its returns in a market shock
- How one gets exposure to VIX and the liquidity profile of VIX futures and options

Section III. VIX Derivatives 101

On page 8, we highlight the unique properties of VIX derivatives. Because the index is itself not tradable and has many unique properties, the pricing of VIX derivatives is very different from regular equity options. Specifically, we cover:

- How VIX derivatives account for mean-reversion through the VIX futures term structure
- The cost of holding VIX contracts due to the shape of the term structure
- The time sensitivity of VIX futures versus the roll cost trade-off
- The slowness of VIX option decay versus regular options
- The shape of the VIX vol surface and how VIX options decay
- How VIX futures compare to forward variance swaps

Section IV. VIX for Equity Hedgers

We continue on page 12 with a discussion of how VIX contracts can be used as an equity hedge because of the negative correlation between volatility and equity returns. Through backtests and empirical analysis, we discuss:

- How to scale a VIX hedge for an S&P500 portfolio
- How to compare the costs of VIX contracts versus S&P500 contracts
- Systematic performance of VIX hedges versus S&P500 hedges
- The long-term performance of VIX spread-based hedges
- The potential systematic cheapness of VIX hedges
- How one can use a unit mismatch between the S&P500 and VIX for downside hedges

Section V. VIX for Alpha-Seekers

OTC index variance swaps have long been used as a part of systematic alpha strategies. However, the events of 2008 have raised questions whether listed VIX contracts can also be used as a part of an alpha strategy

On page 21, we highlight potential systematic VIX alpha strategies using the VIX term structure and the VIX option implied vol of vol. The topics we discuss include:

- How to use VIX derivatives to trade the S&P500 implied vol term structure
- How to construct term structure trades with reduced downside risk
- The historical richness of VIX option implied vol versus subsequent realized vol
- The backtested performance of potential alpha trades

VI. VIX Futures ETPs

For the last major section on page 27, we review the current landscape for VIX Exchange Traded Products ("ETPs") and how the properties of VIX futures affect their performance The points discussed are:.

- What the current landscape is for ETPs and an overview of what is currently available
- How VIX ETPs are affected by the VIX futures rolldown
- The long-term performance of VIX futures going back 15+ years
- The performance of inverse & leveraged forms of these strategies

Section VII. Glossary of Terms

Lastly on page 30, we give a concise glossary of commonly used terms within this document and their definitions.

II. An Introduction to the VIX

The VIX has emerged as an index that is actively tracked by multiple investor types across virtually all asset classes. The popularity of this product eventually led to the launch of other VIX-like indices globally along with VIX derivatives. However, many misconceptions exist about the index and what it truly represents. In this section, we aim to cover:

- *What the VIX is and how it is priced*
- *A history of the index and the growth of global VIX look-alike indices*
- *An analysis of the key properties of the VIX: (1) mean reversion, (2) persistent negative correlation, and (3) the convexity of its returns in a market shock*
- *Getting exposure to VIX and the liquidity profile of VIX futures and options*

A Real-Time Measure of S&P500 Risk

IMPLYING FUTURE EQUITY RISK THROUGH OPTIONS

In the Black-Scholes option pricing model, the largest pricing input aside from the strike is the forecast of future volatility of the underlying. Since an option is hedged by actively managing an amount of an offsetting stock position, higher volatility requires that the hedge be rebalanced more frequently. This incurs higher costs and in turn increases the option premium.

Options are thus a forward-looking instrument, accounting for expectations of future equity risk. This makes implied volatility comparable to the yield curve, which accounts for future expectations of inflation and changes in interest rates. As option trading has become more prevalent, investors have increasingly tracked implied volatility as an indication of the market's expectation of future risk.

VIX AS A BENCHMARK INDICATOR OF EQUITY RISK

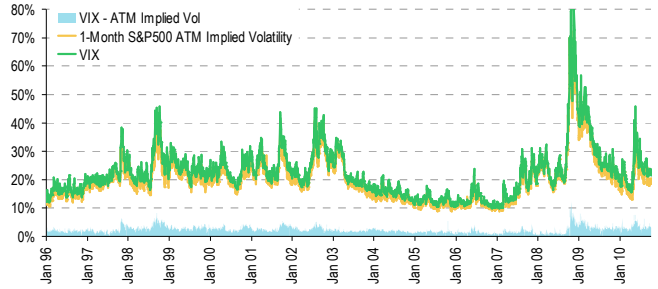
In 1993, the CBOE introduced the VIX as a benchmark of implied equity risk. It later modified the methodology in 2003 to make it easier to link derivatives to it. The VIX is an indication of the implied volatility of the S&P500 over the subsequent 30 calendar days using the live, intraday prices of CBOE-listed S&P500 (SPX) options.

The implied volatility of an option is not a directly observable level, unlike the price of a stock. Computing how much risk an option is implying is a non-trivial calculation that depends on other factors such as interest rates and expected dividends over the life of the option. In addition, implied volatilities differ across strikes and maturities. This makes it difficult to quote one single number as 'the' level of expected future risk.

This is a significant advantage of the VIX since it is quoted as a variance swap strike, which is closely linked to implied volatility. The terms "variance swap strike" and "implied volatility" are sometimes considered verbal substitutes for each other depending on the context (Exhibit 1). In this paper, we often switch from one terminology to the other.[1]

Exhibit 1: The historical difference between 1-month S&P500 at-the-money implied volatility and the VIX, a 1-month S&P500 variance swap

Data from 2 Jan 96 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

A variance swap is computed using a weighted sum of out-of-the-money calls and puts, distilling the implied volatilities across different strikes into a single number representing an "average" level.[2] Variance swap levels are computed across listed maturities intraday and are continuously interpolated to create a constant rolling measure of 30-day risk. This methodology is largely independent of rate and dividend assumptions and is easy to quote intraday since it is based on a basket of listed options.

The success of the VIX has led the CBOE to compute other equity volatility benchmarks such as VXV (a 3-month VIX), VXN (NASDAQ 100 VIX), VXD (DJIA VIX), and RVX (Russell 2000 VIX) along with other VIX-like measures on

[1] A variance swap strike can be thought of as the at-the-money implied volatility plus a skew premium. In fact, if a variance swap is priced using options with the same implied volatility, the variance swap's strike and the implied volatility would be equal.

[2] The portfolio is weighted so that when delta-hedged has a constant dollar gamma regardless of the underlying's path. For more details on the VIX calculation, please refer to the VIX white paper which can be found at http://www.cboe.com/micro/vix/vixwhite.pdf.

gold (GVXX), oil (OVX), and the Euro (EVZ). The CBOE has also begun launching VIX-like indices on select US stocks. As of 23 Mar 11, the universe of single stock VIX indices was on five names: AAPL, AMZN, GOOG, GS, and IBM.

Other global options exchanges have also launched similar benchmark indices on the S&P/TSX 60, Euro STOXX 50, DAX, SMI, FTSE 100, AEX, CAC 40, BEL 20, Mexican Bolsa, Nikkei 225, Nifty 50, TOP 40, KOSPI 200, Nifty, ASX 200, and HSI.

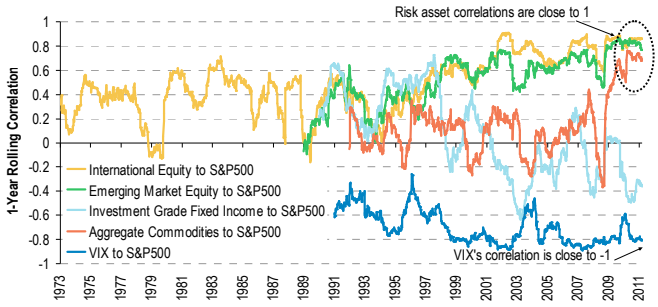
Important Properties of the VIX

NEGATIVE CORRELATION TO EQUITY RETURNS

The feature that makes VIX attractive to investors is its historically negative correlation to equity returns. As equity markets decline, equities tend to become more volatile. Hence, the VIX tends to rise, as the market anticipates increased future volatility.

Exhibit 2: 1-Year rolling correlation between daily changes in the S&P500 and other asset classes

Based on weekly returns from 3 Jan 77 through 23 Mar 11



We use the following indices: MSCI EAFE (International Equity), MSCI EM (Emerging Market Equity), Barclays Aggregate (Investment Grade Fixed Income), and DJ UBS Commodity Index (Aggregate Commodities). Source: Morgan Stanley Quantitative and Derivative Strategies

Exhibit 2 shows the rolling 1-year correlation between the VIX and the S&P500, as well as the correlation of other global risk assets with the S&P500. Throughout its history, the VIX has exhibited a strong and persistent negative correlation with S&P500 returns. For example, over the past year, the VIX/S&P500 correlation was -0.80, one of the strongest sustained levels of negative correlation in the history of the index. Historically, there has never been a period where the correlation has been weaker than -0.40.[3]

[3] Correlation levels were less negative prior to 2001. S&P500 options were much less liquid at the time. If S&P500 options back then had been more liquid, it is likely correlation would have been similar to recent levels.

Other assets classes, on the other hand, have had a mixed correlation history with the S&P500. International and EM equities typically show a positive correlation with the S&P500. Over the past year, correlation was approximately 0.80, one of the highest sustained levels of correlation in its entire history.

While commodities historically have had relatively little correlation to US equities, making them popular diversifying assets, their recent correlation to the S&P500 is similar to that of International and Emerging Market Equities. Fixed income's correlation has varied over time, ranging from positive in the 1990's to a negative relationship currently.

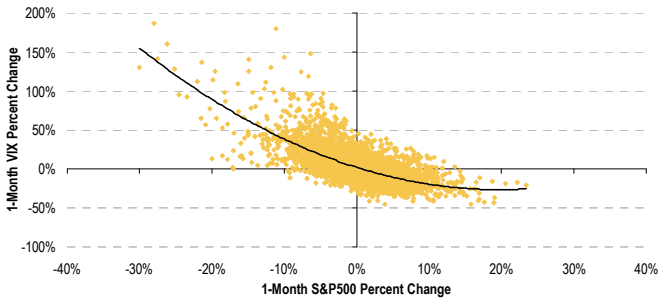
The persistent negative correlation between the VIX and the S&P500 makes the VIX a potential diversifying tool for asset allocators.

LARGE SPIKES FOR SIGNIFICANT EQUITY LOSSES

The VIX also changes asymmetrically to moves in the S&P 500. Volatility expectations tend to spike after large sell-offs but gradually creep down in a rally (Exhibit 3). This is consistent with investor behavior – they are more anxious to purchase protection when equities are falling than they are to sell volatility when the market is rising.

Exhibit 3: The historical relationship between 1-month S&P500 returns and 1-month VIX returns

Data from 2 Jan 90 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

This makes the VIX potentially attractive as a tail risk hedge, due to its negative correlation and its convexity to large negative equity returns. For example, after September 2008, the VIX more than tripled from 25 to its peak at 80 as the S&P500 dropped 40% over the same period.

UNLIKE EQUITIES, VIX IS MEAN REVERTING

Since volatility is a measure of risk, it is bound by zero, which would indicate no variation in the market. While there is no theoretical upper bound, in practice volatility resembles interest rates, which tend to float between zero and an arbitrarily high number. We typically observe volatility drifting between 'low' and 'high' regimes, with the market often spending extended periods in a regime before switching to the other.

Volatility thus has mean-reverting properties. While volatility may be relatively low or high at some point, it eventually will shift away from that extreme towards a longer-term average.

Getting Exposure to the VIX

THE VIX IS NOT A DIRECTLY INVESTABLE INDEX

Unlike equity indices, which can be replicated through a basket of stocks, the VIX is not a directly tradable index. The VIX is a theoretical index that is re-interpolated continuously making a replicating portfolio impossible to construct.

VIX FUTURES AND OPTIONS EXIST AS A SURROGATE

The reconstitution of the VIX in 2003 allowed for futures and options contracts to be developed as a surrogate for exposure to the unreplicatable VIX.

VIX futures were first listed in March 2004, with options following in February 2006. Both contracts have monthly expirations – futures are listed up to eight months out while options are listed up to six months out. Contracts cash-settle to a special opening quote of the VIX on a unique expiration cycle. Consistent with VIX's 30-day tenor, VIX derivatives expire on the day that is exactly 30 days prior to the next months' SPX option expiration.[4] Typically, this is on a Wednesday in the third or fourth week of the month.

LIQUIDITY IN VIX CONTRACTS HAS GROWN TO RIVAL SPX VARIANCE SWAP LIQUIDITY

Trading volume in VIX contracts has grown substantially since inception. VIX futures and options each trade over 37mn expiration vega per day (Exhibit 4).[5] Trading volume increased significantly during 2009, after the VIX reached its all-time highs in 4Q08. This liquidity growth is likely due to (1) increased demand for tail risk hedging, (2) increased trading of VIX as a diversifying asset, and (3) greater tactical usage of the product.

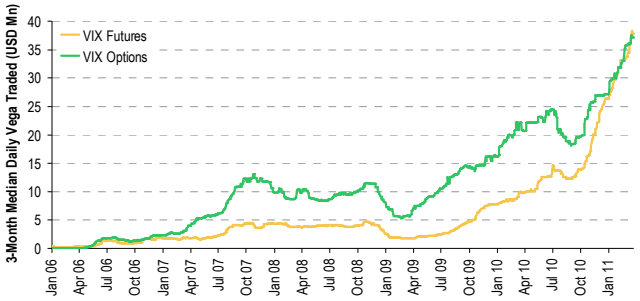
To put VIX derivative liquidity in perspective, the aggregate trading volume across all listed SPX options during 4Q10 was around USD 75mm notional vega per day. OTC SPX variance swaps trade no more than USD 10mn vega notional per day, according to our traders' estimates.

VIX futures and options are often traded in spread positions, which lowers the true net vega traded. Nevertheless, liquidity in these contracts has increased substantially – we estimate that VIX derivatives liquidity is now comparable to that of OTC SPX variance swaps.

It is also important to note that VIX options are the only liquid vehicle for optionality on volatility. OTC options on realized variance are available but have scarce liquidity.

Exhibit 4: The 3-month median S&P500 vega traded in VIX derivatives

Data from 3 Jan 06 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

LIQUIDITY IS HEAVILY FRONT-LOADED WITH FEW LONG-MATURITY TRADES

While the liquidity of VIX contracts is high relative to SPX variance swaps, the time horizon of this liquidity is different. The majority of VIX contract liquidity is concentrated within the first few expirations (Exhibit 5), while SPX variance trades across the term structure. This makes VIX contracts potentially the most liquid way to trade short-dated implied volatility.

The front-loaded nature of VIX liquidity is very persistent over time, as shown in Exhibit 5. Turnover in the front-month contract accounts for 42% of the total VIX futures trading volume currently, with 30% in the second-month contract. Despite these contracts being listed out to eight months, only

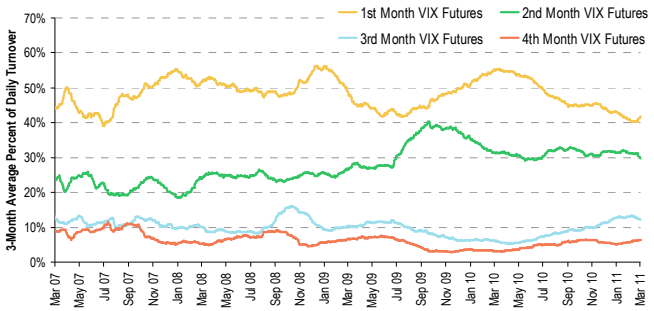
[4] This expiration cycle was picked so that if a person were to hold the portfolio of options comprising the VIX they would have a perfect hedge at expiration for a 30-day variance swap. This occurs 30 days prior to the next SPX option expiration. The usual expiration day for SPX options is a Friday, which makes the day 30 days prior typically a Wednesday.

[5] The vega of a VIX future is simply the contract multiplier (1000). For consistency, we define the vega turnover of VIX options to also be its contract multiplier (100). This methodology is consistent with convention on how to measure a notional options turnover.

16% of the liquidity is in contracts beyond the first three months. VIX options share the same pattern, with 47% and 29% of daily turnover occurring in the first two maturities.

Exhibit 5: The rolling 3-month average of the percent of daily turnover each VIX future contract comprises

Data from 23 Mar 07 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

The sensitivity of VIX futures to movements in the SPX is the likely cause for this front-loaded liquidity. Movements in the underlying cash index affect equity index futures similarly across the maturities. VIX futures, on the other hand, tend to become less sensitive to moves in the VIX the longer-dated they are. We discuss this phenomenon in more detail on page 9.

Since VIX options are priced off VIX futures, a spike in the VIX does not necessarily lead to a large P&L swing for long-dated VIX derivatives. This makes longer-dated contracts less appealing to hold relative to short-dated contracts, particularly when used as a tactical way to execute a volatility view.

ETPS BASED ON VIX FUTURES ALSO EXIST AS A METHOD FOR VIX EXPOSURE

Starting in January 2009, Exchange Traded Products ("ETPs") have been launched as easy-to-access turnkey solutions to give exposure to strategies based on VIX futures. While these strategies are not meant to track the VIX, they can deliver a high correlation to the VIX and exhibit many properties that are similar to those of VIX futures. However, depending on the volatility regime, some of these products exhibit significant negative carry.

In total, assets in these products are now well over $2bn, spread across 13 different products as of 23 Mar 11. We highlight the current universe of these products and the factors affecting their performances on page 27.

The Major Players and Positioning in VIX

VIX DERIVATIVES ARE BEING INCREASINGLY USED BY INSTITUTIONS AS A LISTED, LIQUID VOL VEHICLE

Prior to 4Q08, VIX futures and options trading interest was mainly concentrated in the hedge fund community, who used these contracts as short-term positioning tools. Since then, institutional and even retail market participants have increasingly used these contracts, as "tail risk hedging" became part of investing nomenclature.

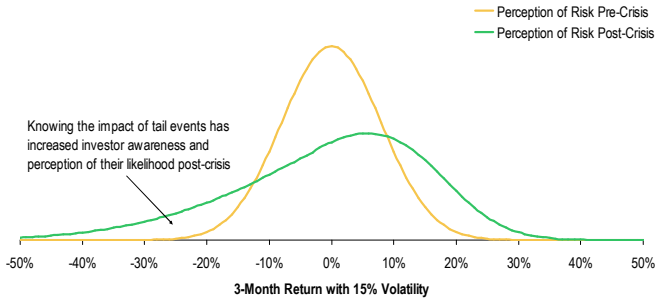
The potential benefit of integrating volatility was shown during the credit crisis, when the VIX rose from 23 the week before Lehman to a peak of 80. The listed nature and intraday liquidity of VIX contracts has made them attractive to investors as a volatility hedge against these types of events. The rise of VIX futures-linked ETPs can be seen as further evidence of the broadening of the participant base.

LIQUIDITY IS LIKELY TO CONTINUE TO GROW AS INVESTORS LOOK TO OWN VOLATILITY

Exhibit 6 shows the shift in investor risk perception pre- and post the credit crisis. After 2008, negative skew ('tail risk') received a greater weighting in investors' risk assessment. The increased skew of longer dated SPX options as well as of VIX call options reflects investors' response to the new, unexpected data points observed during 2008.[6]

This shift in risk assessment can potentially explain the greater use of volatility products such as the VIX. As investors further move to integrate volatility exposure as a tail-risk hedge and for diversification, we might well see further increases in the liquidity of VIX-related products.

Exhibit 6: The perception of tail risk is likely higher than it was before 2008 after going through the credit crisis



Source: Morgan Stanley Quantitative and Derivative Strategies

[6] This phenomenon is studied in a field of statistics known as 'extreme value theory.' A probability distribution may have a significant weighting towards a tail but a limited statistical sample of that distribution is likely to not have a realization from that tail. Therefore it is difficult to infer from the data alone how likely those tail events really are.

III. VIX Derivatives 101

Derivatives on the VIX have many unique properties, because the VIX itself is not tradable. These contracts resemble interest rate derivatives, which have a similarly intangible underlying, more so than they resemble equity derivatives. In this section, we provide an overview of the mechanics of VIX futures and options:

- *VIX derivatives account for volatility mean-reversion through the VIX futures term structure*
- *The shape of the volatility term structure and its impact on the cost of holding VIX contracts*
- *The time sensitivity of VIX futures versus roll cost trade-off*
- *The slowness of VIX option decay versus that of regular options*
- *The shape of the VIX vol surface and how VIX options decay*
- *How VIX futures compare to forward variance swaps*

The Unique Properties of VIX Contracts

CASH + VIX FUTURES DO NOT MAKE VIX

The arbitrage-based pricing of forward / futures contracts means that an investment in an equity index can be replicated through a combination of cash and futures on that index. This replication arises because the underlying index can be traded using a managed basket of equities.

VIX futures do not have this arbitrage-based pricing, as the VIX is not a tradable index. Instead, VIX futures prices reflect expectations on the VIX level at expiration of the futures contract. Should VIX spike but expectations are that the VIX will revert in a month's time, a 1-month VIX futures price should remain unchanged.

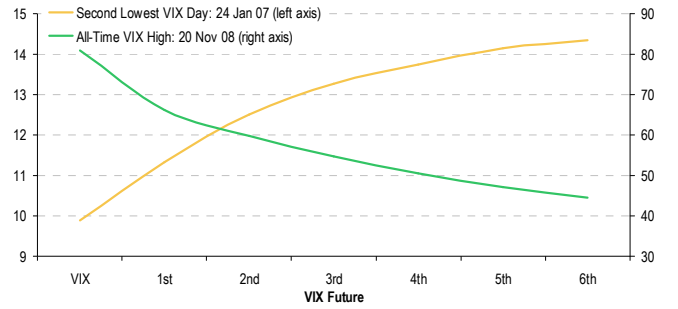
This property makes VIX futures an imperfect surrogate to trade the VIX. It is also responsible for many of the other unique features of VIX contracts.

VIX FUTURES ACCOUNT FOR MEAN REVERSION

Just like volatility, the VIX is a mean-reverting index. VIX futures account for this property and price in expectations of mean reversion.

Exhibit 7 plots the VIX futures term structure on two extreme dates – the day of the VIX's all-time high in 2008, and a day in January 2007 when the VIX reached its second-lowest level in history. At these relative extremes, the VIX futures term structure priced in an expectation of mean reversion. At the relative low in 2007, the 6-month VIX future was over four vol points higher than the spot VIX, while at the relative high in 2008, the 6-month VIX future was over 45 vol points lower than the spot VIX.

Exhibit 7: The VIX future term structure at relative VIX highs and lows



Source: Morgan Stanley Quantitative and Derivative Strategies

This changing shape of the term structure is necessary for a mean-reverting underlying. Otherwise, one could devise a statistical arbitrage trading strategy that buys the index at its relative lows and shorts it when it is at its relative highs.

Most of the time, the term structure of the VIX futures is upwards sloping. This is because VIX futures are priced off the S&P500 implied volatility term structure, which is usually upwards-sloping.

The slope reflects a volatility premium – since the VIX and implied volatility tend to spike in times of market stress, VIX futures should trade at a premium to spot VIX, accounting for the probability of such a spike.

VIX FUTURES HAVE A TIME DEPENDENT BETA TO VIX

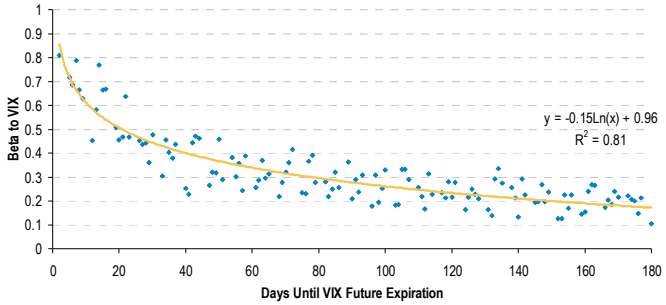
The mean reversion priced into the VIX futures term structure means that different futures maturities show varying responsiveness to spot VIX. Shorter-dated VIX contracts are more sensitive to spot VIX, because there is less time for volatility to mean-revert. The longer the maturity of the contract, the higher is the probability of mean reversion. Shocks to spot VIX should thus have less of an impact.

Exhibit 8 plots the sensitivity of VIX futures to changes in the VIX. We group all historically traded VIX futures by their time to maturity and compute their betas to daily vol point changes in VIX. Six-month VIX futures generally move less

than 20% of the amount VIX does on any given day. This sensitivity remains low for most of the life of a VIX future until just prior to expiration. VIX futures under 20 days to maturity typically have a beta between 0.6 and 0.8 to spot VIX.

Exhibit 8: The beta of VIX futures to changes in spot VIX as a function of time to maturity

Based on daily VIX futures data from 26 Mar 04 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

This causes front-month futures to be the most volatile while the back-month futures have only a fraction of the volatility of the VIX.

THE SHORT-END IS THE COSTLIEST POINT TO BUY

The shape of the VIX futures term structure gives insight into the holding costs of going long VIX futures. For example, if VIX futures are priced two vol points above spot VIX, then one would expect to pay two vol points at maturity if VIX is unchanged.

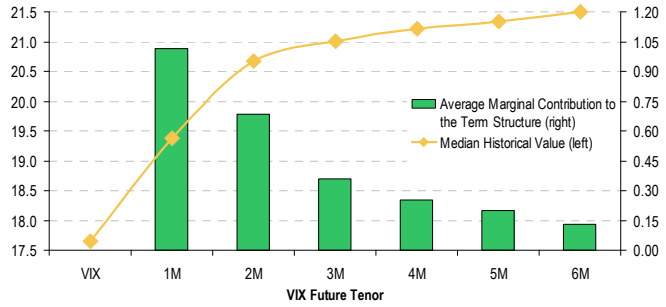
Since VIX futures typically trade at a premium to spot VIX, particularly in a low-volatility regime, long VIX futures holders will lose this premium most of the time. They are compensated for this by substantial gains when volatility spikes. The tradeoff between holding costs and spikes has historically been asymmetric, creating potential alpha opportunities. We discuss strategies around this tradeoff starting on page 21.

Exhibit 9 plots the median historical term structure of VIX futures, as well as the marginal contribution of each futures maturity to the overall term structure. This allows us to assess the incremental cost of holding VIX futures of longer maturity, relative to the spot VIX.

The median level of 1-month VIX futures is 1.0 vol points higher than spot VIX while 2-month futures are 0.68 vol points above the 1-month VIX futures. This marginal contribution flattens out quickly with 6-month futures adding only 0.1 vol points to the term structure.

Exhibit 9: The median VIX futures term structure and the steepness between each point on average

Based on daily VIX futures data from 26 Mar 04 through 23 Mar 11



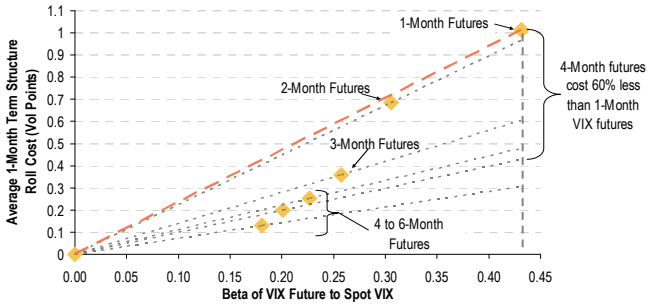
Source: Morgan Stanley Quantitative and Derivative Strategies

This implies that the rolldown cost for VIX futures is greatest in the front-end while flattening out quickly beyond the 3-month point. This produces a trade-off between trading the desired volatility of VIX in the front-end with higher costs associated with that position.

We highlight this tradeoff in more detail in Exhibit 10 where we plot these marginal contributions to the term structure versus the beta of that VIX future to spot VIX (data from Exhibit 8 and Exhibit 9). This gives a measure of the cost of holding a VIX future per unit of exposure it gives to VIX.

Exhibit 10: The marginal contribution to the VIX futures term structure versus the beta of that future to spot VIX

Based on daily VIX futures data from 26 Mar 04 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

1-month futures have the greatest cost per exposure ratio by far, while 4 to 6-month future contracts scale much better. For example, an exposure to a 4-month future that is scaled to give the same exposure to the spot VIX as a 1-month future would have only 40% of the holding cost of the 1-month future on average.

However, the lower cost per unit of spot VIX exposure of longer-dated futures has to be counterbalanced with the considerably lower liquidity in these contracts. These liquidity considerations have to be taken into account when developing

strategies that leverage this systematic bias for hedging or alpha.

THE ATM VIX VOL STRIKE IS BASED ON THE FUTURES

VIX futures represent forward-looking expectations of future VIX levels at each maturity date. As a consequence, the at-the-money strike of VIX options is determined with reference to the VIX future level for a given maturity, rather than to the cash VIX level. This is in contrast to the cash equities options market.

Because the VIX futures term structure is generally upwards sloping, costs of out-of-the-money VIX calls are optically high relative to spot VIX, while VIX puts appear cheap. However, this reflects the at-the-money level for each maturity, which forms a more appropriate base line.

THE VIX OPTION IMPLIED VOL TERM STRUCTURE IS PERSISTENTLY INVERTED

The realized volatility of VIX futures declines the longer-dated they are. Since implied volatility represents the expected future realized volatility, we find that VIX options implied volatility has a permanently inverted term structure. The implied volatility of a short-dated VIX option anticipates volatility over the near term, which may itself be more volatile. Given mean-reverting properties of the VIX, a longer tenor averages in less volatile periods for that VIX future, and hence a lower implied volatility.

Exhibit 11 plots the rolling time series of ATM 1-month and 5-month VIX implied volatilities, as well as their spread and the VIX itself. Long-dated implied volatilities are relatively stable and significantly lower than 1-month implied volatility. Shorter-dated VIX implied volatility also reacts more to spikes in the VIX. Similar to the S&P500 option term structure, the spread between long- and short-dated volatility shifts significantly when volatility spikes since the VIX and its implied volatility both tend to rise during times of distress.[7]

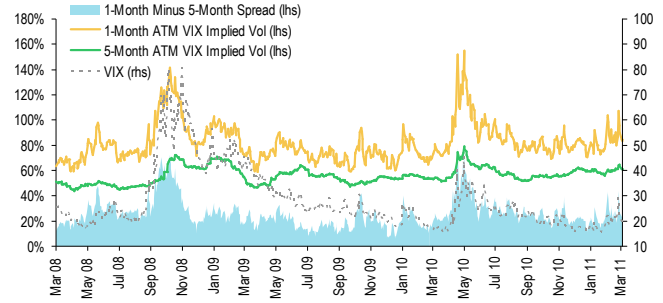
VIX OPTION SKEW IS ALWAYS TILTED TO CALLS

Unlike S&P500 options, the skew in the VIX implied vol surface is tilted towards calls instead of puts (Exhibit 12). This makes sense since VIX implied volatility generally rises when the VIX does (Exhibit 11).

[7] VIX implied vol actually has a strong relationship to S&P500 skew. The skew of SPX options is a measure the implied volatility of volatility. Assume that the SPX fixed-strike implied vol surface is unchanged while the SPX falls. The new ATM implied vol would have to roll up the SPX put skew to a higher level. The steeper the skew, the more ATM implied vol changes per 1% change in the S&P500.

Exhibit 11: The implied vol and vol term structure of VIX options

Based on daily data from 23 Mar 08 through 23 Mar 11

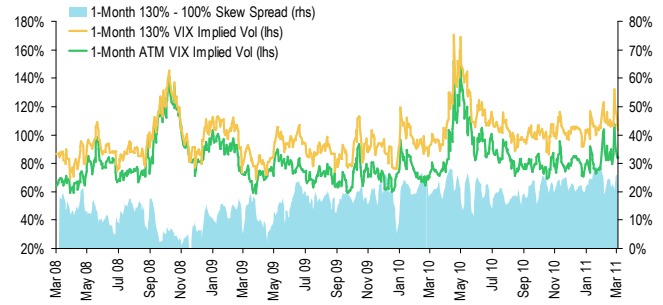


Source: Morgan Stanley Quantitative and Derivative Strategies

Along with a generally upward sloping VIX futures term structure, a steep VIX call skew further helps to elevate the costs of VIX calls. Strategies that leverage this, such as OTM call spreads, are often relatively attractive, particularly in a high-skew regime. Ever since 2009, VIX option skew has been steepening and is currently near an all-time high. We highlight how to leverage this phenomenon on page 18.

Exhibit 12: The implied vol and 130%-100% 1-month VIX option skew

Based on daily data from 23 Mar 08 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

VIX OPTIONS DECAY SLOWLY UNTIL EXPIRATION

Option prices are largely functions of two inputs: (1) the moneyness of the option and (2) its non-annualized implied volatility ($\sigma\sqrt{t}$). In general, the higher the latter component is, the higher the option price.[8]

Since the VIX option implied volatility term structure is generally inverted, VIX options tend to decay slowly until

[8] If we replace the factor $\sigma\sqrt{t}$ with a single total implied volatility, $\tilde{\sigma}$ and zero interest rates, the Black 1976 model for a VIX call option price reduces to:

$$Call = F\Phi\left[\frac{\ln(F/K)+0.5\tilde{\sigma}^2}{\tilde{\sigma}}\right] - K\Phi\left[\frac{\ln(F/K)-0.5\tilde{\sigma}^2}{\tilde{\sigma}}\right]$$

where F denotes the futures price, K the strike, and Φ denotes the cumulative density of the standard normal distribution. This has no independent implied volatility and time to maturity factors.

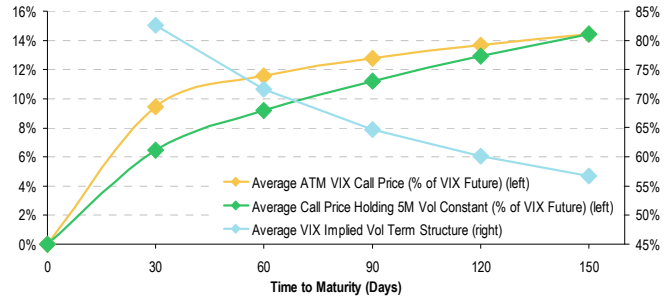
close to expiration. While the time to maturity *t* shrinks, the implied volatility σ rolls up the term structure. These offsetting factors tend to slow the decay in option prices until a few weeks before expiration.

We show this in Exhibit 13 where we plot the average shape of the VIX implied volatility term structure using 1- to 5-month ATM implied vols. We use these levels to price ATM VIX calls over time as they roll down the term structure. We assume zero interest rates. We also plot option prices assuming a flat implied volatility term structure (at the level of 5-month implied volatility).

Because of the roll-up effect, option prices decay more slowly than in the case of a flat term structure. For example, the price of ATM calls drops on average from 14% for 5-month tenors to 10% for 1-month maturities. Under a flat term structure, prices would decay to around 6% for 1-month maturity. Since calls that are not in the money have to converge to zero at maturity, this implies a rapid decay just before expiration.

Exhibit 13: The average costs of ATM VIX call options versus the average shape of the VIX implied vol term structure

Based on daily data from 24 Feb 06 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

VIX Contracts versus Variance Contracts

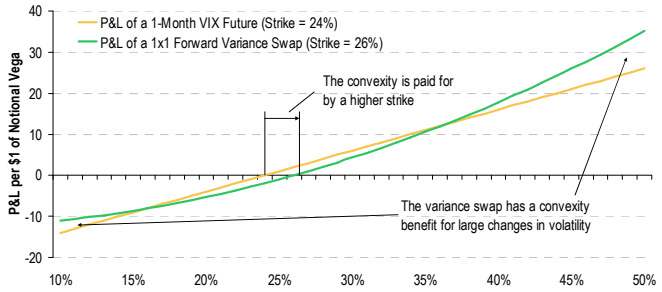
COMPARING THE PAYOFF OF VIX VERSUS VARIANCE

Futures based on VIX deliver a linear payoff with respect to changes in VIX. For every vol point change in the strike of a VIX future, the expiration P&L change will be a fixed multiplier times the strike change (see Exhibit 14).

This is in contrast to OTC index variance swaps. For forward-starting variance swaps, the payoff at the end of the forward period is quite similar to that of a VIX future. However, the payoff of these products is based on variance, the square of volatility. This creates a convex payoff with respect to changes in volatility.[9]

We compare these payoffs in Exhibit 14 using a hypothetical 1-month VIX future and a 1-month variance swap that forward starts in one month (1x1 forward variance). The long variance swap gives a convexity benefit for large changes in volatility. This benefit comes at the cost of a higher strike than a VIX future with the same maturity. Since 2004, the strike difference has averaged around 0.7 vol points for 1-month maturities.

Exhibit 14: The payoffs of a hypothetical 1-month VIX future and a hypothetical 1x1 forward starting variance swap in one month's time



Source: Morgan Stanley Quantitative and Derivative Strategies

VIX IS LIQUID FOR ONLY NEAR-TERM MATURITIES

Variance swaps are the preferred vehicle to trade volatility globally, primarily because of the ease of creation and hedging. Maturities can exist out to ten years, depending on the market. Moreover, tenors and forward starting periods can be fully customized in this OTC product.

VIX products, in contrast, are standardized instruments. Their liquidity is largely concentrated in the first three months, while variance swaps are traded across the term structure. For short-dated volatility views, VIX contracts are by far the most liquid vehicles, while variance is more liquid for longer-dated views.

VIX IS THE ONLY LIQUID VEHICLE FOR VOL OPTIONS

VIX options are the most liquid way to obtain optionality on volatility, opening up more avenues to express volatility views with precision. While options on variance swaps exist in the OTC market, they tend to be relatively illiquid with wide bid/offer spreads.

[9] It can be shown that a variance swap can be replicated using a static portfolio of delta-hedged OTM options, unlike VIX futures which have no semi-static hedge. This has made variance swaps relatively ease to create - they remain the preferred vehicle to trade volatility in most markets.

IV. VIX for Equity Hedgers

One of the key benefits of integrating volatility exposure in an equity portfolio is the inherent diversification benefit of the negative correlation between equity returns and volatility. Exploiting this 'tail risk hedge' benefit requires the specification of an appropriate strategy – how and when volatility should be scaled into a portfolio. In this section, we frame the set of potential strategies, and introduce a number of backtests of the benefits of VIX-based hedging. In this section, we cover:

- *Scaling a VIX hedge into an S&P500 portfolio*
- *Costs of VIX contracts versus S&P500 contracts*
- *Systematic performance of VIX hedges versus S&P500 hedges*
- *Long-term performance of VIX spread-based hedges*
- *Potential systematic cheapness of VIX hedges*
- *Exploiting the unit mismatch between the S&P500 and VIX for downside hedges*

Integrating VIX into Long-Only Portfolios

HEDGING AN EQUITY PORTFOLIO USING VOLATILITY

Because of the inherent negative correlation between equity returns and volatility, there are potential diversification benefits from integrating volatility into an equity portfolio.

Scaling a VIX trade is somewhat more complex than using regular index options, since the performance of the equity portfolio and that of the hedge are not directly linked. Based on our earlier analysis, the sensitivity of a volatility-based hedge to negative returns in equities will allow us to determine optimal scaling ratios. We assume an S&P500 portfolio for the subsequent analysis in this section.

FOCUS ON SHORT-DATED VIX-BASED HEDGES

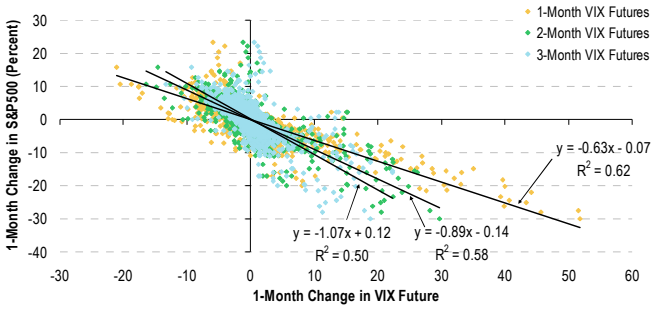
We focus on hedges using short-dated VIX contracts only. This is driven by three factors: (1) the liquidity profile of VIX contracts, (2) the sensitivity of VIX futures to changes in the spot VIX, and (3) the favorable decay characteristics. Hedges using equity index options, in contrast, often use three to six month maturities as these tend to give the most favorable cost/benefit tradeoff.

SCALING A VIX POSITION USING REGRESSION

To compute the notional size required to scale a VIX hedge into an equity portfolio, we use a historical regression model. For the entire history of VIX futures trading, which began in March 2004, we compute a dataset of daily rolling 1-month, 2-month, and 3-month VIX futures prices. We then compute how many vol points each contract changed after one month – the spread of 1-month futures versus spot VIX one month later, that of 2-month futures versus 1-month futures one month later, and so on.

Exhibit 15: The responsiveness of the S&P500 as a function of changes in the first three VIX futures

Based on daily data from 26 Mar 04 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

We then regress the 1-month S&P 500 returns on these changes in VIX futures, which give us the change in the S&P 500 for a given change in the VIX futures. While this is the inverse of the typical volatility regression, it allows us a more direct way to compute the required hedge ratios.[10] Based on our sample, shown in Exhibit 15, we derive the following hedge ratios:

- 0.63 1-Month VIX Contracts per $100 of S&P500
- 0.89 2-Month VIX Contracts per $100 of S&P500
- 1.07 3-Month VIX Contracts per $100 of S&P500

As expected, the hedge ratio increases for longer-dated contracts. Since longer-dated VIX futures are not as volatile as short-dated futures, we need more of them to overcome their lower sensitivity to VIX changes.

[10] When the regression is performed in the conventional way where the change in volatility is a function of the market return, the beta has to be inverted to compute the hedge ratio. Under imperfect correlation, a low beta could be computed and then inverted, creating a high hedge ratio and overhedging of the portfolio. The opposite regression form mitigates this.

VIX Futures as a Portfolio Hedge

SYSTEMATIC BACKTESTS OF COMMON STRATEGIES

We backtest a number of systematic hedging strategies using VIX contracts with rolling 1-, 2- and 3-month maturities. Our backtests begin in May 2007, when the three months maturities were first listed regularly. We base our analysis on listed prices, and add a $0.10 bid/ask spread to account for the relative lack of liquidity in VIX contracts early in their history.

Endless configurations of VIX hedges are possible. To illustrate the potential merits of VIX-based hedges, we consider sample backtests of various VIX futures, ATM VIX call, and OTM VIX call hedging strategies.

OVERVIEW OF VIX FUTURES HEDGING STRATEGIES

Long VIX futures strategies are the most direct way of hedging equity risk with VIX contracts. VIX futures will capture the spike in volatility that typically coincides with an equity selloff. Conversely, since these are futures contracts, performance would be negative if volatility were to fall sharply. We can summarize these effects as follows:

Pros:

- An intuitive and direct way to go long volatility as a hedge
- Zero up-front cost strategy, unlike long option strategies (excluding margin requirements)

Cons:

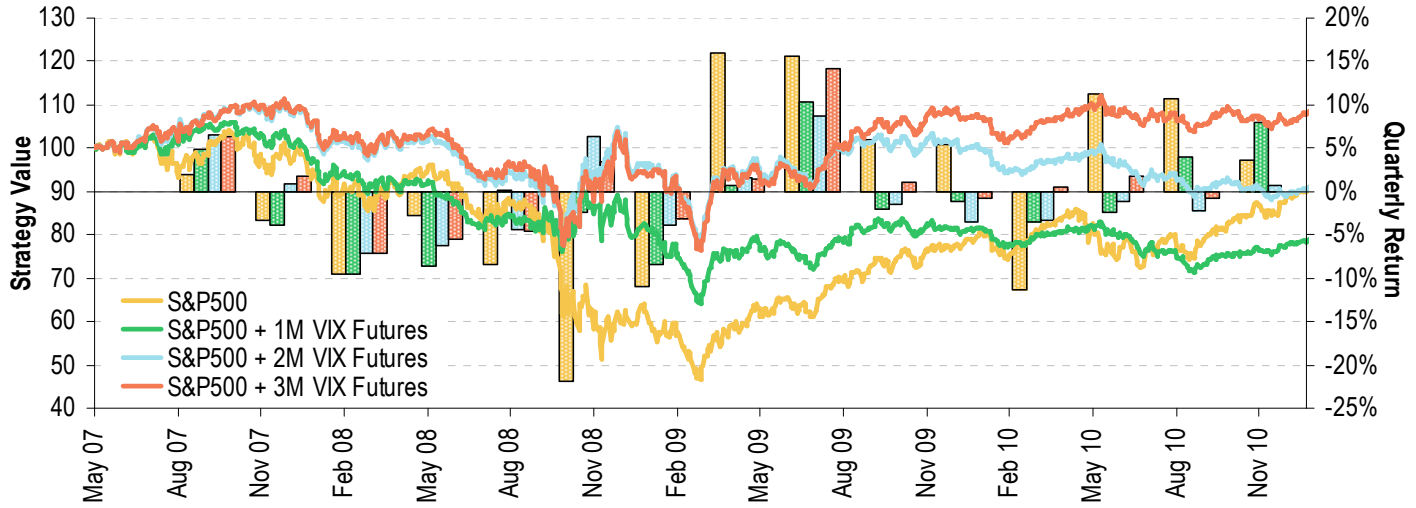
- Full upside and downside exposure to volatility changes
- Long VIX futures is generally a negative carry strategy due to the upward-sloping shape of the term structure

BACKTESTED STRATEGY PERFORMANCE

We backtest a strategy that combines a long S&P500 position with long VIX futures overlays, using 1 to 3 month maturities. We use the hedge ratios derived in the previous section. The futures are rolled monthly at expiration. Exhibit 16 shows the historical performance of these overlays.

Exhibit 16: The historical performance of systematic VIX futures overlay strategies

Based on daily data from 16 May 07 through 23 Mar 11



	S&P500	S&P500 + 1M VIX Futures	S&P500 + 2M VIX Futures	S&P500 + 3M VIX Futures
3Q07	2.0%	4.8%	6.5%	6.3%
4Q07	-3.3%	-3.8%	0.9%	1.8%
1Q08	-9.4%	-9.5%	-7.2%	-7.2%
2Q08	-2.7%	-8.6%	-6.2%	-5.5%
3Q08	-8.4%	0.1%	-4.5%	-4.7%
4Q08	-21.9%	-2.5%	6.4%	3.5%
1Q09	-11.0%	-8.4%	-3.9%	-3.1%
2Q09	15.9%	0.6%	1.5%	1.4%

	S&P500	S&P500 + 1M VIX Futures	S&P500 + 2M VIX Futures	S&P500 + 3M VIX Futures
3Q09	15.6%	10.4%	8.7%	14.2%
4Q09	6.0%	-2.0%	-1.5%	1.1%
1Q10	5.4%	-1.1%	-3.4%	-0.7%
2Q10	-11.4%	-3.4%	-3.2%	0.5%
3Q10	11.3%	-2.3%	-1.2%	1.8%
4Q10	10.8%	3.9%	-2.2%	-0.8%
1Q11	3.6%	7.9%	0.6%	0.0%

Source: Morgan Stanley Quantitative and Derivative Strategies

All three variations of the strategies worked as effective downside hedges. During 4Q08, when the S&P500 dropped 22%, the performance of the S&P500 portfolios with futures overlays ranged from a 3% loss to a 6% gain. In addition, as expected, the strongest S&P500 quarter (2Q09, +16%) caused the futures overlay strategies to underperform, with the portfolios with overlays delivering a gain between 1% to 2%.

The most obvious difference between the three overlays is in their long-term performance. The strategy utilizing 3-month futures significantly outperforms the strategy using 1-month futures. This is consistent with our earlier finding that per unit of spot VIX exposure, shorter-dated VIX futures were more expensive. Through holding higher notional exposure of 3-month futures, this difference leads to more efficient hedge.

A steep VIX futures term structure, such as in the period after 4Q09, is particularly beneficial for strategies using longer-dated futures maturities. During this time, the 3-month VIX futures strategy minimized the carry cost of the position, compared to strategies using shorter-dated futures.

Overall, the 3-month futures strategy outperformed the 1-month strategy in 12 of 14 full quarters in our sample, with an average quarterly outperformance of 2.1%. During the four worst S&P500 quarters (4Q08, 2Q10, 1Q09 and 1Q08), the S&P500 lost -13% on average. Adding a VIX futures overlay improved the average returns during these quarters to -6.1% for 1-month, -2.0% for 2-month, and -1.6% for 3-month futures – this again demonstrates the potential benefit of using longer-dated futures.

During bull markets, on the other hand, VIX futures can introduce a drag on portfolio performance. During the four best full S&P500 quarters (2Q09, 3Q09, 3Q10 and 4Q10), the S&P500 returned 13% on average. Meanwhile, 1-, 2-, and 3-month futures overlays reduced the average returns to 3%, 2%, and 4% per quarter, respectively.

RETURN AND RISK PROFILE OF FUTURES HEDGES

Exhibit 17 shows the annualized return and risk characteristics of the different hedging strategies across the entire backtesting period. The 3-month futures overlay strategy was the only one with a positive return over this period. Risk reduction was similar across all overlay strategies, whether measured by the standard deviation or by the 5% CVaR.

Exhibit 17: The return and risk profile of VIX futures hedges

Based on daily data from 16 May 07 through 23 Mar 11

	S&P500	S&P500 + 1M VIX Future	S&P500 + 2M VIX Future	S&P500 + 3M VIX Future
Return (Ann.)	-1.8%	-4.3%	-2.4%	1.9%
Std. Dev. (Ann.)	27.9%	17.5%	17.1%	17.4%
5% CVaR	-4.4%	-2.6%	-2.6%	-2.7%
Sharpe Ratio	-0.12	-0.33	-0.23	0.03

Source: Morgan Stanley Quantitative and Derivative Strategies

VIX Calls as a Portfolio Hedge

OVERVIEW OF VIX CALL HEDGING STRATEGIES

VIX call options are potentially another approach to hedge downside risk in equity positions. Compared to VIX futures, call options give similar upside volatility exposure but reduced downside exposure. Depending on the VIX implied volatility regime (the 'vol of vol'), such a strategy can be attractive:

Pros:

- Reduced downside risk in falling vol environments
- Calls can reduce potential rolldown costs, depending on the VIX implied vol regime

Cons:

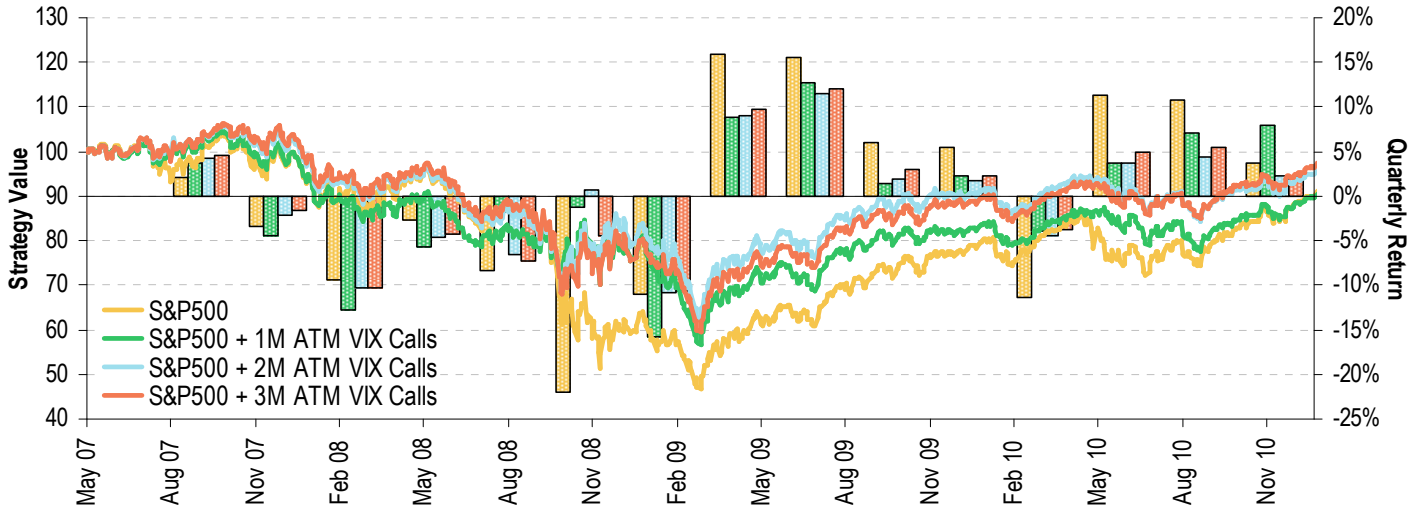
- Up-front premium payment for options exposure, unlike futures which have no up-front premium outside of margin
- The mark-to-market of VIX options may not be equal to changes in the spot VIX prior to expiration

BACKTESTED STRATEGY PERFORMANCE USING ATM VIX OPTIONS

We start by backtesting strategies using ATM VIX call overlays, with 1, 2 and 3 months to expiry. Exhibit 18 shows the historical performance of these overlays. Compared to VIX futures overlays, which hedge against both increases and decreases in volatility, the one-sidedness of VIX options means that they only reduce risk in a single direction. As a result, the payoff profile of an S&P500 position with VIX options overlays is much closer to that of the S&P500 hedged with protective puts.

Exhibit 18: The historical performance of systematic ATM VIX call overlay strategies

Based on daily data from 16 May 07 through 23 Mar 11



	S&P500	S&P500 + 1M ATM VIX Calls	S&P500 + 2M ATM VIX Calls	S&P500 + 3M ATM VIX Calls
3Q07	2.0%	3.7%	4.2%	4.5%
4Q07	-3.3%	-4.4%	-2.2%	-1.6%
1Q08	-9.4%	-12.7%	-10.3%	-10.2%
2Q08	-2.7%	-5.7%	-4.6%	-4.2%
3Q08	-8.4%	-1.7%	-6.6%	-7.2%
4Q08	-21.9%	-1.3%	0.8%	-4.4%
1Q09	-11.0%	-15.7%	-10.9%	-10.7%
2Q09	15.9%	8.8%	9.0%	9.7%
3Q09	15.6%	12.7%	11.5%	12.0%
4Q09	6.0%	1.4%	1.9%	3.0%
1Q10	5.4%	2.4%	1.8%	2.4%
2Q10	-11.4%	-3.9%	-4.4%	-3.7%
3Q10	11.3%	3.6%	3.6%	4.9%
4Q10	10.8%	7.0%	4.4%	5.5%
1Q11	3.6%	8.0%	2.3%	2.2%

Source: Morgan Stanley Quantitative and Derivative Strategies

For example, during the four worst full quarters for the S&P500 in our sample, the S&P500 lost on average -13%, while the three strategies with the VIX options overlay lost between -6% and -8%, in part due to the call premiums paid. During the four best quarters for the S&P500, in contrast, while the S&P500 gained 13%, the three overlay strategies gained between 7% and 8%. Compared to the overlays using VIX futures, this represents greater upside participation during S&P500 rallies.

In the most extreme quarter (4Q08), when the S&P500 lost 22%, these hedging strategies were either flat or slightly down (-4% to +1% return). During the best S&P 500 quarter in 2Q09, the S&P 500 gained 16%, while the hedged strategies returned between 9% and 10%.

Strategies using longer-dated VIX calls generally slightly outperform those using shorter-dated calls. On average, the 2-month strategy outperformed the 1-month strategy by 27bps a quarter while the 3-month strategy outperformed by 41bps a quarter. This shows that scaling between the different maturities can give very similar volatility exposure, due to the low decay properties of VIX calls.

However, this slight outperformance comes at the cost of significantly higher premium to purchase these calls due to the (1) longer-dated nature of the options and (2) a higher hedging ratio.

RETURN AND RISK PROFILE OF ATM CALL HEDGES

Exhibit 19 shows the annualized return and risk characteristics of the ATM VIX call overlays. Risk reduction was generally smaller than in the case of VIX futures overlays. On the other hand, the average returns of the 1- or 2-month overlays are generally more attractive than for VIX futures overlays.

Exhibit 19: The return and risk profile of ATM VIX call hedges

Based on daily data from 16 May 07 through 23 Mar 11

	S&P500	S&P500 + 1M ATM VIX Calls	S&P500 + 2M ATM VIX Calls	S&P500 + 3M ATM VIX Calls
Return (Ann.)	-1.8%	-0.9%	-0.8%	-0.4%
Std. Dev. (Ann.)	27.9%	21.3%	20.9%	21.5%
5% CVaR	-4.4%	-3.1%	-3.1%	-3.3%
Sharpe Ratio	-0.12	-0.11	-0.11	-0.08

Source: Morgan Stanley Quantitative and Derivative Strategies

WHAT ABOUT OUT OF THE MONEY CALL OPTIONS?

Like hedges using regular equity puts, VIX call hedges can be configured in any combination of maturities and strikes. To indicate the potential benefits of using OTM VIX calls, we show backtests of various 1-month OTM VIX call strategies, using 10-, 20-, and 30-delta calls.

Since the calls are OTM and thus have a lower mark-to-market to spot VIX changes, we double the notional exposure for these calls. A larger notional exposure in OTM VIX calls can still be cheaper than a single ATM VIX call of equal maturity. While this exposure in OTM VIX calls will be beneficial when volatility rises sharply, it would give much less protection in gradually increasing volatility scenarios.

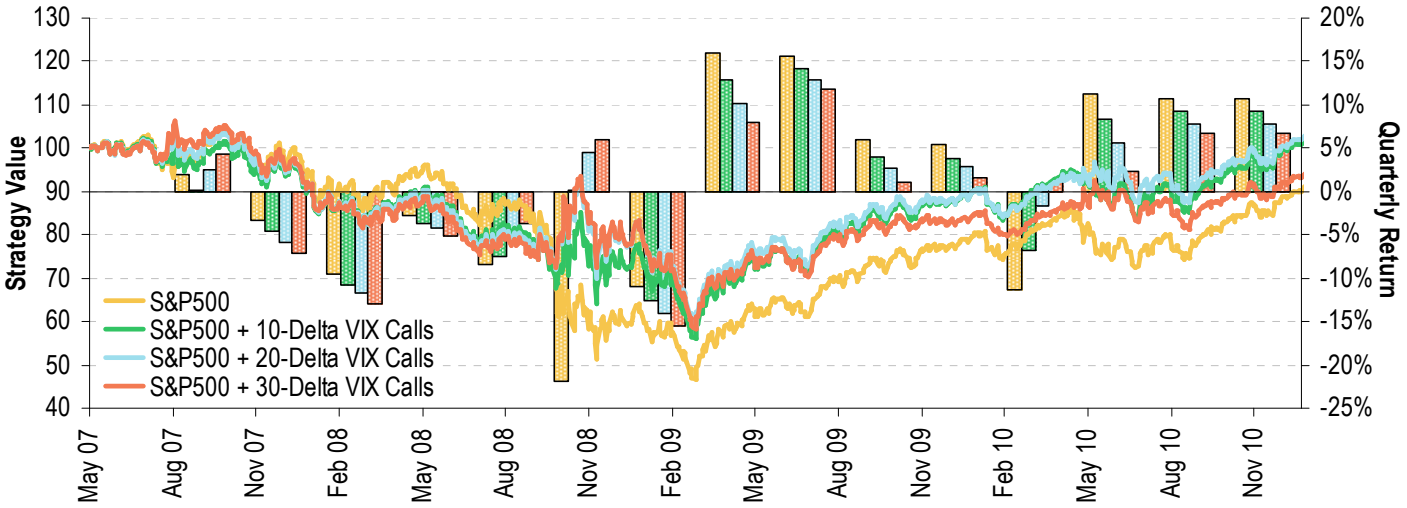
Exhibit 20 shows the results of our historical backtest. In 4Q08, the quarter with the worst S&P500 performance, the hedges performed quite well, with the strategies returning anywhere from 68bps (10-delta calls) to 5.6% (30-delta calls). Meanwhile, the ATM call strategies had returns between +80bp and -4.4%, depending on maturity (see Exhibit 18). Similarly, during the four best S&P500 quarters, OTM VIX call strategies outperformed the ATM VIX call strategies, with returns ranging from 7% (30-delta calls) to 11% (10-delta calls). This compares to an average 13% return for the S&P500, and 7%-8% returns for ATM call strategies. This reflects the lower premiums for OTM VIX call options than for ATM options, even after the scaling of the notional exposure.

On the other hand, OTM call strategies underperform ATM strategies during small declines in the S&P 500. During the two quarters in which S&P500 returns were between 0% and -5%, ATM calls generally performed better than OTM calls, particularly longer-dated ATM calls

.

Exhibit 20: The historical performance of systematic OTM VIX call overlay strategies

Based on daily data from 16 May 07 through 23 Mar 11



	S&P500	S&P500 10-Delta VIX Calls	S&P500 20-Delta VIX Calls	S&P500 30-Delta VIX Calls
3Q07	2.0%	0.2%	2.5%	4.4%
4Q07	-3.3%	-4.6%	-5.9%	-7.1%
1Q08	-9.4%	-10.8%	-11.8%	-13.0%
2Q08	-2.7%	-3.8%	-4.3%	-5.1%
3Q08	-8.4%	-7.6%	-4.5%	-3.7%
4Q08	-21.9%	0.1%	4.6%	6.0%
1Q09	-11.0%	-12.6%	-14.1%	-15.6%
2Q09	15.9%	12.9%	10.1%	8.0%
3Q09	15.6%	14.2%	12.9%	11.9%
4Q09	6.0%	4.0%	2.7%	1.1%
1Q10	5.4%	3.8%	2.8%	1.7%
2Q10	-11.4%	-6.7%	-1.6%	1.1%
3Q10	11.3%	8.3%	5.7%	2.3%
4Q10	10.8%	9.3%	7.9%	6.6%
1Q11	10.8%	9.3%	7.9%	6.6%

Source: Morgan Stanley Quantitative and Derivative Strategies

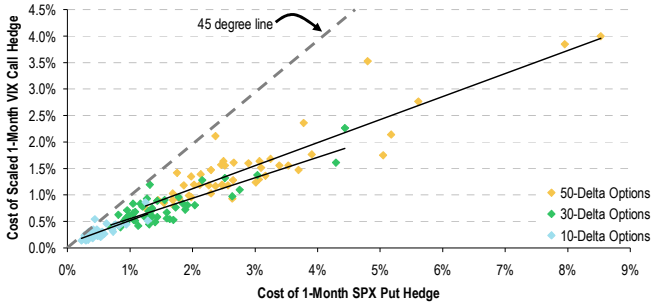
VIX Calls or SPX Puts for Hedging?

HISTORICALLY, VIX CALLS HAVE BEEN CHEAPER

To compare the relative costs of using VIX calls versus SPX puts, Exhibit 21 shows the historical premiums for both. We construct a set of systematic strategies that use either SPX puts or a scaled notional of VIX calls as per our previous scaling ratios. On each roll date, we value the cost of the strategies using 10- through 50-delta options.

Exhibit 21: The cost of 1-month SPX put hedges versus scaled 1-month VIX call hedges

Based on data from 16 May 07 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

Based on these scaling ratios, VIX calls with a given delta have been persistently cheaper than SPX puts with the same delta. Moreover, this cheapness has been relatively consistent and ranges from a 55% cheaper (50-delta options) to 60% cheaper (30-delta options).

However, this cheapness is based on the assumption of a constant scaling or hedging ratio. In practice, the optimal hedge ratio is variable, as indicated by the R-squared of the regressions in Exhibit 15. This may lead to over- or under-hedging. Using SPX puts does not carry that risk.

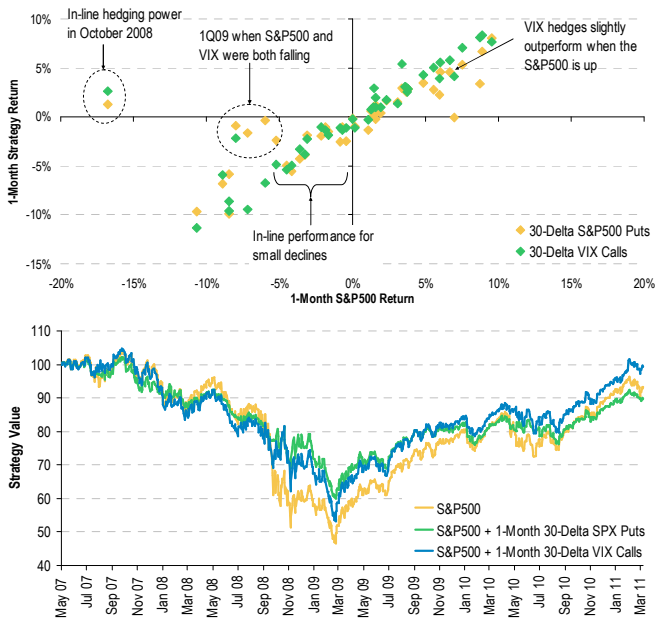
In addition, while VIX calls may seem optically cheap based on their up-front premium, an investor in these instruments also implicitly pays for the shape of the term structure. Since the term structure is generally upward-sloping, ATM VIX call strikes are generally higher than spot VIX levels. Unless this gap is overcome by expiry through rising spot VIX levels, the VIX call cannot be monetized.

IN-LINE PERFORMANCE VERSUS S&P500 PUTS

We perform an empirical analysis of the true potential 'cheapness' of VIX calls versus SPX puts through a set of backtests. We construct sets of 1-month option overlays on the S&P500 using 10-delta to 50-delta VIX calls and SPX puts. All options are held to expiration and then rolled into the next month's contract.

Exhibit 22: The returns of the S&P500 hedged with 30-delta S&P500 puts and VIX calls versus the S&P500 return

Based on daily data from 16 May 07 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

The first chart in Exhibit 22 compares the monthly performance of S&P 500 overlaid with 30-delta VIX calls and 30-delta SPX puts, versus the performance of the S&P 500. The results for other delta levels were generally comparable. In rising market environments, VIX hedges tended to outperform SPX put hedges slightly, due to their relative cheapness. During the 26 months of positive S&P500 returns in our backtest sample, the VIX hedge outperformed the SPX put hedge by 1.1% per month on average.

In months with small declines in the S&P500 (0% to -5%), the performance of VIX call hedges outperformed the S&P500 put hedge by 32bps per month on average. For larger declines – up to -10% - SPX put hedges generally outperformed VIX call hedges by 0.9% per month.

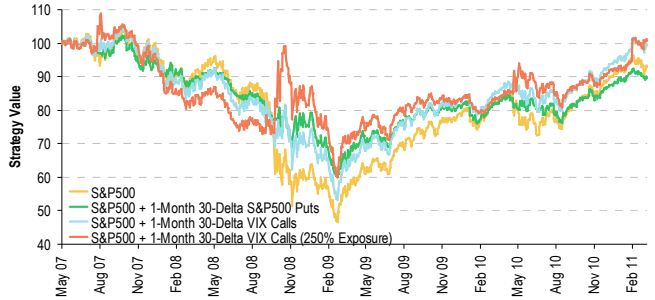
For very large declines, returns were in-line again. During Oct08 when the S&P500 was down 17%, the VIX call-hedged strategy performed nearly in-line with the SPX put-hedged strategy.

Over the long-run, a systematic VIX call hedge would have outperformed an SPX put hedge, while providing nearly the same hedging power in S&P500 drawdown periods (see lower chart in Exhibit 22).

Since the upfront premium costs of scaled 30-delta VIX calls were only about 40% of the price of 30-delta SPX puts, Exhibit 23 shows the results of a hedging backtest where we scale the VIX call exposure to the same premium outlay as the SPX puts.

Exhibit 23: The cumulative returns of a systematic 30-delta S&P500 overlays including one with amplified VIX call exposure

Based on daily data from 16 May 07 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

Over the longer term, the performance of this scaled VIX call hedge is similar to that of the 'regular' VIX call hedge. While the performance in periods of rising S&P500 was generally lower (6bps outperformance over SPX put hedge per month, versus 1.1% on average for the 'regular' VIX call hedge), performance in declining S&P 500 periods was substantially higher.

In 4Q08, for example, our scaled VIX call hedge plus an S&P500 position returned 31%. In contrast, 'regular' VIX call hedges or SPX equity put hedges were up by 1-2%, while the S&P500 alone was down by around -17% over this period. In May 2010, with the S&P500 down -8%, the scaled VIX hedge was up 6% while the other two hedging strategies were down -1% to -2%.

On the other hand, the higher notional VIX exposure also highlights periods of hedging mismatch. In Nov 08, the VIX started to decline very quickly after reaching its all-time high, even though the S&P 500 did not bottom until Mar 09. VIX hedges did not provide downside protection during this period, since VIX and S&P500 were both falling at the same time. During Nov 08, the S&P500 was down -7% while the 30-delta S&P500 put strategy fell approximately -2%. The regular-sized and higher notional VIX call strategy actually fell -9% and -13%, respectively, because of the sharp decline in implied volatility during this period.

These results highlight the tactical nature of many volatility-based hedges. The appropriateness of VIX-based hedges depends on the level of the VIX as well as on the recent direction of volatility changes.

Performance of Spread-Based VIX Hedges

BACKTESTING OTHER SPREAD-BASED VIX HEDGES

Similar to SPX put-spread based hedging strategies, we can also consider VIX call spread hedging strategies to target changes in volatility more precisely. The upper chart in Exhibit 24 shows the results of four backtests involving commonly used VIX option hedging strategies:

- Buy 1x 1-month 40-delta VIX call
- Buy 1x 1-month 40-delta VIX calls, Sell 1x 1-month 20-Delta VIX call
- Sell 1x 1-month 40-delta VIX call, Buy 2x 1-month 20-Delta VIX call
- Buy 1x 1-month 40-delta VIX call, sell 1x 2-month VIX call with the same strike

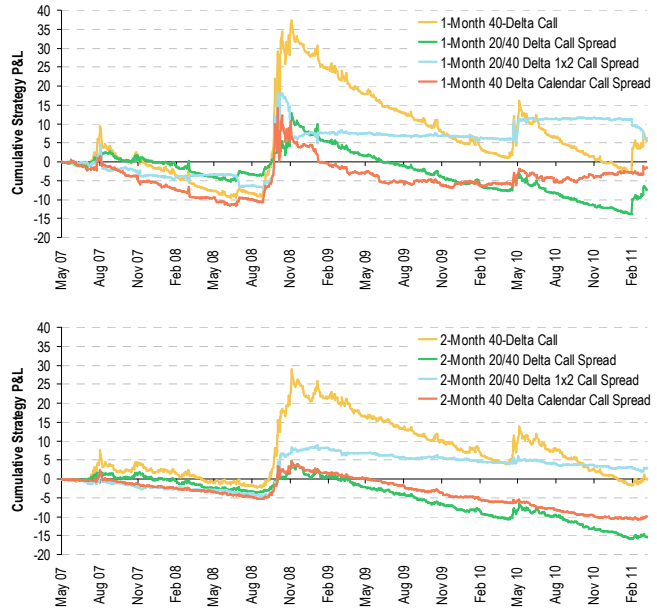
The lower chart shows the same strategies, but pushes out all maturities by one month. All strategies are rolled on the monthly VIX expiration dates. We assume a $0.10 bid-ask spread for every transaction.

Our benchmark is the 40-delta call strategy. The call spread strategy shows the impact of selling some upside to cheapen the hedge, with the deltas chosen to result in approximately a 50% premium reduction. The 1x2 call spread strategy is thus approximately zero premium, and is designed to gain when the VIX is rising sharply while accepting a small loss when the VIX rises slightly. The mark-to-market profile of this trade is attractive – the position only tends to lose significantly right near expiration if VIX is near the long call strike. This is because of the slow decay of VIX options. However, full upside is given up in case of a volatility shock.

The calendar call spread purchases a near-dated call while attempting to fund the trade by selling a longer-dated VIX call. The rolldown of the term structure for the longer-dated call will typically offset some of the cost of holding the near-dated call. If volatility spikes sharply, the shorter-dated call should increase in value faster than the longer-dated call. However, this trade takes on other term structure risks such as (1) a persistently flat term structure and (2) parallel shifts in the term structure.

Exhibit 24: The cumulative P&L of various systematic alternate hedging strategies using VIX calls

Based on daily data from 16 May 07 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

1X2 CALL SPREADS DELIVER HIGH PAYOUTS IN CRISIS SCENARIOS WITH LOW HOLDING COSTS

While simple VIX call spreads generally reduced the cost of the hedge, upside participation in volatility spikes was significantly reduced as well, making the tradeoff between cost and upside participation unattractive. The strategy generally decays over time, while underperforming other hedging strategies during volatility spikes.

Calendar spread structures are particularly attractive during periods of steep, upward-sloping term structures, such as the one in force since late 2009. In such an environment, calendar call spreads can minimize holding costs due to decay. However, in relatively flat term structure environments – like in 2007 – these strategies are generally unattractive as the decay in front-month options is much faster than that for longer-dated options. Moreover, P&L of calendar spreads tends to be more volatile than that of other strategies, since calendar spreads involve two separate maturities.

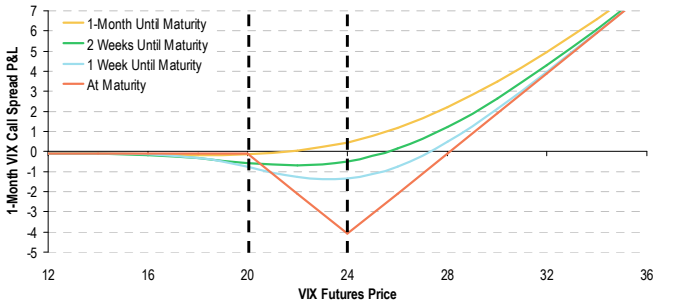
The 40-delta call worked the best in a 2008-style scenario with sharply rising volatility due to its lack of an upside cap. When factoring long-run holding costs, a 1x2 call spread worked better as a tail risk hedge. The up-front premium for this trade is generally close to zero. This benefits performance in a falling volatility environment, while still providing upside exposure when volatility spikes.

On the other hand, this trade suffers during small volatility spikes, such as March 2011. On the back of Middle East protests and the Japanese earthquake, VIX rose but not to crash levels. When our systematic 1-month rolled in February, it traded a March 2011 20-24 1x2 call spread. The options settled to a March opening print of 25.14 and created a loss.

A VIX 1X2 CALL SPREADS NEED TO BE ACTIVELY MANAGED TO AVOID POTENTIAL LOSSES

The mark-to-market profile of the 1x2 call spread is greatly affected by the slow decay of VIX options. We display in Exhibit 25 the mark-to-market profile of a 20-24 1x2 call spread which was nearly zero cost on 23 Mar 11.

Exhibit 25: The hypothetical future mark-to-market profile of an April VIX 20-24 1x2 calls spread as of 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

The structure on a mark-to-market basis gives full upside in the case of a volatility spike. However there is a 8 volatility point gap in the middle at expiration that could produce a loss. The calls decay slowly though which mitigates most of this risk. This position should be rolled at the latest a week before expiration to avoid a loss due to rapid decay. This requires the hedge to be actively managed to avoid this expiration loss.

Using a Scaling Mismatch for a VIX Hedge

UTILIZING THE SCALING MISMATCH OF INDICES

VIX and the S&P500 are denominated in different units. $1 is about 5% (1/20) of the VIX, but only about 8bps of the S&P500 (1/1300). Therefore, a VIX call option costing $1 should purchase more VIX upside than a $1 SPX put option would purchase in S&P500 downside.

A trade that sells a $1 S&P500 put to finance a $1 VIX call would be selling very deep OTM S&P500 exposure to buy a more near-the-money VIX hedge for zero upfront premium. If the S&P500 declines, there is a positive probability that the

VIX call will be ITM at expiration. As long as the S&P500 does not cross the SPX put strike, this strategy will yield a positive payoff in this scenario.

However, because the S&P500 is denominated in larger units, an X% sell-off in the S&P500 causes a larger S&P500 point shift than the VIX point shift under an X% rise in the VIX. For example, a 10% drop in the S&P500 corresponds to approximately 130 index points (1300 * 10%) while a 10% rise in the VIX corresponds to 2 index points (20 * 10%).

If an equity sell-off is substantial and the S&P500 breaches the put strike, the SPX put would thus rise faster in value than the VIX call. In a 1987-style scenario, this scaling mismatch would likely cause such a strategy to be substantially unprofitable.

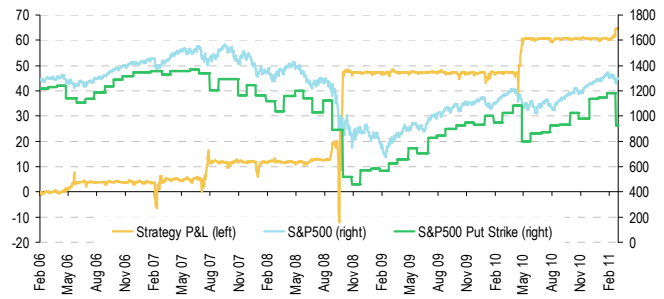
SINCE VIX OPTIONS WERE LISTED IN 2006, THE S&P500 HAS NOT CROSSED ITS PUT STRIKE…YET

Exhibit 26 shows the backtest of a strategy that buys the listed 1-month VIX call with a bid closest to $1, using prices at the close of every listed VIX expiration. We then construct a set of 1-month theoretical SPX put prices using the volatility surface of listed options. We assume a $1 bid/offer spread for the SPX puts and compute a put strike that would have had a theoretical bid with the same price as the VIX call.

We plot the cumulative P&L of this strategy, the level of the S&P500, and the strike of the $1 SPX put over time. In our backtest, the S&P500 never crossed the put strikes. As a result, a loss was never realized at roll time, while the strategy provided upside participation through the VIX call, resulting in positive P&L in times of rapid VIX spikes.

Exhibit 26: The cumulative P&L of a strategy that sells 1-month S&P500 puts costing $1 and buys 1-month VIX calls costing $1

Based on daily data from 24 Feb 06 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

On a mark-to-market basis, the trade did become unprofitable whenever the S&P500 neared the put strike. For example on 10 Oct 08, the S&P500 reached 899 while the put for this period was struck at 894. The mark-to-market value of the SPX put rose much faster than the value of the VIX call. If the S&P500 had continued to fall, the value of the SPX put would have continued to rise more rapidly. However, the S&P500 rose 105 points on the next day, mitigating the mark-to-market loss.

SUDDEN MARKET CRASHES HOWEVER WILL PRODUCE A LOSS WITH THIS STRATEGY, SUCH AS '87

In our backtest, 1-month SPX puts with around a $1 premium were on average 15% OTM, ranging from 5% to 46% OTM. If market were in a low implied volatility regime and equities were to suddenly drop, such as in the October 87 crash, it is likely this trade would have been very unprofitable.

We can highlight this possibility using the dynamics of the 1987 crash. During the 1987 crash, the S&P500 dropped by 32%, while the old VIX rose from 23 to 150, an increase of 127 points.

At current S&P 500 and volatility levels, our strategy would lead us to short an S&P 500 put that is 15% OTM, and a VIX call with about a 27.5 strike. A crash like in 1987 would lead to an increase in the intrinsic value of the S&P 500 put of 1300* (32%-15%) = $221, while the VIX call would have increased in intrinsic value by 150 – 27.5 = $122.5. This would product a mark-to-market loss of approximately $221 - $122.5 = $98.5.

Note that this might be a conservative estimate of the mark-to-market loss, since we did not consider the time value of the options. The VIX call would be so far in the money that it would trade with very little time value – it would be equivalent to a cash + VIX futures position. The S&P 500 put, on the other hand, would have a substantial short volatility exposure due to its higher time value. This would tend to exacerbate the mark-to-market loss of this position. We can see this in the volatility of the P&L of our strategy in Exhibit 26, for example during October 2008.

V. VIX for Alpha-Seekers

Volatility has long been an alpha source for many absolute return strategies using index OTC variance swaps. After the events of 2008, many question whether liquid, listed VIX derivatives can complement or replace index variance swaps in these systematic alpha strategies

This section provides a framework for using VIX futures & options as volatility alpha vehicles, highlighting advantages as well as potential risks and drawbacks:

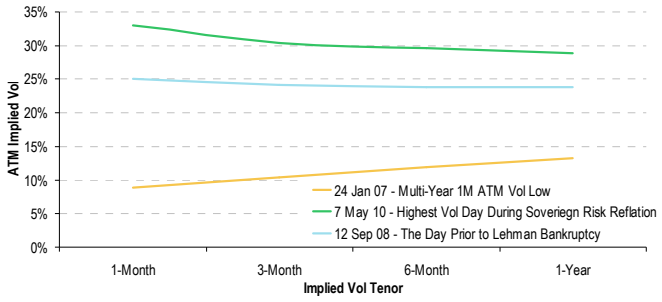
- *Using VIX derivatives to trade the S&P500 implied vol term structure*
- *Constructing term structure trades with reduced downside risk*
- *VIX options implied volatility has historically traded rich versus subsequent realized vol*
- *We backtest the performance of potential alpha trades*

A Listed Vehicle to Arb the Term Structure

VIX FUTURES VS. THE SPX VOL TERM STRUCTURE

The SPX implied volatility term structure is generally upward sloping – the implied volatility of longer-dated options is higher than that of shorter-dated options. Exhibit 27 shows three sample term structures – upwards sloping, flat and inverted. Over the past five years, the term structure was upwards sloping on 78% of trading days. Inversions of the term structure typically only occur in distressed market scenarios. The shape and slope of the term structure during inversions can be more extreme than when the term structure is upwards sloping – see Exhibit 28.

Exhibit 27: Three single day examples of potential term structure shapes: upward sloping, downward sloping, and flat



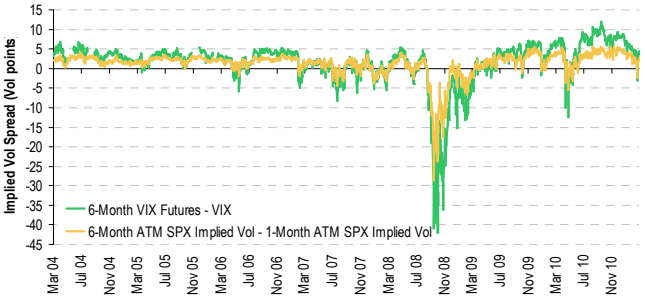
Source: Morgan Stanley Quantitative and Derivative Strategies

The upward-sloping term structure of implied volatility is often attributed to supply-demand dynamics. Demand for volatility comes from tactical option positions as well as downside hedging strategies. Volatility suppliers, such as covered call writers or outright variance swaps sellers, fill this demand. Further out the term structure, there are fewer natural sellers of volatility. The premium for longer-dated tail risk increases, helping to push the term structure upwards.

VIX futures are priced off the SPX implied volatility term structure, and are related to the 1-month forward starting implied volatility.[11] As a result, the basis of VIX futures tends to track the shape of the S&P500 term structure (Exhibit 28).

Exhibit 28: The VIX futures term structure has a similar shape as the S&P500 implied vol term structure

Based on daily data from 26 Mar 04 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

YIELD FROM UPWARD-SLOPING TERM STRUCTURES

One of the most common volatility alpha strategies is to exploit the generally upward-sloping term structure through risk premium extraction, for example by systematically selling forward starting variance swaps. The term structure of forward starting implied volatilities tends to be upwards sloping as well, driven by the shape of SPX implied volatilities. Forward starting implied volatility can be traded via VIX futures.

[11] One can express the price of the VIX at time t=T as an expectation of future realized volatility from time T to time T+30:

$$VIX_T = \sqrt{E^{t=T}[RVol^2{}_{T-T+30}]}.$$

The price of a VIX future, however, is an expectation of where the expectation of realized vol will be in the future. So at time t=0, the price of a VIX future can be thought of as:

$$VIX\_Fut_T = E^{t=0}[VIX_T] = E^{t=0}[\sqrt{E^{t=T}[RVol^2{}_{T-T+30}]}].$$

Using Jensen's Inequality, it can be shown that:

$$E^{t=0}[E^{t=T}[\sqrt{RVol^2{}_{T-T+30}}]] \le VIX\_Fut_T \le \sqrt{E^{t=0}[E^{t=T}[RVol^2{}_{T-T+30}]]}$$

which simplifies to:

$$ForwardVolSwap_{T-T+30} \le VIX\_Fut_T \le FowardVarSwap_{T-T+30}$$

For more information, please refer to "A Tale of Two Indices," Carr & Wu, *The Journal of Derivatives*, Spring 2006.

For example, if spot VIX remained unchanged over the lifespan of a VIX future, the price of the VIX future has to converge towards the spot VIX as it moves towards expiry. In an upwards-sloping term structure environment, this 'rolldown effect' can be exploited by selling the VIX future.

Spikes in volatility would typically lead to a loss in this scenario, which can often be multiples of the potential risk premium gain. Successful premium extraction strategies of this type therefore require a hedging strategy that mitigates the impact of volatility spikes.

FOUR METHODS TO GENERATE HEDGED ALPHA

VIX- based alpha strategies are often based on exploiting the richness of the SPX implied volatility term structure. In addition, VIX options tend to trade at a premium relative to the realized volatility of VIX futures in low-risk environments. Through selling (delta-hedged) VIX options, we can also exploit this 'vol-of-vol' effect as another potential alpha source.

Utilizing all the payoff profiles that combinations of VIX futures and options allow, we can structure different trades that can extract this rolldown P&L while minimizing potential losses. We examine four basic types of trades as examples of pure alpha trades around the VIX:

- VIX future calendar spreads
- VIX put spreads
- VIX calendar put spreads
- Delta-hedged VIX straddles

VIX future calendar spreads are the most direct way to leverage the term structure steepness. Put spreads can reduce the exposure to volatility spikes. Delta-hedged VIX straddles are pure plays on the 'vol-of-vol' effect.

In addition to analyzing each of these strategies individually, we will also highlight the potential benefits of aggregating them into a single strategy.

VIX Futures Calendar Spreads

MOST DIRECT WAY TO TRADE THE TERM STRUCTURE

Selling short-dated VIX futures is the simplest way of exploiting the steepness of the upward-sloping term structure. However, the strategy is exposed to sudden spikes in the VIX.

Calendar spreads can mitigate the impact of spikes in the VIX. Exhibit 10 earlier in the paper showed that the rolldown cost per unit of VIX exposure was not uniform across all maturities. Longer-dated contracts tend to have a smaller rolldown cost than a 1-month future. By using some of the rolldown yield from selling a 1-month VIX future to purchase an amount of longer-dated VIX futures, the overall strategy can be effectively hedged against term structure inversions and spikes in the VIX.

Based on historical rolling VIX futures data, we find that 2- to 6-month futures have a sensitivity to 1-month futures of 1.4, 1.7, 1.9, 2.1 and 2.4 times, respectively. Using these ratios, we can scale a hedging strategy that would profit in steep term structure environments. If the term structure remains upward-sloping, and if the historical hedge ratio is accurate, such a strategy could be profitable. Two major risks remain: (1) parallel shifts inconsistent with these hedge ratios and (2) a sustained inversion in the term structure. An inverted term structure would cause the entire strategy to work in reverse as the short 1-month future rolls up the futures curve rather than down.

1-MONTH / 3- OR 4-MONTH SPREADS WORKED BEST

Using these historical hedge ratios of longer-dated VIX futures to 1-month futures, we backtested a series of systematic strategies that execute this trade monthly. For every $100 of strategy value, we sell one 1-month VIX future while buying 2- through 6-month futures according to our hedge ratios. The cash component earns the Effective Overnight Federal Funds rate and the strategies are rolled on the listed VIX futures expirations. All futures trades assume execution at their daily closing prices.

We have extended the history of VIX futures from their Mar 2004 first listing back to January 1996, using a regression model.[12] This longer period covers three bull markets and two recessions, allowing us to evaluate our strategies more robustly.

Exhibit 29 shows the performance of these VIX futures calendar spreads, comparing them to that of a strategy that is short the 1-month VIX futures without a hedge. The table

[12] Because VIX futures are strongly linked to forward starting volatility, we construct a two-factor regression model. We regress in-sample the VIX futures basis on (1) the spread between the equivalent ATM forward volatility level and spot 1-month implied vol and (2) the square root of time until maturity. In sample, this model has a regression R^2 of 98% and we use the in-sample results to extrapolate the data using S&P500 volatilities.

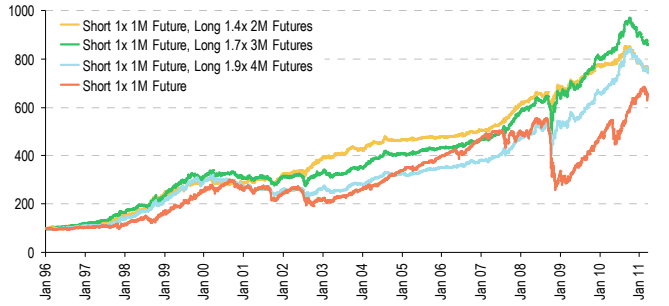
separates the performance of the strategies during the backfilled period from that over the whole period.

Strategies using longer-dated VIX futures as hedges yielded a higher return in general, since the longer-dated vol term structure tends to be quite flat. However, volatility and CVaR are higher for these strategies as well, compared to shorter-dated hedges, since longer-dated futures are a less effective hedging tool.

Most strategies outperformed the unhedged trade on both an absolute and a relative basis. Using historical VIX futures data since 2004, the highest Sharpe Ratio (1.15) strategy was based on hedging with 4-month VIX futures. Over the whole period since 1996, which includes our backfilled data, using 3-month VIX futures yielded the highest Sharpe Ratio (0.85).

Exhibit 29: The historical performance of hedged VIX futures spread strategies and a naked short VIX futures strategy

Based on daily data from 4 Jan 96 through 23 Mar 11



	Long VIX Future Maturity					
	Unhedged	2-Month	3-Month	4-Month	5-Month	6-Month
Out-of-Sample Results: 4 Jan 96 - 23 Mar 11						
Return (Ann.)	13.2%	14.2%	15.2%	14.1%	14.2%	14.6%
Risk (Ann.)	20.2%	13.7%	13.9%	13.7%	15.0%	17.6%
5% CVaR	-3.1%	-2.0%	-2.1%	-2.0%	-2.2%	-2.6%
Sharpe Ratio	0.48	0.79	0.85	0.78	0.72	0.64
In-Sample Results: 24 Mar 04 - 23 Mar 11						
Return (Ann.)	13.9%	7.8%	12.5%	14.1%	14.3%	14.1%
Risk (Ann.)	21.0%	8.5%	9.5%	10.1%	10.6%	12.1%
5% CVaR	-3.5%	-1.1%	-1.3%	-1.4%	-1.5%	-1.7%
Sharpe Ratio	0.55	0.63	1.06	1.15	1.11	0.96

Source: Morgan Stanley Quantitative and Derivative Strategies

During the 4Q08 vol spike, the hedged strategies were able to minimize losses and recovered relatively quickly, while the unhedged strategy required nearly two years to recover to its pre-4Q08 highs. During the higher-volatility period between 2000 and 2002, all strategies suffered. The implied volatility term structure oscillated from relatively flat to inverted for a sustained period, which tends to make these volatility premium extraction strategies unprofitable.

Short-Dated VIX Ratio Put Spreads

SELLING THE TERM STRUCTURE THROUGH PUTS

To mitigate the downside risk from volatility spikes that is inherent in a VIX futures selling strategy, we can hedge using long positions in longer-dated VIX futures. Another strategy involves trading short-dated puts on the VIX instead, which have limited downside.

For VIX options, the ATM strike is defined as the level of the corresponding VIX future. When the term structure is upwards-sloping, this ATM strike will be higher than the spot VIX level. If the term structure remains unchanged, an ATM put becomes increasingly ITM as the VIX futures price approaches the VIX spot.

Unlike strategies involving VIX futures, buying VIX puts requires an up-front premium. The level of the VIX at expiration has to drop by more than the option premium for the strategy to break even. We would expect strategies involving VIX puts to underperform those using VIX futures in moderately upwards-sloping term structure regimes, as the P&L gained on the put may not be enough to cover the initial premium. We investigate selling other options to fund the VIX put premium.

SHORT-DATED STRATEGIES TEND TO WORK BEST

Similar to the VIX futures backtest, we backtest four VIX put strategies to highlight various characteristics of these trades:

- Buy a 1-month ATM put
- Buy a 1-month ATM put, sell an 80% 1-month put
- Buy a 1-month ATM put, sell 2x an 80% 1-month put
- Buy a 2-month ATM put, sell 2x an 80% 2-month put and roll monthly

For every $100 of capital, the strategy buys a single VIX put or put spread on each roll date. The remaining cash accrues the overnight Federal Funds rate. All option transactions assume a bid-ask spread of $0.10.

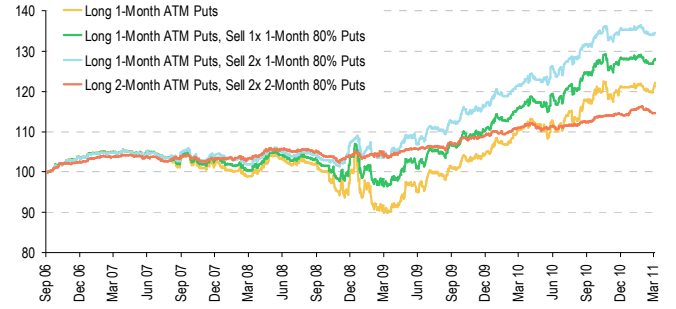
Exhibit 30 shows the historical backtest of the strategies since September 2006. The period until March 2009 was generally unprofitable for long ATM put strategies, as expected – rising volatility and inverted term structures were drags on the performance. Since the S&P500 low in March 2009, when the index began one of its strongest rallies in history, long ATM

put strategies have been profitable. This was driven both by declining volatility and by a strongly upwards-sloping term structure.

Selling OTM VIX puts to raise partial funding for the long ATM put position can help to overcome the drag in performance of long ATM put strategies. Both the 1x1 and the 1x2 put spreads showed higher returns and higher Sharpe Ratios than the long ATM put strategy in our backtest.

Exhibit 30: The historical performance of VIX put spread strategies

Based on daily data from 20 Sep 06 through 23 Mar 11



	1-Month Puts	1-Month Put Spread	1-Month 1x2 Put Spread	2-Month 1x2 Put Spread
Return (Ann.)	4.5%	5.7%	6.8%	3.1%
Risk (Ann.)	8.5%	6.8%	5.7%	2.6%
5% CVaR	-1.3%	-1.0%	-0.8%	-0.4%
Sharpe Ratio	0.30	0.54	0.85	0.41

Source: Morgan Stanley Quantitative and Derivative Strategies

Extending the maturity of the put spreads has a detrimental effect on returns and Sharpe Ratio. Since the term structure is not as steep for longer maturities, the roll-down benefit to performance is less strong, even in falling volatility environments.

Weighted VIX Calendar Put Spreads

VIX FUTURES CALENDAR SPREADS THROUGH PUTS

We can introduce an additional time dimension into the put spread strategy, similar to the VIX futures calendar spread we considered earlier. In this trade, we purchase a short-dated ATM or ITM VIX put while selling a longer-dated put with the same strike. In effect, this is equivalent to a VIX futures calendar spread, where we buy a short-dated VIX call and sell a longer-dated VIX call to reduce exposure to spikes in the VIX.

If the term structure remains unchanged, the long ATM put would become increasingly ITM over time as its corresponding VIX future rolls down the term structure. This benefit is counterbalanced by the cost of the initial put premium. To help fund this, an investor can sell a weighted amount of a longer-dated put with the same strike as the long put. The rolldown of the longer-dated put is less than the shorter dated put, given the shape of the term structure. The long put should increase in value faster than the short put – this difference in decay helps to pay for the long put position.

The key risk in this strategy comes from the shape of the term structure. Should the term structure become relatively flat or inverted, the long put would not be ITM at maturity, contributing to potential losses. Moreover, a breakdown in the regression relationship between changes in different volatility tenors would also produce a mishedge and potentially losses.

LONGER-DATED, ITM CALENDAR PUTS WORK BEST

We consider four representative sample strategies for VIX calendar put spreads to evaluate historical benefits and risks. In all cases, we set the short put strike to be the same as the long put strike.

- Buy a 1-month ATM put, sell 1.4x a 2-month put
- Buy a 1-month 10% ITM put, sell 1.4x a 2-month put
- Buy a 1-month 20% ITM put, sell 1.4x a 2-month put
- Buy a 1-month 20% ITM put, sell 1.7x a 3-month put

The 1.4x and 1.7x hedging ratios in the short puts are consistent with the ratios used for VIX futures calendar spreads in the previous sections.

Like the other backtests, this strategy buys one VIX option for every $100 of strategy value, with the remaining cash accruing Overnight Fed Funds. Strategies are rolled at the monthly VIX expirations, and a $0.10 bid-ask spread was assumed on all trades.

Our backtests start in May 2007, when expirations up to 3 months were listed on a consistent basis. Because VIX option liquidity is concentrated in the first three months, we did not backtest strategies using longer-dated options.

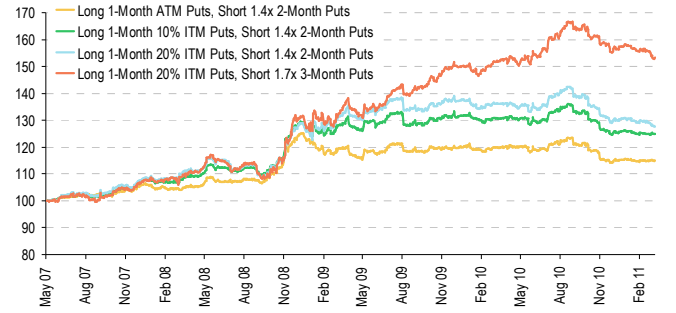
Exhibit 31 shows the historical performance of the weighted calendar VIX put spread strategies. The performance of ITM put spread strategies was consistently above that of the ATM put spread strategy. We attribute this to the lower time value embedded in ITM puts, which reduces the net premium of the put positions that has to be overcome by the term structure

slide.[13] While using ITM strikes increases potential exposure to a volatility spike, the risk of a volatility spike is offset by the premium gain from the short put position.

Moreover, performance strongly picked up when the longer-dated set of 3-month options was used. This is consistent with our findings from the VIX futures calendar spreads that showed stronger returns when extending to longer maturities.

Exhibit 31: The historical performance of weighted calendar VIX put spread strategies

Based on daily data from 16 May 07 through 23 Mar 11



	1-Month / 2-Month ATM Strategy	1-Month / 2-Month 10% ITM Strategy	1-Month / 2-Month 20% ITM Strategy	1-Month / 3-Month 20% ITM Strategy
Return (Ann.)	3.7%	5.9%	6.6%	11.7%
Risk (Ann.)	5.4%	6.4%	7.3%	8.5%
5% CVaR	-0.8%	-1.0%	-1.1%	-1.2%
Sharpe Ratio	0.42	0.71	0.71	1.21

Source: Morgan Stanley Quantitative and Derivative Strategies

The strategy benefited greatly during the 4Q08 volatility spike. During this rapid rise in volatility, both of the puts became deep OTM puts that converged towards a zero price. Since this strategy is short more of the longer-dated puts than it owns in short-dated puts, this produced a net premium benefit for the strategy.

Delta-Hedged VIX Straddles

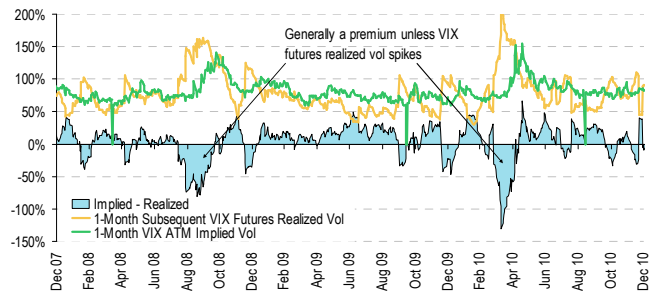
TRADING THE RICHNESS OF VIX IMPLIED VOLATILITY

Much like S&P500 options, VIX options generally trade rich – their implied volatility is typically greater than subsequent realized volatility. Exhibit 32 shows the 1-month ATM implied volatility of VIX options as well as the subsequent realized volatility of a theoretical, corresponding VIX future.[14]

Unless VIX volatility is spiking (e.g. in 4Q08 or 2Q10), VIX implied volatility is priced at a premium to subsequent VIX futures realized volatility. This is driven by the same structural forces that cause SPX options to trade at a premium to realized volatility. Investors are generally net demanders of optionality – for example through OTM SPX puts for hedging purposes. Market makers supply this optionality, which makes them short volatility. The implied/realized volatility premium compensates for the risk of this short volatility position. Similarly, investors are likely net demanders of VIX options, for example for VIX upside calls as tail risk hedges. Again, the implied/realized VIX volatility premium is a compensation for the risk to the suppliers of this volatility.

Exhibit 32: The implied – realized volatility spread in VIX options

Based on daily data from 31 Dec 07 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

STRONGER RETURNS THAN SHORT SPX STRADDLES

Exhibit 33 shows the backtested performance of a strategy that systematically shorts 1-month ATM VIX straddles, delta-hedged. We compare this strategy to one without a delta hedge, as well as to a delta-hedged straddle using SPX options instead of VIX options

The VIX strategy sells one VIX straddle for every $100 of index value every month; the SPX strategy sells $100 of notional straddles for every $100 of strategy value. We assume a $0.10 bid-ask spread on each option for the VIX straddle, and a 20bps bid-ask spread for SPX options. Trades are executed at closing prices, and cash collateral accrues overnight Fed Funds.

The risk profile of the delta-hedged strategies is relatively similar – 5% CVaRs are nearly identical (-1.0% vs. -1.1%) while the annualized standard deviations were within 63bps of

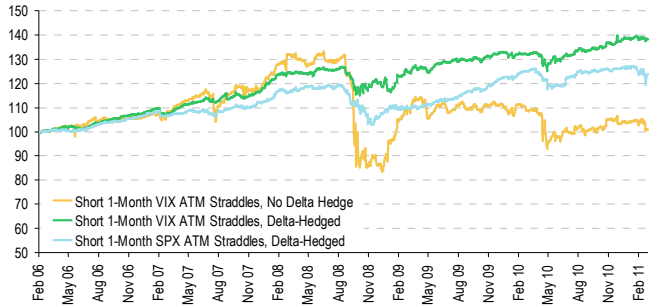
[13] An easier way to think of this is to decompose these puts into positions in VIX futures and VIX calls. Being long a 2-month put and short a 1-month put is almost like being long (1) a 2-month minus 1-month futures spread and long (2) a 1-month minus 2-month calendar call spread. When the call strikes become further OTM, the price of this call spread reduces to zero.

[14] Unlike regular equity index futures, VIX futures' realized volatility is heavily dependent on time to maturity. Using a set of futures data, we create a strip of theoretical VIX futures that have daily expirations. This way for each day's ATM implied volatility level, there is a VIX future with exact 30 days until maturity. We then compute the realized volatility of this future as it becomes increasingly volatile over time.

each other. However, VIX strategy returns were much stronger over the backtest period, particularly given our aggressive bid-ask spread assumptions. The delta-hedged VIX strategy has outperformed the SPX strategy by over 228bps per year despite its lower risk. The unhedged strategy has performed poorly in comparison, combining near-zero returns with higher risk.

Exhibit 33: The historical performance of delta-hedged & unhedged short VIX straddles and delta-hedged short SPX straddles

Based on daily data from 24 Feb 06 through 23 Mar 11



	Short 1-Month Unhedged VIX Straddles	Short 1-Month Hedged VIX Straddles	Short 1-Month Hedged SPX Straddles
Return (Ann.)	0.1%	6.6%	4.3%
Risk (Ann.)	17.5%	5.9%	6.6%
5% CVaR	-2.7%	-1.0%	-1.2%
Sharpe Ratio	-0.13	0.72	0.30

Source: Morgan Stanley Quantitative and Derivative Strategies

One potential driver for the performance differential of VIX straddles versus SPX straddles may be a greater mismatch between the supply and demand of VIX optionality. VIX options were introduced to the market much more recently. Moreover, trading the richness of VIX options requires an active delta hedge. SPX variance swaps, in contrast, are a common way of trading SPX volatility without the need to manage delta actively. Since there is no equivalent product for the VIX, the set of suppliers of VIX volatility is likely to be much smaller, which may account for VIX implied volatility staying rich.

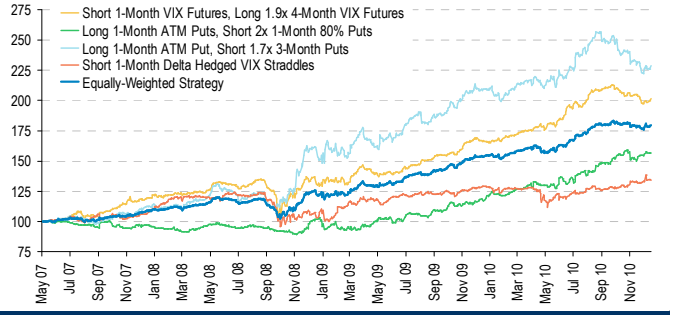
Aggregating VIX Options Strategies

PERFORMANCE OF ALLOCATING TO ALL STRATEGIES

In this section, we have reviewed a number of different alpha strategies using VIX instruments. The strategies exploited the shape of the term structure of the VIX, the skew, as well as the implied-to-realized volatility premium. To gauge the potential attractiveness of these alpha strategies, we take the best performing strategy from each of the strategy types we considered. Exhibit 34 shows the historical performance of a strategy that allocates to each of those strategies on every VIX expiration date. For every dollar allocated to the VIX futures calendar spread, we allocate two dollars to the other three strategies to make the risk contributions comparable.

Exhibit 34: The historical performance of all VIX alpha strategies and a monthly-rebalanced strategy that allocates between them

Based on daily data from 16 May 07 through 23 Mar 11



	VIX Futures Calendar Spread	1x2 VIX Put Spreads	VIX Calendar Put Spreads	Delta-Hedged VIX Straddles	Equally-Weighted Allocation
Return (Ann.)	17.9%	12.0%	22.3%	8.1%	15.5%
Risk (Ann.)	12.8%	12.0%	16.9%	14.3%	9.0%
5% CVaR	-1.9%	-1.7%	-2.3%	-2.5%	-1.4%
Sharpe Ratio	1.29	0.88	1.23	0.47	1.56

Source: Morgan Stanley Quantitative and Derivative Strategies

The strategies clearly show correlation with each other, particularly during 4Q08 and during the recovery phase that started in March 2009. Combining the strategies nevertheless provided diversification benefits resulting in a superior risk and return profile. The annualized standard deviation of the combined strategy is significantly below that of individual strategies, as is the CVaR.

VI. VIX Futures ETPs

In the previous two sections, we analyzed how the properties of VIX derivatives affected the performance of systematic VIX-based portfolio hedging and alpha extraction strategies. In this section, we overview the emerging VIX ETP market and how the properties of VIX derivatives also affect their behavior. The points we cover include:

- *Current ETP landscape - what is currently available?*
- *Impact of VIX futures rolldown on VIX ETPs*
- *The long-term performance of these indices going back 15+ years*
- *The hypothetical performance of inverse & leveraged strategies*

Overview of US-Listed VIX Futures ETPs

CURRENT LANDSCAPE & AVAILABILITY OF VIX ETPS

ETFs and ETNs linked to VIX futures have grown substantially since the first were listed in January 2009. At the time of this publication, 14 ETPs were listed in the US, with 7 products linked to the Short-Term VIX Futures index and 6 linked to the Medium Term VIX Futures index. The remaining one is an arbitrage strategy that trades these two indices against each other to collect a risk premium.

Three products are also listed in Europe while two products are linked to equivalent indices using VSTOXX futures. Exhibit 35 provides an overview of basic characteristics of the strategies backing these products. We omit other listed products that contain VIX futures amongst other instruments, and focus on pure volatility products.

The two ETPs that were listed first – the VXX and VXZ – have the majority of AUM. As of 23 Mar 2011, all other products have less than USD 100mm AUM. These two ETPs track the short- and medium-term VIX indices, respectively. While the other ETPs have yet to gain significant assets, they have increased the variety of products, with some products offering -1x inverse and 2x long exposure to these indices.

THE STRATEGIES BEHIND VIX FUTURES INDICES

The indices that back this new class of ETPs are based on the returns of VIX futures rather than spot VIX. The portfolios of VIX futures underlying these indices are designed to have a high correlation with the spot VIX. However, they do not track the spot VIX – as discussed earlier, spot VIX does not equal cash plus VIX futures.

Exhibit 35: US-listed VIX futures-linked volatility indices as of 23 Mar 2011

	EXCHANGE TRADED FUNDS		EXCHANGE TRADED NOTES											
	VIXY	VIXM	VXX	XXV	IVO	VXZ	VZZ	XVIX	VIIX	TVIX	XIV	VIIZ	TVIZ	ZIV
Issuer	ProShares		Barclays					UBS	VelocityShares					
Description	VIX Short-Term Futures ETF	VIX Mid-Term Futures ETF	VIX Short-Term Futures ETN	Inverse VIX Short-Term Futures ETN	Inverse January 2021 Short-Term Futures ETN	VIX Mid-Term Futures ETN	Long Enhanced VIX Mid-Term Futures ETN	Daily Long-Short VIX ETN	VIX Short-Term Futures ETN	Daily 2x VIX Short-Term Futures ETN	Daily Inverse VIX Short-Term ETN	VIX Mid-Term Futures ETN	Daily 2x VIX Mid-Term Futures ETN	Daily Inverse VIX Mid-Term ETN
Suggested Usage	Tactical	Tactical / Hedging	Tactical	Tactical / Yield Generation	Tactical / Yield Generation	Tactical / Hedging	Tactical	Tactical / Yield Generation	Tactical	Tactical	Tactical / Yield Generation	Tactical / Hedging	Tactical	Tactical / Yield Generation
Underlying Index	1x Long SPVXSP	1x Long SPVXMP	1x Long SPVXSTR	1x Short SPVXSP	1x Short SPVXSP	1x Long SPVXMTR	2x Long SPVXMTR	1x Long SPVXTSER	1x Long SPVXSP	2x Long SPVXSP	1x Short SPVXSP	1x Long SPVXMP	2x Long SPVXMP	1x Short SPVXMP
Long or Short Vol Exposure	Long	Long	Long	Short (No Reset)	Short (No Reset)	Long	Leveraged Long (Daily Reset)	Long / Short	Long	Leveraged Long (Daily Reset)	Short (Daily Reset)	Long	Leveraged Long (Daily Reset)	Short (Daily Reset)
Leverage	1x	1x	1x	1x	1x	1x	2x	2x Long / 1x Short	1x	2x	1x	1x	2x	1x
Launch Date	3-Jan-11	3-Jan-11	29-Jan-09	19-Jul-10	14-Jan-11	29-Jan-09	30-Nov-10	1-Dec-10	29-Nov-10	29-Nov-10	29-Nov-10	29-Nov-10	29-Nov-10	29-Nov-10
AUM (on 23 Mar 11)	25mn	7mn	1,340mn	29mn	40mn	592mn	18mn	70mn	7mn	30mn	73mn	4mn	4mn	6mn
Term Structure Held	1-Month	5-Month	1-Month	1-Month	1-Month	5-Month	5-Month	Long 5m / Short 1m	1-Month	1-Month	1-Month	5-Month	5-Month	5-Month
Reactivity to Volatility	High	Medium	High	High	High	Medium	High	Low	High	Very High	High	Medium	High	Medium
Rolldown Exposure	High	Medium	High	High	High	Medium	High	Medium	High	Very High	High	Medium	High	Medium
Management Fee	0.85%	0.85%	0.89%	0.89%	0.89%	0.89%	0.89%	0.85%	0.89%	1.65%	1.35%	0.89%	1.65%	1.35%

Source: Morgan Stanley Quantitative and Derivative Strategies

The short-term futures index holds a portfolio of two VIX futures that are time-weighted to deliver a constant maturity 1-month VIX future. For example if the first two contracts were 15 and 45 days from maturity, the strategy would hold both in approximately equal amounts. Every day, as these contracts become shorter-dated, an amount of the front-month contract is sold to buy the second month contract. To limit downside risk to the amount invested, notionals are set such that if the entire VIX futures term structure were at zero, so would be the value of the index.

Almost the same exact strategy is used for the medium-term VIX futures indices. The strategy holds 4- to 7-month futures for a time-weighted exposure of approximately 5½ months. Each day, an amount of the 4-month future is sold to buy the 7-month future.

EXPOSURE TO THE VIX FUTURES ROLLDOWN

Currently, all the strategies underlying these ETPs are backed by VIX futures. They therefore exhibit the properties one would expect with VIX futures, namely (1) less volatility than the VIX and (2) rolldown losses most of the time.

While we would expect the short-dated VIX futures index to be more volatile than the medium-term index, we also would anticipate higher rolldown costs in the short-dated index. The term structure is particularly steep for short-dated futures in upward sloping term structure environments. This is the crux of many of the VIX alpha trades in Section V.

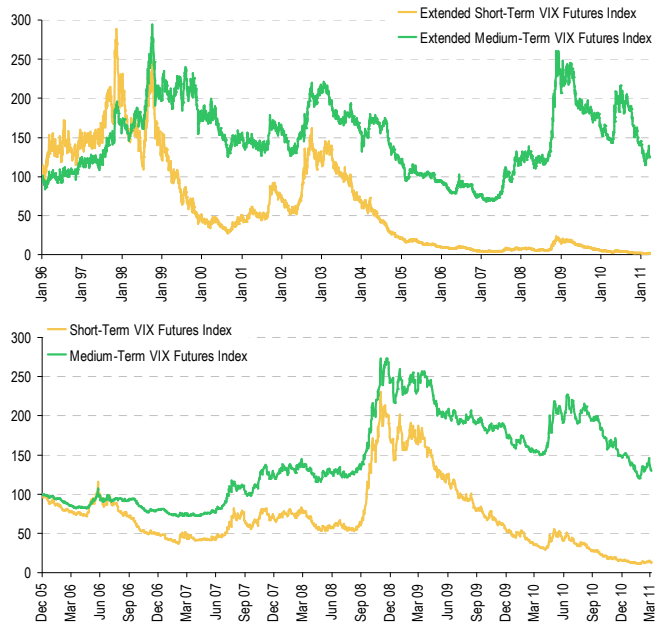
Exhibit 36 shows the performance of the short- and medium term volatility indices since their inception (bottom chart). We have extended the performance in the top chart using the regression-fitted VIX futures we constructed in Section V.

The effect of the rolldown cost is significant – the short-term VIX futures index has lost virtually its entire value over both sample periods. The medium-term VIX futures index, which targets a part of the term structure that is typically less steep, has been able to maintain its value. In very volatile periods, on the other hand, the short-term index performed much stronger than the medium-term index.

We therefore see different use cases for these two products. While the medium-term index is more attractive for systematic hedging strategies, the rapid decay of the short-term index suggests usage for tactical volatility positioning with short expected holding periods.

Exhibit 36: Extended short- and medium-term VIX futures index performance (top) and actual performance (bottom)

All data through 23 Mar 11. Extended performance begins on 3 Jan 96 while actual performance begins on 20 Dec 05



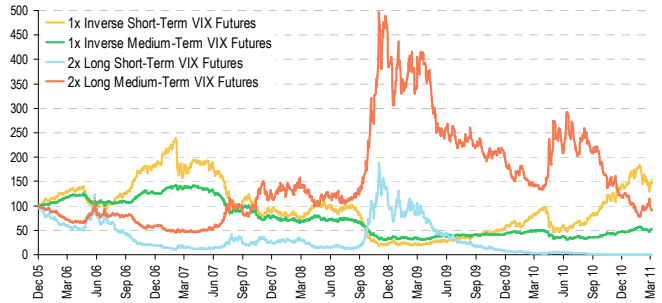
Source: Morgan Stanley Quantitative and Derivative Strategies

INVERSE & LEVERAGED VIX FUTURES INDICES?

The expansion of VIX futures ETPs into the inverse & leveraged space has opened up new opportunities for short-term volatility trading. Our recent report on inverse and leveraged ETFs[15] highlighted that these products are best used for very short-term, tactical views. The directional view of the investor has to be substantial relative to the volatility of the underlying. Otherwise, the compounding effects inherent in the daily resetting of leverage can cause the value of these ETFs to decay quickly, particularly for volatile underliers.

Exhibit 37: Replicated performance of daily-resetting 1x inverse and 2x long strategies on the short- and medium-term VIX futures indices

Based on daily data from 31 Dec 07 through 23 Mar 11



Source: Morgan Stanley Quantitative and Derivative Strategies

[15] See 'Vega Times: Inverse & Leveraged ETF Primer', Morgan Stanley Quantitative and Derivative Strategies, October 2010.

Exhibit 37 shows the replicated performance of -1x inverse and 2x leveraged strategies on short- and medium-term VIX futures indices. The indices generally perform poorly, especially the 2x long strategy based on the short-term VIX futures index. This is expected, as the strategy combines the compounding effect of leveraged ETFs, the rolldown decay of the index, and the index's high realized volatility. On the other hand, during 4Q08, the 2x long medium-term VIX futures strategy would have produced significantly higher returns due to (1) its naturally low decay and (2) increased leverage.

VII. Glossary of Terms

A Reference on Commonly Used Terms

At-the-money (ATM): An ATM option is any option whose strike price is equal to the current underlying spot price.

Basis: The basis of a future is the difference between its price and the underlying spot price. It is typically quoted as the futures price minus the spot price. The basis of VIX futures is a measure of the steepness of the futures term structure.

Beta: The beta of an asset represents the sensitivity of its expected return to the return in another asset. In this paper, we often express the beta of volatility to the S&P500 as the as the change in vol points for a given percentage change in the S&P 500. For example, a beta of -2 in this case would mean for a 1% fall in the S&P500, a volatility measure would be expected to rise by 2 vol points.

Call Option: An option that gives an investor the right but not the obligation to buy an underlying security at a set price in the future.

Convexity: Within the volatility space, this typically refers to the non-linear variance swap payoff for a linear change in volatility. Compared to a (linear) VIX future, a variance swap will outperform for a given change in volatility. Variance swaps trade at a premium to linear vol instruments to compensate for this more attractive payoff.

CVaR: VaR is a threshold such that returns at or above that level occur with a certain probability. For example, a 5% VaR equal to -2% means that we expect daily returns of less than -2% to occur 5% of the time.

The CVaR measures the expected return given that the threshold is crossed. It is therefore a measure of the fat-tailedness of a return distribution. For example, a 5% CVaR of -3% means that if the 5% VaR level is crossed, we expect a daily return of -3%.

Delta: The option delta represents the expected change in the value of an option for a $1 change in the underlying. For example if an option has a delta of 0.50, it is expected to increase or decrease in value by $0.50 for every $1 change in the underlying. By extension, delta also represents the number of shares of the underlying required to delta-hedge the option. The deltas of a call range from 0 to 1 while the deltas of a put range from -1 to 0.

Delta-Hedge: To hedge out the risk to an option's value due to movements in its underlying, we can use a dynamic trading strategy known as delta-hedging. Hedge ratios are set such that for a $1 change in the value of an option, a -1$ opposing change in the value of the underlying is gained. For example, if an investor was long a call option with a delta of 0.50, they could short sell 0.50 shares of the underlying against it for a delta hedge. For small changes in the underlying, the net position has no exposure to price movements. However, the hedge will have to be reset after larger changes in the underlying to keep the delta exposure at zero – hence the need for a dynamic trading strategy. .

Exchange Traded Product ("ETP"): An ETP is a general term that encompasses exchange traded funds, notes, and commodities.

In-the-money (ITM): An ITM option is one with a strike such that if the option expired immediately, the option would have a positive payout. In the case of puts, this means the spot prices is lower than the strike while the opposite is true for calls.

Mean Reversion: Mean-reversion is a phenomenon when a certain index or underlying tends to be range bound, has pressure to rise when it gets to a relative low, and tends to fall when it reaches a relative high. Volatility is well known to be mean-reverting.

Moneyness: Moneyness is a term colloquially used to express the relative value of an option strike versus the spot. A moneyness of 95% indicates that the strike price is 5% lower than the current spot price.

Out-of-the-money (OTM): An OTM option is one with a strike such that if the option expired immediately, the option would have no payout. In the case of puts, this means the spot prices is higher than the strike while the opposite is true for calls.

Put Option: An option that gives an investor the right but not the obligation to sell an underlying security at a set price in the future.

Rolldown: With an upward-sloping term structure, the rolldown is the expected loss (in volatility points) of a long vol trade if the term structure remained unchanged until expiry of

the trade. For example if 1-month VIX futures were 3 vol points higher than spot VIX, we would be expected to lose 3 vol points in rolldown if spot VIX were unchanged at expiration.

Sharpe Ratio: The Sharpe Ratio is a measure of the relative attractiveness of an investing strategy, by comparing the annualized excess return of an asset / strategy over a risk-free rate with the strategy's annualized volatility. The Sharpe Ratio is a well-defined when returns are normally distributed. However, for heavy-tailed returns, this measure fails to fully measure the strategy's true downside risk. Other indicators such as CVaR or the Sortino Ratio aim to measure this risk.

Skew: Skew measures how much higher OTM implied volatilities are relative to an ATM implied volatility. For regular index options, generally put implied vols are higher than call implied vols, while the opposite is true for VIX options. One of the most common and simple measures of skew is the different of the implied vols of a 90% moneyness option and a 110% moneyness option.

Straddle: An option strategy that goes long both a put and a call. The strategy benefits if the underlying either goes up or down, but loses if the underlying stays close to its current value. A delta-hedged straddle can be used for pure implied volatility exposure.

Term Structure (Futures): The futures term structure refers to the strip of futures prices for different maturities. This gives a market-implied view on where the price of the underlying will be at maturity. The shape of the term structure is often quoted as the basis.

Term Structure (Volatility): The implied vol term structure is the strip of ATM implied volatilities for different maturities. Typically, the S&P500 implied term structure is upward sloping while the VIX option implied vol term structure is inverted. The shape of the term structure is a visual indicator or the cost of holding onto a volatility position due to rolldown.

Variance Swap: A variance swap is a contract whose long position receives the square of the difference between the realized volatility over the life of the variance and a certain strike. A forward starting variance swap is similar, except that the realized volatility does not begin calculation until some point later on in the future.

Variance swaps have attractive replication properties – they can be semi-statically hedged using a strip of options. This is unlike a volatility swap which cannot be directly replicated. This replication property has made variance swaps the most popular way to trade volatility globally.

Vega: The vega of an option represents the expected dollar change in the price of an option per point change in its implied volatility. A vega of $1 means if an option's implied vol goes from 15% to 16%, the option would increase in value by $1.

The vega of a variance swap represents the expected P&L swing per 1 vol point change from the swap's strike. For example, a vega of $100 on a variance swap means we would expect to gain $200 if realized volatility is 2 vol points higher than the variance swap strike.

Volatility Swap: A long volatility swap is an OTC contract that receives the future realized volatility of an underlying in exchange for a pre-set strike. This product is much less common in the US because it cannot be directly replicated, unlike a variance swap.

Important Information and Qualifications

The information provided herein was prepared by sales, trading, or other non-research personnel of one of the following: Morgan Stanley & Co. Incorporated, Morgan Stanley & Co. International PLC, Morgan Stanley MUFG Securities Co., Ltd, Morgan Stanley Capital Group Inc. and/or Morgan Stanley Asia Limited (together with their affiliates, hereinafter "Morgan Stanley"), but is not a product of Morgan Stanley's Equity Research or Fixed Income Research Departments. This communication is a marketing communication and is not a research report, though it may refer to a Morgan Stanley research report or the views of a Morgan Stanley research analyst. We are not commenting on the fundamentals of any companies mentioned. Unless indicated, all views expressed herein are the views of the author's and may differ from or conflict with those of the Morgan Stanley Equity Research or Fixed Income Research Departments or others in the Firm. For additional information, research reports and important disclosures, see https://secure.ms.com.

Morgan Stanley is not acting as a municipal advisor and the opinions or views contained herein are not intended to be, and do not constitute, advice, including within the meaning of Section 975 of the Dodd-Frank Wall Street Reform and Consumer Protection Act.

This material is not (and should not be construed to be) investment advice (as defined under ERISA or similar concepts under applicable law) from Morgan Stanley with respect to an employee benefit plan or to any person acting as a Fiduciary for an employee benefit plan, or as a primary basis for any particular plan investment decision.

The information provided herein has been prepared solely for informational purposes and is not an offer to buy or sell or a solicitation of an offer to buy or sell the securities or instruments mentioned or to participate in any particular trading strategy. These materials have been based upon information generally available to the public from sources believed to be reliable. No representation is given with respect to their accuracy or completeness, and they may change without notice. Morgan Stanley on its own behalf and on behalf of its affiliates disclaims any and all liability relating to these materials, including, without limitation, any express or implied representations or warranties for statements or errors contained in, or omissions from, these materials. Morgan Stanley and others associated with it may make markets or specialize in, have or may in the future enter into principal or proprietary positions (long or short) in and effect transactions in securities of companies or trading strategies mentioned or described herein and may also perform or seek to perform investment banking, brokerage or other services for those companies and may enter into transactions with them. We may at any time modify or liquidate all or a portion of such positions and we are under no obligation to contact you to disclose any such intention to modify or liquidate or any such modification or liquidation. Morgan Stanley acts as "prime broker" and lender for a number of hedge funds. As a result, Morgan Stanley may indirectly benefit from increases in investments in hedge funds.

Unless stated otherwise, the material contained herein has not been based on a consideration of any individual client circumstances and as such should not be considered to be a personal recommendation. We remind investors that these investments are subject to market risk and will fluctuate in value. The investments discussed or recommended in this communication may be unsuitable for investors depending upon their specific investment objectives and financial position. Where an investment is denominated in a currency other than the investor's currency, changes in rates of exchange may have an adverse effect on the value, price of, or income derived from the investment. The performance data quoted represents past performance. Past performance is not indicative of future returns. No representation or warranty is made that any returns indicated will be achieved. Certain assumptions may have been made in this analysis which have resulted in any returns detailed herein. Transaction costs (such as commissions) are not included in the calculation of returns. Changes to the assumptions may have a material impact on any returns detailed. Potential investors should be aware that certain legal, accounting and tax restrictions, margin requirements, commissions and other transaction costs and changes to the assumptions set forth herein may significantly affect the economic consequences of the transactions discussed herein. The information and analyses contained herein are not intended as tax, legal or investment advice and may not be suitable for your specific circumstances. By submitting this communication to you, Morgan Stanley is not advising you to take any particular action based on the information, opinions or views contained herein, and acceptance of such document will be deemed by you acceptance of these conclusions. You should consult with your own municipal, financial, accounting and legal advisors regarding the information, opinions or views contained in this communication.

These materials may not be distributed in any jurisdiction where it is unlawful to do so. The products described in this communication may not be marketed or sold or be available for offer or sale in a number of jurisdictions where it is unlawful to do so. This publication is disseminated in Japan by Morgan Stanley MUFG Securities Co., Ltd only to those investors who are "Professional Investors" (*tokutei toushika)* as defined in the Financial Instrument Exchange Law of Japan and may not be redistributed to other types of investors without the prior written consent of Morgan Stanley; in Hong Kong by Morgan Stanley Asia Limited; in Singapore by Morgan Stanley Asia (Singapore) Pte. and/or Morgan Stanley Asia (Singapore) Securities Pte. Ltd., each of which is regulated by the Monetary Authority of Singapore and accepts responsibility for its contents of these materials, only to those investors who are institutional investors, accredited investors or expert investors, as defined in the Securities and Futures Act, Chapter 289 of Singapore; in Australia by Morgan Stanley Australia Limited A.B.N. 67 003 734 576, A.F.S.L. No. 233742 and/or Morgan Stanley Australia Securities Limited A.B.N. 55 078 652 276, A.F.S.L. No. 233741, which accept responsibility for its contents; in Canada by Morgan Stanley Canada Limited, which has approved of, and has agreed to take responsibility for, the contents of this publication in Canada; in Spain by Morgan Stanley, S.V., S.A., a Morgan Stanley group company, which is supervised by the Spanish Securities Markets Commission (CNMV) and states that this document has been written and distributed in accordance with the rules of conduct applicable to financial research as established under Spanish regulations; in the United States it is directed only to institutional clients and is distributed by Morgan Stanley & Co. Incorporated, which accepts responsibility for its contents; and in the United Kingdom it is directed only to those persons who are eligible counterparties or professional clients and must not be acted on or relied upon by retail clients (each as defined in the UK Financial Services Authority's rules) and is distributed in the European Union by Morgan Stanley & Co. International plc, except as provided above. Private U.K. investors should obtain the advice of their Morgan Stanley & Co. International plc representative about the investments concerned. In Australia, this publication, and any access to it, is intended only for "wholesale clients" within the meaning of the Australian Corporations Act. The trademarks and service marks contained herein are the property of their respective owners. Third-party data providers make no warranties or representations of any kind relating to the accuracy, completeness, or timeliness of the data they provide and shall not have liability for any damages of any kind relating to such data.

HYPOTHETICAL PERFORMANCE RESULTS HAVE MANY INHERENT LIMITATIONS, SOME OF WHICH ARE DESCRIBED BELOW. NO REPRESENTATION IS BEING MADE THAT ANY ACCOUNT WILL OR IS LIKELY TO ACHIEVE PROFITS OR LOSSES SIMILAR TO THOSE SHOWN. IN FACT, THERE ARE FREQUENTLY SHARP DIFFERENCES BETWEEN HYPOTHETICAL PERFORMANCE RESULTS AND THE ACTUAL RESULTS AND THE ACTUAL RESULTS SUBSEQUENTLY ACHIEVED BY ANY PARTICULAR TRADING PROGRAM.

ONE OF THE LIMITATIONS OF HYPOTHETICAL PERFORMANCE RESULTS IS THAT THEY ARE GENERALLY PREPARED WITH THE BENEFIT OF HINDSIGHT. IN ADDITION, HYPOTHETICAL TRADING DOES NOT INVOLVE FINANCIAL RISK, AND NO HYPOTHETICAL TRADING RECORD CAN COMPLETELY ACCOUNT FOR THE IMPACT OF FINANCIAL RISK IN ACTUAL TRADING. FOR EXAMPLE, THE ABILITY TO WITHSTAND LOSSES OR TO ADHERE TO A PARTICULAR TRADING STRATEGY IN SPITE OF TRADING LOSSES ARE MATERIAL POINTS WHICH CAN ALSO ADVERSELY AFFECT ACTUAL TRADING RESULTS. THERE ARE NUMEROUS OTHER FACTORS RELATED TO THE MARKETS IN GENERAL OR TO THE IMPLEMENTATION OF ANY SPECIFIC TRADING PROGRAM WHICH CANNOT BE FULLY ACCOUNTED FOR IN THE PREPARATION OF HYPOTHETICAL PERFORMANCE RESULTS AND ALL OF WHICH CAN ADVERSELY AFFECT ACTUAL TRADING RESULTS.

Any estimates, projections or predictions (including in tabular form) given in this communication are intended to be forward-looking statements. Although Morgan Stanley believes that the expectations in such forward-looking statement are reasonable, it can give no assurance that any forward-looking statements will prove to be correct. Such estimates are subject to actual known and unknown risks, uncertainties and other factors that could cause actual results to differ materially from those projected. These forward-looking statements speak only as of the date of this communication. Morgan Stanley expressly disclaims any obligation or undertaking to update or revise any forward-looking statement contained herein to reflect any change in its expectations or any change in circumstances upon which such statement is based. Prices indicated are Morgan Stanley offer prices at the close of the date indicated. Actual transactions at these prices may not have been effected.

Morgan Stanley

The trademarks and service marks contained herein are the property of their respective owners. Additional information on recommended securities discussed herein is available on request. This communication or any portion hereof, may not be reprinted, resold or redistributed without the prior written consent of Morgan Stanley.

Options are not for everyone. Before engaging in the purchasing or writing of options, investors should understand the nature and extent of their rights and obligations and be aware of the risks involved, including the risks pertaining to the business and financial condition of the issuer and the underlying stock. A secondary market may not exist for these securities. *For customers of Morgan Stanley & Co. Incorporated who are purchasing or writing exchange-traded options, your attention is called to the publication* ***"Characteristics and Risks of Standardized Options". That publication, which you should have read and understood prior to investing in options, can be viewed on the Web at the following address: http://www.optionsclearing.com/about/publications/character-risks.jsp***
Clients engaging in the execution structure known as Spreading should understand that Spreading may also entail substantial commissions, because it involves at least twice the number of contracts as a long or short position and because spreads are almost invariably closed out prior to expiration. Potential investors should be advised that the tax treatment applicable to spread transactions should be carefully reviewed prior to entering into any transaction. Also, it should be pointed out that while the investor who engages in spread transactions may be reducing risk, he is also reducing his profit potential. The risk/ reward ratio, hence, is an important consideration.
The risk of exercise in a spread position is the same as that in a short position. Certain investors may be able to anticipate exercise and execute a "rollover" transaction. However, should exercise occur, it would clearly mark the end of the spread position and thereby change the risk/reward ratio. Due to early assignments of the short side of the spread, what appears to be a limited risk spread may have more risk than initially perceived. An investor with a spread position in index options that is assigned an exercise is at risk for any adverse movement in the current level between the time the settlement value is determined on the date when the exercise notice is filed with OCC and the time when such investor sells or exercises the long leg of the spread. Other multiple-option strategies involving cash settled options, including combinations and straddles, present similar risk.

The trading of futures or options on futures contains inherent risks. We remind investors that these investments are subject to market risk and will fluctuate in value. The investments discussed or recommended in this communication may be unsuitable for investors depending upon their specific investment objectives and financial position. Where an investment is denominated in a currency other than the investor's currency, changes in rates of exchange may have an adverse effect on the value, price of, or income derived from the investment.

Any performance data included herein represents past performance. Past performance does not guarantee future results. Investment return and principal value of an investment will fluctuate so that an investor's shares, when redeemed, may be worth more or less than their original cost. Current performance may be lower or higher than the performance data quoted.

Please click on the following link for closing market price and net asset value ("NAV") performance data for periods of 1, 5, and 10 years (or the life of the fund, if shorter) for funds discussed in this communication: http://www.morganstanley.com/etf/performance/etfperformance.html.

Please be advised that Morgan Stanley's Institutional Equity Division frequently trades as principal and may have recently traded in the securities that are the discussed in this communication. As a result, Morgan Stanley may have a long or short position in these securities and may or may not have traded in a manner that is consistent with the above comments prior to its dissemination.

We remind investors that these investments are subject to market risk and will fluctuate in value. Investors may obtain prospectuses for the funds described in this sales communication from the ETF distributor. The distributor for the iShares and ProShares ETFs is SEI Investments Distribution Co. The distributor for Dow Diamonds, S&P 500, Mid Cap SPDRs SPDRs, Nasdaq 100 Index, US Oil Fund *ETF* (*USO*), and Select Sector SPDRs is Alps Mutual Fund Services. The distributor for streetTRACKS is State Street Capital Markets, LLC. The distributor for the SPDR Gold Trust ETF (GLD) and the KBW Regional Banking ETF is State Street Global Markets, LLC. The distributor for the Vanguard ETFs is Vanguard Marketing Corporation. The distributor for Rydex ETFs is Rydex Distributors, Inc. The distributor for WisdomTree ETFs is ALPS Distributor, Inc. The distributor for Claymore ETFs is Claymore Securities, Inc. The distributor for PowerShares is Invesco Aim Distributors, Inc. The distributor for ProShares is SEI Investments Distribution Co. The distributor for iPath ETNs is Barclays Capital Inc. The distributor for Market Vectors ETFs is Van Eck Securities Corp. The distributor for Claymore ETFs is Claymore Securities Inc. The distributor for Bear Stearns ETF is Bear Stearns & Co. Inc. The distributor for Direxion Shares and RevenueShares™ ETFs is Foreside Fund Services LLC. The distributor for ELEMENTS^{SM} ETNs is Nuveen Investments/Merrill Lynch & Co. The distributor for First Trust ETFs is First Trust Portfolios L.P. The distributor for MacroShares^{TM} ETFs is W.R. Hambrecht & Co., LLC. The distributor for RydexShares^{TM} is Rydex Distributors, Inc. The distributor for UBS E-TRACS ETNs is UBS Securities LLC. The prospectuses contain more complete and important information about the ETFs and should be read carefully before investing. We define exchange-traded funds as encompassing passively managed index-linked exchange-traded funds, HOLDRs, and closed-end funds. This report is focused on US exchange-traded funds. These funds are registered with the SEC and trade as a single stock under SEC exemptions. ETFs are (i) redeemable only in creation unit size aggregations and may not be individually redeemed, (ii) redeemable only through Authorized Participants, and (iii) redeemable on an "in-kind" basis.

ETFs do not charge sales loads or other nonrecurring fees, but you may pay a brokerage commission on the purchase or sale of ETF shares. Any performance data shown in this communication does not reflect the deduction of a brokerage commission, which would reduce the performance quoted.

Please contact your Morgan Stanley representative for the name of the name of the distributor of any funds mentioned in this sales communication that have not been included above.

Morgan Stanley