Volatility as an asset class

Some insights

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Contents

1. Volatility as an asset class

Introduction to Volatility – A Powerful Risk Management Tool

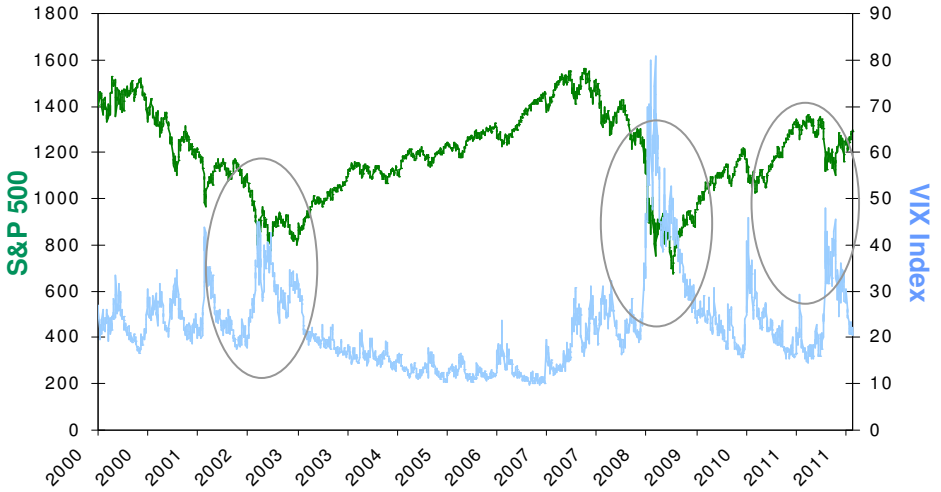
When Everything is Going Down at the Same Time…Volatility Tends to Spike!

Volatility as risk indicator

- Volatility has been a long used indicator for measuring risk
- It has emerged as a key component in building asset allocation under risk budgeting methodology

Volatility as asset class & tail risk hedge

- Due to its negative correlation with equities and other asset classes, volatility has become popular among investors of all types
- Equity volatility is now commonly used not only as a systematic hedge to an equity portfolio, but also tactically to generate alpha
- The popularity of using equity volatility as both a hedge and a tactical investment is evident through the growth of VIX futures contracts



"VIX falls below key 30 level as fear eases" *FT, 5/20/2009*

"Fear index jumps amid new worries over banking losses" *FT, 12/28/2007*

"Fear fuels VIX's jump" *WSJ, 10/2/2009*

Volatility emerges as both a risk indicator and an asset class

Source: Bloomberg, BNP Paribas. Data from January 1, 2000 to March 1, 2012. Past performance is not indicative of future performance.

Volatility – an asset class of its own

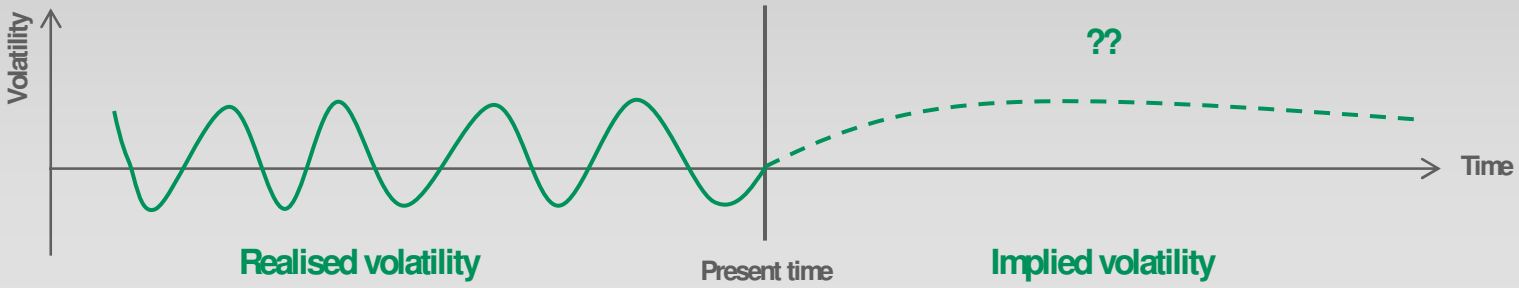
Two notions of volatility: Implied and realised

Realised Volatility – Observation

- Historical volatility is calculated from the known past returns of an asset
- It is a mathematical observation only (it is not an asset class)

Implied Volatility – Market Price

- The market's assessment of future volatility, the price of volatility given by the market
- It is truly an asset as volatility is traded at this price



Hypothetical example for illustrative purposes only and not indicative of actual trading results.

Volatility: The only truly anti-correlated asset class

Explaining factors for the anti-correlation of volatility to traditional asset classes

- **Leverage Effect (Fundamental Explanation)[1]**
  - When equity market prices are decreasing, the debt/equity ratio of companies increases implying that the stock market becomes more risky as a whole. This leads to **higher Implied Volatility priced in by the market**

- **Market Stress**
  - A change in equity markets leads to portfolio moves generated by investors taking their gains. This is particularly true when stop-loss limits are being breached. The **overall increase of traded volumes leads to higher volatility levels in the market**, hence to an increase of the risk appreciated by vanilla traders

- **Vanilla Markets**
  - Decreasing equity market prices generate a need for portfolio hedges by different financial institutions/ real money managers. **A rising demand for vanilla puts** leads to an increase of implied volatility

[1] *Christie, 1982 – "The Stochastic Behavior of Common Stock Variances: Value, Leverage and Interest Rate Effects"*

2. How to trade volatility?

Options used as hedging instruments

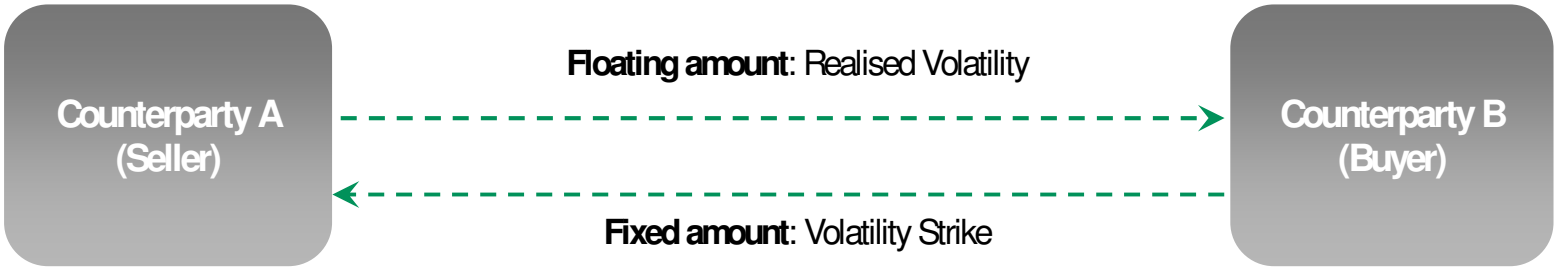
- **Buying Vanilla Puts – a first option when thinking of hedging a portfolio**
  - Vanilla Puts pay directly the positive difference between a pre-determined level (strike) and the final spot
  - Buying options procures exposure to the market spot price and interest rates
  - **Vega decay:** loss of sensitivity to volatility (Vega) as time goes by
  - The main issue with Vanilla Puts is a market timing issue:
    - Vanillas are only effective if the entry and exit points are optimal
  - **Linear Exposure to Volatility**, plus other sensitivities

- **Options can be delta hedged to gain a pure volatility exposure**
  - Vega decay becomes very problematic
  - Options lose sensitivity when the spot price moves!
  - **Linear Exposure to Volatility**

Volatility Swaps: a pure and linear exposure to volatility

Definition:

Volatility Swaps are Over-the-Counter (OTC) instruments through which one can gain exposure to **pure volatility**. Volatility Swaps allow investors to **focus on Realised Volatility**. For a given underlying, a Volatility Swap is the exchange of a floating amount, the unknown future Realised Volatility (σR), against a pre-determined fixed amount, the Volatility Strike (KVOL), both applied on a specified notional amount (N), also referred to as Volatility Units



Capturing the premium between Realised and Implied volatility

Payoff:

$$\text{Notional} \times (\sigma_R - \text{K}_{\text{Vol}}) \times N$$

Realised Volatility:

$$\sigma_{\text{R}} = 100 \times \sqrt{\frac{252 \times \sum_{t=1}^{N} \left(Ln\left(\frac{P_t}{P_{t-1}}\right)\right)^2}{\text{Expected}N}}$$

- P_t and P_{t-1} are the official levels of the underlying on respectively the t^{th} and $t\text{-}1^{th}$ observation days (in most cases: daily closing price)
- **N** is the total number of realised trade days
- **Expected N** is the number of agreed trading days

Hypothetical examples for illustrative purposes only and not indicative of actual trading results.

Hedging with Volatility Swaps

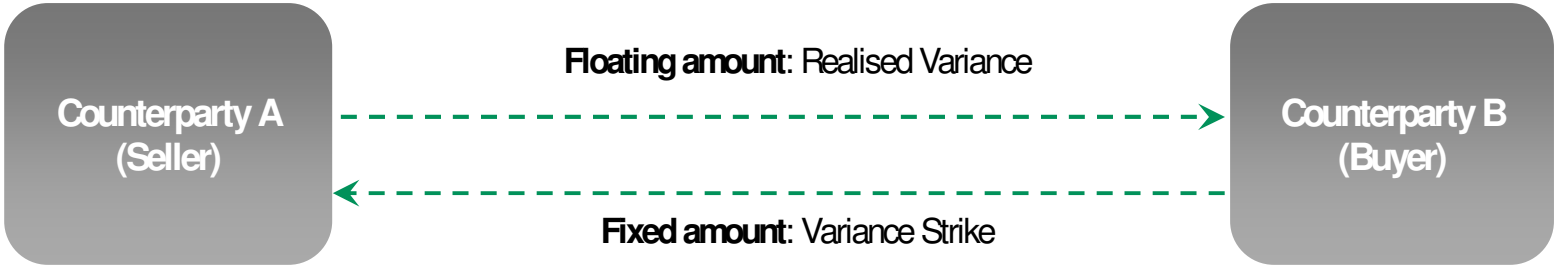
- **Volatility Swaps offer a linear exposure to Realised Volatility but are still not an optimal hedging solution**
  - High dependency on market timing (entry point)
  - **High Cost of Carry** as there is a risk premium between Implied and Realised Volatilities
  - **Vega decay:** Vega decreases as time goes by
  - **Linear exposure to Realised Volatility**

Benefits	Drawbacks
■ Simple and efficient tool to trade pure volatility ■ Low maintenance: No delta hedging required ■ Zero upfront cost ■ Liquid markets on main indices & blue chips	■ Low liquidity on smaller indices and stocks ■ Cost of Carry on being long volatility ■ Vega decay ■ Complicated to evaluate

Variance Swaps: a pure exposure to volatility with a simple payoff structure

Definition:

One of the most liquid instrument in the Over-the-Counter (OTC) market through which one can obtain exposure to **pure volatility**. Variance Swaps allow investors to **focus on Realised Variance**. For a given underlying, a Variance Swap is the exchange of a floating amount, the unknown future Realised Variance (σR^2), against a pre-determined fixed amount, the Variance Strike (KVAR), both applied on a specified notional amount (N), also referred to as Variance Units



Capturing the premium between Realised and Implied Variance

Payoff:

$$\text{Notional} \times \left(\sigma^2 - \text{K}^2\right)$$

Realised Volatility:

$$\sigma_{\text{R}} = 100 \times \sqrt{\frac{252 \times \sum_{t=1}^{N} \left(Ln\left(\frac{P_t}{P_{t-1}}\right)\right)^2}{\text{Expected}N}}$$

- P_t and P_{t-1} are the official levels of the underlying on respectively the t^{th} and $t\text{-}1^{th}$ observation days (in most cases: daily closing price)
- **N** is the total number of realised trade days
- **Expected N** is the number of agreed trading days

Hypothetical examples for illustrative purposes only and not indicative of actual trading results.

Hedging with Variance Swaps

Buying Realised Variance

- Assuming that the price of a 1-year Variance Swap was 100 with a reference volatility at 21%. The table below shows the sensitivity of the 1-year Variance Swap prices, if the volatility has realized at 17% for a given period of time (e.g. 1 month, 2 months …) and if the implied level is at 25% for the remaining time until maturity (e.g. 11 months, 10 months …)

	1M	2M	3M	4M	5M	6M	7M	8M	9M	10M	11M	12M
Var Swap	135*	129	123	116	110	104**	97	91	85	78	72	66***

A Var Swap loses Vega as time goes by

Variance Swaps are not an efficient hedging solution

- High dependency on market timing (entry point)
- **High cost of carry** as there is a risk premium between Implied and Realised Volatilities
- **Vega decay**: Vega decreases as time goes by
- **Convex (Square) exposure to Realised Volatility**

Benefits	Drawbacks
■ Efficient tool to trade pure volatility	■ Low liquidity on smaller indices and stocks
■ Low maintenance: No delta hedging required	■ Cost of carry on being long volatility
■ Zero upfront cost	■ Vega decay
■ Liquid markets on main indices & blue chips	
■ Relatively easy to replicate and price	
■ Implied/ Realised additivity	

*Hypothetical examples for illustrative purposes only and not indicative of actual trading results. * 135 = (25^2 * 11/12 + 17^2 * 1/12)/ 21^2). ** 104 = (25^2 * 6/12 + 17^2 * 6/12)/ 21^2). *** 66 = $17^2/21^2$.*

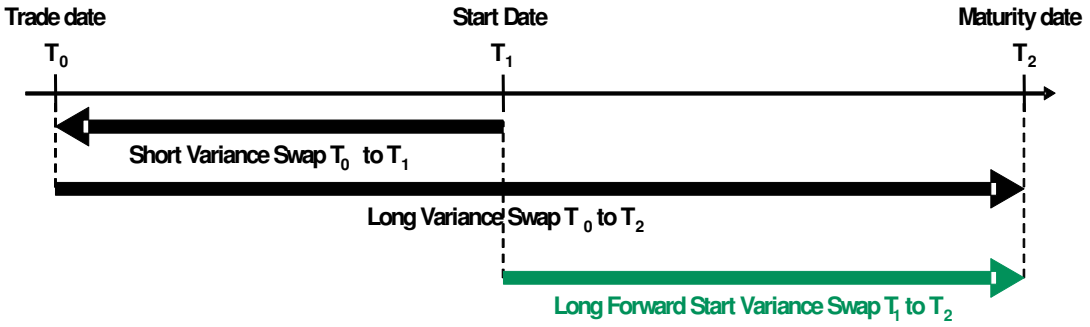
Forward Variance Swap: avoid Implied vs. Realised Volatility issues

- **Definition:**

  Similar principle as a Variance Swap with the exception that the observation start date begins at some time in the future after the trade date. They enable investors to take a position on the value of future volatility and thus the investor can capture **Forward Implied Volatility** with a calendar spread between two pre-fixed future dates

- **Replication with standard Variance Swaps:**

Pure exposure to Implied Volatility



- **Payoff:** $\text{Notional} \times \sigma_R^2 \text{ (between } T_1 \text{ and } T_2)$

- **Realised Volatility:**

$$\sigma_R = 100 \times \sqrt{\frac{252 \times \sum_{i=T+1}^{T'} \left(\ln\left(\frac{P_i}{P_{i-1}} \right) \right)^2}{T_2 - T_1}}$$

- P_t and P_{t-1} are the official levels of the underlying on respectively the t^{th} and $t\text{-}1^{th}$ observation days (in most cases: daily closing price)
- **T** is the official level of the underlying on the t^{the} observation day (in most cases daily closing price)

Hedging with Forward Implied Volatility

Buying Implied Volatility

- Assuming that the prices of a 1-year Variance Swap and a 1-year Forward Variance Swap were 100 each with a reference volatility of 21% for the Variance Swap and 22% for the Forward Variance Swap. The table below shows the sensitivity of the 1-year Variance Swap prices, if the volatility has realised at 17% for a given period of time (e.g. 1 month, 2 months …) and if the implied level is at 25% for the remaining time until maturity (e.g. 11 months, 10 months …)

	1M	2M	3M	4M	5M	6M	7M	8M	9M	10M	11M	12M
Var Swap	135*	129	123	116	110	104	97	91	85	78	72	66
Fwd Var Swap	129**	129	129	129	129	129	129	129	129	129	129	129

A Variance Swap loses Vega as time goes by –> Forward Variance Swaps do not

Forward Variance Swaps, an efficient hedging solution

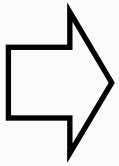
- **Excellent reactivity to market drops** and **structurally floored**
  - Implied Volatility goes up when markets go down
  - No trader wants to sell volatility at a low level because the potential gain is by far much lower than the potential loss
- **Strong de-correlation in bearish, less in bullish markets**
  - Reactivity is greater in times of crisis; however, volatility needs time to go back to low levels
- **No Vega decay**
  - Sensitivity to volatility is the same from the beginning to the end
- **No Carry Costs**
  - the investor buys and receives Implied Volatility
- **Convex exposure to Implied Volatility**

Benefits	Drawbacks
■ **Cost-effective way** to buy exposure to Implied Volatility (only before start date) ■ No net exposure to Realised Volatility until after the expiry of the shorter dated swap ■ Low maintenance ■ Zero upfront cost ■ **No Vega decay, No Carry Costs, Convex exposure to Implied Volatility**	■ With a steeper term structure, there is a negative carry on the Forward Start Variance swap compared to a standard Variance Swap

*Hypothetical examples for illustrative purposes only and not indicative of actual trading results. * 135 = (25^2 * 11/12 + 17^2 * 1/12)/ 21^2). ** 129 = 25^2/ 22^2.*

Instruments used to invest in volatility

- **Puts**
- **Delta hedged Puts**
- **Variance Swaps: Investing in the Spot Implied Volatility**
  - Exchange of **Realised Volatility** at maturity with a **pre-determined fixed amount**, the "Variance Strike"
    - **High Carry Costs**: Implied volatility (strike) is structurally higher than Realised Volatility
    - **Sensitivity to volatility decreases** as volatility progressively realises over time
- **Volatility Swaps**
- **Forward Variance Swaps: Investing in Forward Volatility**
  - Exchange of **Forward Realised Volatility** at maturity with a **pre-determined fixed amount**, the "Variance Strike"



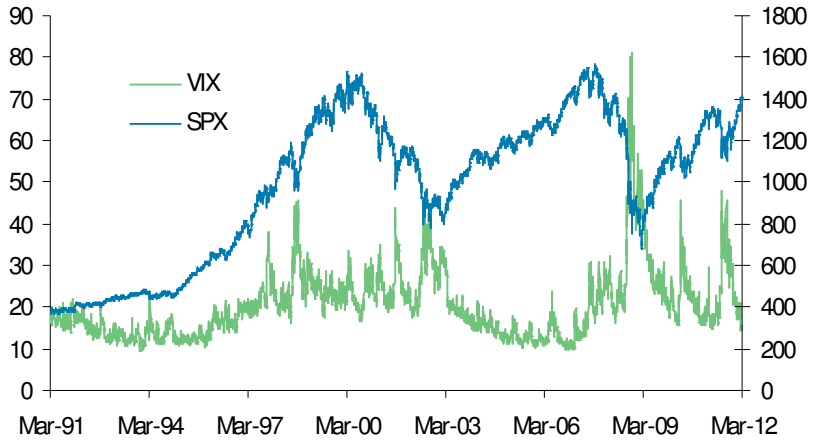
- **No Carry Costs** (but possible roll cost)
- **Pure exposure** to implied volatility
- **Excellent reactivity** to market drops

3. A case study

Why Investors trade volatility?

Diversify a portfolio/Tail-Risk Protection

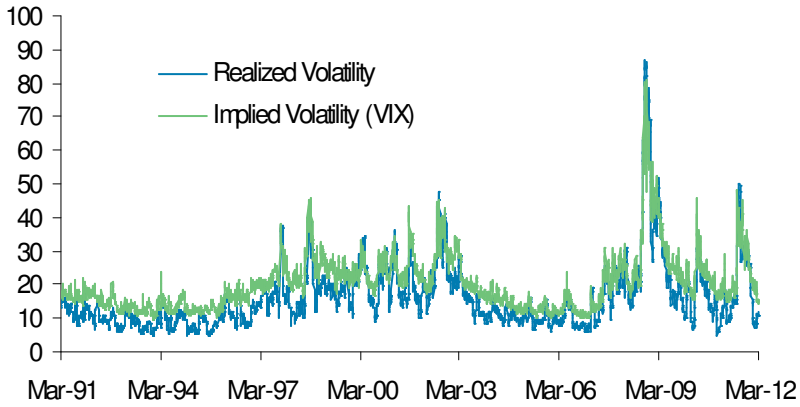
S&P 500 & 1-Month Implied Vol (VIX)



Source: BNP Paribas Equity Derivative Strategies
Past performance is not indicative of future results, which may be better or worse than prior results.

Take active exposure to new risks

S&P 500 & 1-Month Implied Vol (VIX)



Source: BNP Paribas Equity Derivative Strategies, Bloomberg
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First order volatility strategy

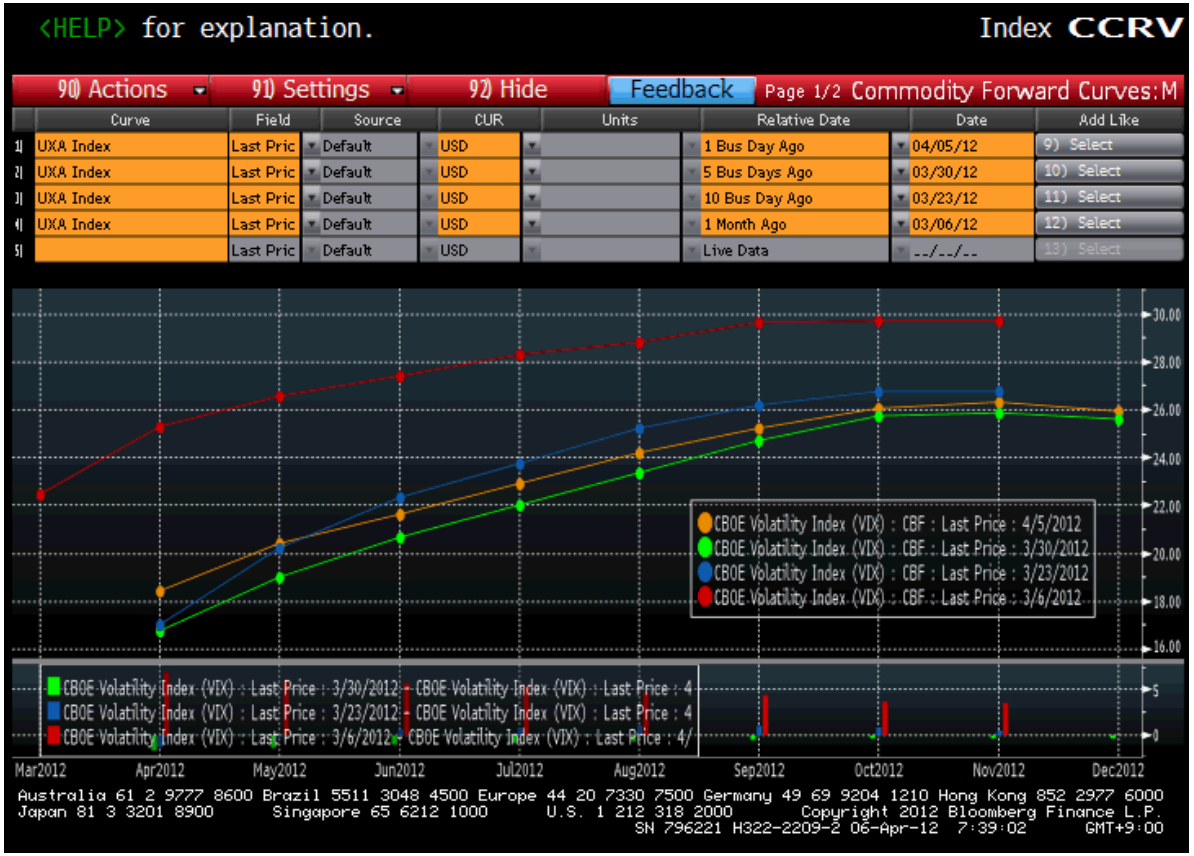
Diversify a portfolio
Tail Risk Hedging

Second order volatility strategy

Pick up a volatility risk premium…
- **the implied-to-realized volatility spread**
- **trade tactically in short-term**
- **trade strategically in long-term**

…or higher-order vol risk premia...
- **term structure steepness**
- **skew steepness**
- **convexity**

The shape of the VIX Term Structure



➡ **As the term structure is more often in "Contango", there is a roll cost or *perhaps an opportunity***

Hypothetical example for illustrative purposes only and not indicative of actual trading results.

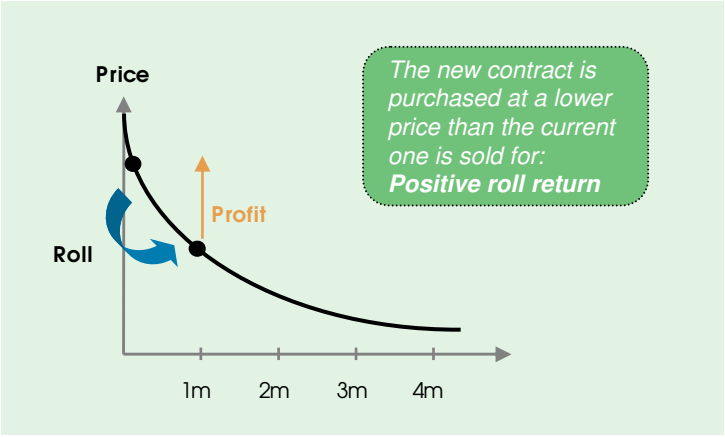
The Ups and Downs of the Roll Cost

- ***To maintain a forward exposure, any strategy invested in futures needs to roll its position***
- ***Depending on the term structure of volatility, the roll is made at a loss or at a gain.***

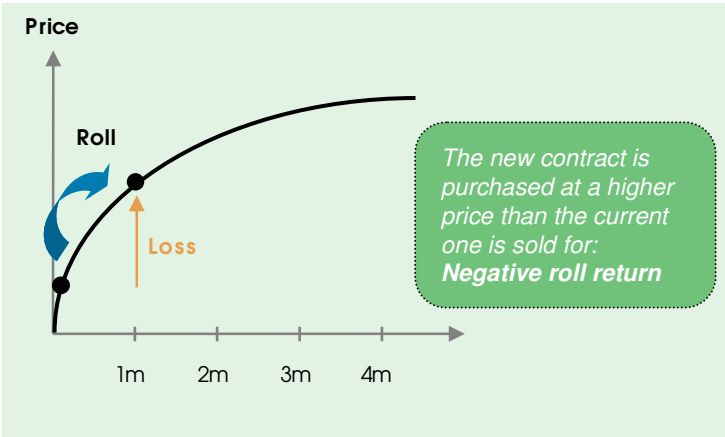
If term structure is in "Backwardation" the roll will be made at a gain

If term structure is in "Contango", the roll will be made at a loss.

Forward curve in backwardation



Forward curve in contango



Hypothetical example for illustrative purposes only and not indicative of actual trading results.

How to minimize the contango effect yet maintain a long vol position?

BNPIVIX combines techniques of roll enhancement from commodity space and integrates layers of risk control

BNP Paribas Enhanced Volatility Index

- **High Beta to VIX**
- **Enhanced Carry (*)**

Portfolio allocation is modified daily so as to:

- **Be 100% invested across the 7 nearest term futures**
- **Dynamically reallocate to optimize the carry of the portfolio:** five days for full reallocation in front month
- **Monitor liquidity constraints:** limits are imposed on the rebalancing amount allowed for each future contract based on available liquidity
- **Monitor over-exposure risk:** avoid being over exposed to front month futures as expiry approaches
- The performance of BNPIVIX is inclusive of **replication costs**

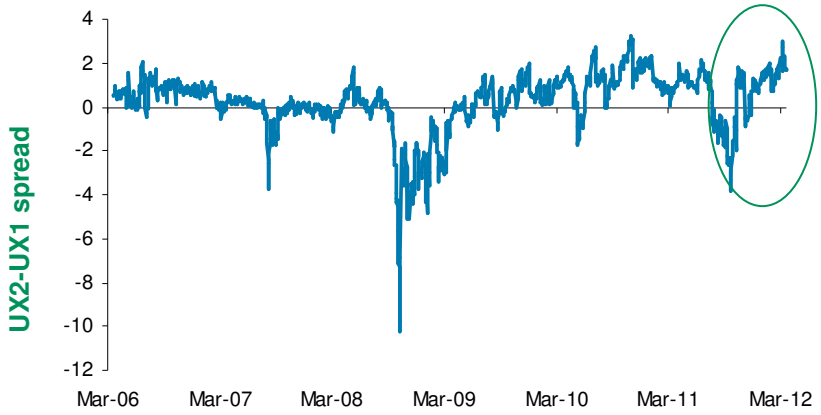
(*) Risk Disclosure : A long exposure to BNPIVIX can incur a negative cost of carry

VIX Term structure – Second order volatility strategy

Exploring Factors behind the steepness of the Volatility Term-Structure

The State of the Volatility Term-Structure

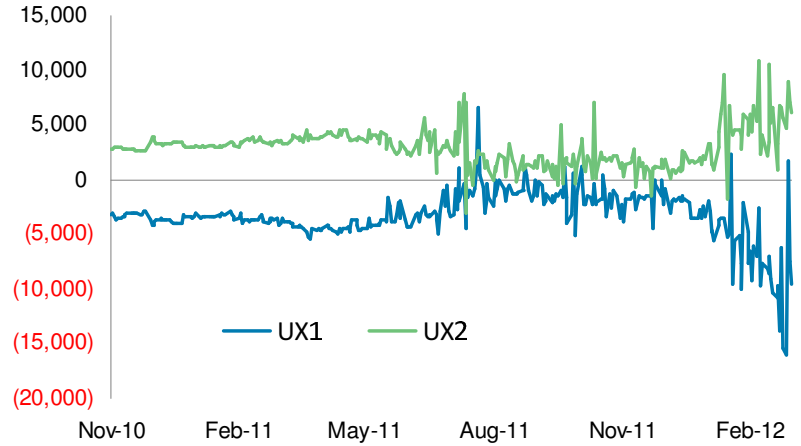
- The elevated level of steepness is at least partially due to the ultra-low level of realized volatility that we have witnessed in recent months.
- The profitability of hedging short-dated options (which have significant "gamma" exposure) is heavily dependent on the level of realized volatility.
- As a result of this relationship, the implied volatility of short-dated SPX options (measured succinctly by the VIX) closely tracks SPX realized volatility.



Volatility ETPs Likely Exacerbate Steepness

- In addition to the aforementioned effect of low realized volatility, we find that the elevated level of steepness has likely been exacerbated by the increasing popularity of volatility exchange traded products (ETPs).
- This is because many of the large volatility ETPs have to systematically buy VIX 2nd month futures and sell VIX front month futures on a daily basis to fulfill their mandate.
- Moreover, the assets under management of the largest volatility ETPs have increased dramatically, causing this activity to become an increasingly large share of total VIX futures trading.

Daily UX1 and UX2 Volume Needed to hedge VIX ETPs (# of shares of UX1 and UX2)



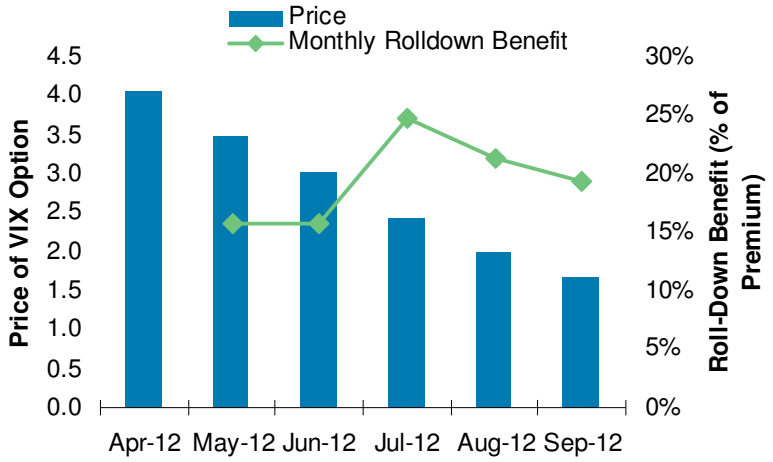
Source: Bloomberg, BNP Paribas. Data from January 1, 2000 to March 1, 2012. Past performance is not indicative of future performance.

How to monetize the VIX Term structure

Exploring Ways to Play the Steep Volatility Term-Structure

Rationale for Buying VIX Put Options

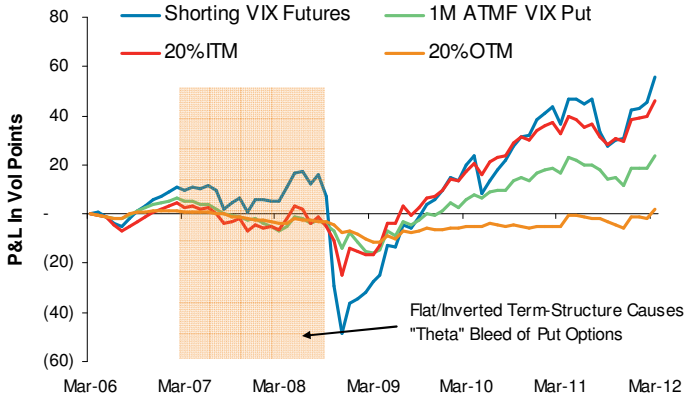
- This strategy is particularly attractive for investors who wish to position for lower volatility while limiting their losses to the premium paid. (*The risk of buying a put option is the loss of the entire amount of the premium paid.)*
- It is interesting to note that, because the term-structure is upward sloping, investors can buy VIX put options that cost less than their intrinsic value with respect to VIX spot. For example, the July 20-strike put option indicatively costs 2.35, while VIX spot last closed at 15.51 (as of this writing).



A Systematic Comparison vs. Selling VIX Futures

- For investors who don't wish to spend upfront premium on VIX positioning, a more aggressive strategy to consider is selling VIX futures directly.
- In order to objectively compare both strategies, we backtested a variety of systematic short VIX strategies (using front-month options or futures), including 1) Selling VIX futures outright; 2) Buying ATM VIX puts; 3) Buying OTM VIX puts; 4) Buying ITM VIX puts.
- For the ITM and OTM backtests, we used 120% and 80% moneyness as a percentage of the futures price, respectively, (or the nearest strike available to 120% and 80%) at trade inception.

Time Series of Different VIX Strategies



Source: BNP Paribas. These simulations are the result of estimates made by BNP Paribas at a given moment on the basis of the parameters selected by BNP Paribas, of market conditions at this given moment and of historical data, which should not be used as guidance, in any way, of future performance.

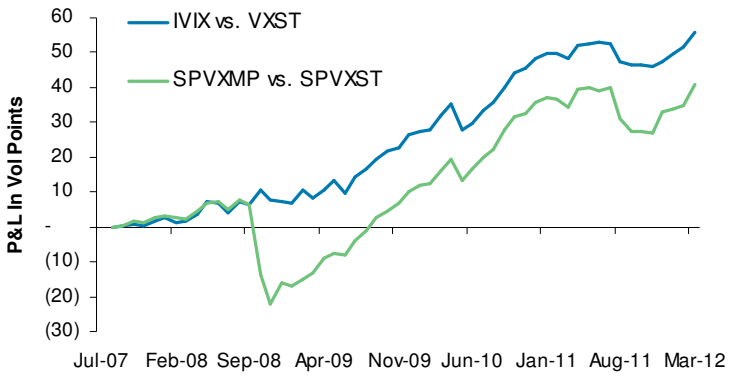
How to monetize the VIX Term structure

Exploring Ways to Play the Steep Volatility Term-Structure

Strategies to Play the Term-Structure With Indices

- Generally speaking, the steepest portion of the VIX term-structure tends to be at short-dated maturities.
- "Thus, investors who wish to monetize the term-structure roll-down without executing an outright view on volatility should consider buying IVIX vs selling a short dated VIX futures product such as VXX or BNPIVZXST.
- Because IVIX dynamically allocates exposure across the term-structure, this L/S strategy avoids much of the poor returns when the term-structure is inverted. This is because when volatility is elevated, the term-structure tends to be inverted, causing IVIX to position in shorter-dated VIX futures.

L/S Strategy : IVIX / IVXST vs. SPVXMP / SPVXST



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L/S Strategy Statistics*

	Avg Monthly Return	Standard Deviation	Return vs. Risk	Correlation to Short VIX Futures
BNPIVIX vs BNPVXST	1.01	2.50	0.40	0.43
SPVXMP vs. SPVXST	0.75	4.20	0.18	0.94
Short VIX Futures	0.97	8.00	0.12	1.00

Source: BNP Paribas.
**Statistics differ from those on previous page as the data sample we used is different (starting in 2007 vs. 2006). Past performance is not indicative of future results, which may be better or worse than prior results.*

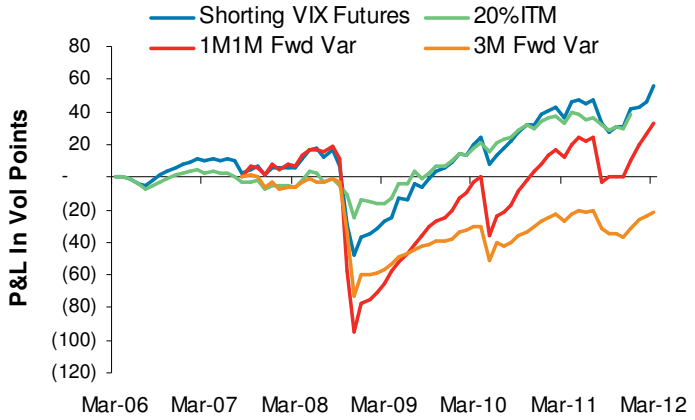
How to monetize the VIX Term structure

Exploring Ways to Play the Steep Volatility Term-Structure

General Conclusions on Selling Volatility

- For investors looking to capture volatility risk premia, VIX futures and puts have historically provided better risk-adjusted returns than forward variance swaps.
- Short VIX futures positions outperformed variance positions particularly in tumultuous markets. This is because VIX futures do not have the dangerous volatility convexity embedded in variance swaps.
- Of the short volatility strategies that we analyzed, selling volatility through ITM VIX put options has historically provided the best risk-adjusted returns.
- Compared to the other short volatility strategies discussed, ITM VIX put options protected investors from volatility shocks such as Fall 2008, May 2010 and August 2011.

Backtests of Various Strategies



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Statistical Comparison of Short Volatility Strategies*

	Avg Monthly Return	Standard Deviation	Return vs. Risk	Correlation to Short VIX Futures
ITM VIX Put	0.81	4.50	0.18	0.83
Short VIX Futures	0.97	8.00	0.12	1.00
Short 1M1M Fwd Var	0.61	13.56	0.04	0.92
Short 3M3M FwdVar	-0.39	8.31	-0.05	0.86

Source: BNP Paribas.
**Statistics differ from those on previous page as the data sample we used is different (starting in 2007 vs. 2006). Past performance is not indicative of future results, which may be better or worse than prior results.*

Conclusion

Benefits of volatility Strategies

1. **Diversification**: An uncorrelated asset class
2. **Protection** a long volatility profile should mitigate some downside risk during crises
3. **Alpha source** volatility trades can bring a new source of alpha via higher order strategies

RISK: One must bear in mind that most volatility strategies will incur a steep carry cost.

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