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CBOE S&P 500[®] VARB-X[™] Strategy Benchmark

Volatility is a key component in option pricing; and correctly forecasting volatility is something of a “holy grail” to many options traders. Implied volatility – the volatility theoretically implied by option prices – is simply a prediction of realized volatility, or volatility based on actual prices of the index or stock on which the options are based.

Remarkably, the market’s best guess of future volatility, as measured by option prices, is often wrong. Over time, index implied volatility has tended to be higher than realized volatility. In an effort to capture this difference, various option strategies have been devised, collectively referred to as “selling vol” or “selling premium.” These strategies involve large amounts of risk, can be complex and costly to implement and are often difficult to manage. As a result, they are likely to be used by only a handful of professional traders.

A few years ago, over-the-counter dealers began offering products designed to facilitate volatility trading. As the market has evolved, the most liquid and competitively quoted contracts have been based on variance (volatility squared) rather than volatility. This is because variance contracts are generally easier to model and hedge than contracts based on volatility.

In June 2004, the CBOE Futures Exchange (CFE[®]) introduced CBOE S&P 500 Three-Month Variance Futures, the first exchange-traded contract in the U.S. to isolate pure realized variance exposure. This contract allows investors to cleanly trade the difference between implied and realized variance of the S&P 500 Index.

The CBOE S&P 500[®] VARB-X[™] (“Volatility ARBitrage”) Strategy Benchmark is CBOE’s most recent effort to highlight new and interesting trading strategies that use options and futures. The VARB-X Benchmark capitalizes on the historical spread between implied and realized volatility by holding a rolling short position in three-month variance futures, subject to a set of objective risk-limiting guidelines.

The VARB-X Benchmark was set to 100.00 as of June 17, 2004. Since inception, the VARB-X Benchmark has grown at a compounded annual rate of 8.6% with an annualized volatility of 4.5%. As of October 25, 2007, the Benchmark level was 132.08. On March 14, 2007, CBOE began disseminating daily VARB-X values under the ticker symbol “VTY”.

VARB-X Benchmark Construction

The VARB-X Benchmark tracks the return of a hypothetical strategy that involves systematically selling CBOE S&P 500 Three-Month Variance Futures contracts. Assuming an initial cash investment of \$1 million, the VARB-X Benchmark employs a set of guidelines intended to limit trading losses of a strategy that is inherently risky and can result in dramatic drawdowns.

The first guideline is a fixed notional limit of 25%; i.e., each quarter, the notional value of the short variance futures position may not exceed 25% of available capital. For example, the notional value of a variance futures contract with a price of 400 is \$20,000 (400 x \$50 per point).

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Applying the 25% notional limit to the initial capital of \$1 million, the allowable size of the short variance futures position would be 12.5 contracts (25% x \$1 million / \$20,000).

The second guideline constrains the size of the short position based on potential trading losses. VARB-X is designed so that the number of contracts deemed sold is limited by the trading loss that would occur if three-month realized volatility was 25 points higher than the volatility implied by the sale price of the variance futures contract.

In the example above, if three-month realized volatility at settlement were 45% (25 points higher than the volatility implied by the sale price of the variance futures), the expected loss on 12.5 short futures would exceed \$1 million. In order to satisfy the second guideline, the position would be reduced to 3.07 contracts ($3.07 \times \{45^2 - 20^2\} \times \$50 = \$249,438$).

Since January 2002, three-month realized volatility has exceeded three-month implied volatility¹ less than 16% of the time. On average, the difference between realized and implied volatility was just over 4 points, and never greater than 14 points.

Between 1928 and 2001, three month realized volatility has exceeded three month implied² by more than 25 points 4.2% of the time. However, that number drops to just 0.4% by excluding market activity prior to 1940. Three month realized volatility has exceeded 65% only twice since 1928: in the weeks following the 1929 stock market crash and again in October 1932. Moreover, 99.7%, about three standard deviations, of rolling three-month realized volatility observations of the S&P 500 Index have been less than 65%.

VARB-X Benchmark Calculation

The VARB-X Benchmark is calculated by stringing together returns from successive three-month Trading Periods. A Trading Period begins with the sale of the variance futures position at the open on the third Friday of each calendar quarter and ends when the futures expire, at the open on the third Friday of the following calendar quarter. Daily VARB-X Benchmark values, disseminated as **VTY**, are calculated as follows:

$$VTY_t = VTY_{\text{Period Init},i} \times [1 + \text{Period Return}_i];$$

$VTY_{\text{Period Init},i}$ is the value of the VARB-X Benchmark at the beginning of the i^{th} Trading Period.

VARB-X Benchmark Period Returns are derived from two sources. The first is simply the cumulative futures income/loss for a given Trading Period:

$$F_{P\&L} = \text{Futures Income/Loss} = [P_{\text{init}} - P_t]$$

Where:

P_{init} = Sale price of three-month variance futures

¹ As measured by the CBOE S&P 500 3-Month Volatility Index (VXV)

² VXV historical values have not been calculated prior to 2002. A proxy for three month implied volatility is deemed to be the long-term average of rolling three month realized volatility of the S&P 500 Index (15.7%) from 1928 through 2001.

P_t = Price of three-month variance futures on day t

The second source of returns is the interest income on available capital compounded daily at the Three-Month U.S. Treasury Bill rate³:

$$I_t = \text{Daily Interest Income} = (1+R) \times (C_A + I_{\text{Cumulative},t-1}) \times \Delta t ;$$

And

$$I_{\text{Cumulative}} = \sum_{\text{Trading Period}} I_t$$

Where:

C_A = Available capital; i.e., initial capital *plus* cumulative strategy income/loss through the latest completed trading period; futures income/loss in the current trading period does not earn interest.

$I_{\text{Cumulative}}$ = Cumulative interest for trading period

R = Three-Month U.S. Treasury Bill Rate

Δt = Number of calendar days between consecutive trading days \div 360

VARB-X Benchmark Period Returns are calculated by dividing the strategy's total income/loss in a Trading Period by the available capital at the beginning of that period:

$$\text{Period Return}_i = (F_{P\&L,i} + I_{\text{Cumulative},i}) / C_A$$

Initial Trading Period

At inception on June 18, 2004, the initial capital allocated to the VARB-X strategy was \$1 million. The opening price of CBOE S&P 500 Three-Month Variance futures expiring in September was 288.50 (16.99 volatility) – corresponding to a notional value of \$14,425 (288.50 x \$50 / variance point). Subject to the 25% notional limit, the strategy called for the sale of 17.33 volatility contracts (\$1 million x 25% / \$14,425).

The trading loss for this position, assuming a three-month realized volatility at settlement of 41.99 (16.99 + 25), would be \$73,700 ($\{1,762.50 - 288.50\} \times \50) per contract, or a total loss of almost \$1,277,000, more than 5 times the established target of \$250,000! In order to stay within the strategy's risk guidelines, the number of volatility futures contracts deemed sold was reduced to 3.39 ($\$250,000 / \$73,700$).

On June 18, 2004, the closing price of the variance futures was 293.50. As shown in the following table, the P&L on that day was simply the futures loss of \$847.50 (3.39 contracts x 5.00 x \$50), a Period Return of -0.08%. The VARB-X level for June 18, 2004, then was 99.92 (100.00 x [1 - 0.0008]). On subsequent days, the daily Total P&L is a combination of Futures P&L plus interest on the cash balance available at the beginning of a Trading Period.

³ Based on CBOE Three-Month U.S. Treasury Bill Index (IRX)

| Date | Number of Short Volatility Futures | Futures Price | Futures P&L (F _{P&L}) | T-Bill Rate | Interest (I _{Cumulative}) | Total P&L | Period Return | VTY |
|-----------|------------------------------------|---------------|-------------------------------------|-------------|-------------------------------------|-----------|---------------|---------------|
| 17-Jun-04 | 3.39 | | | | | | | 100.00 |
| 18-Jun-04 | 3.39 | 293.50 | (\$848) | 1.24% | \$0 | (\$848) | -0.08% | 99.92 |
| 21-Jun-04 | 3.39 | 284.00 | \$763 | 1.24% | \$103 | \$866 | 0.17% | 100.09 |
| 22-Jun-04 | 3.39 | 260.00 | \$4,831 | 1.29% | \$138 | \$4,968 | 0.41% | 100.50 |
| 23-Jun-04 | 3.39 | 242.00 | \$7,882 | 1.26% | \$173 | \$8,055 | 0.31% | 100.81 |
| | | | | | | | | |
| 13-Sep-04 | 3.39 | 111.50 | \$30,002 | 1.62% | \$3,384 | \$33,386 | 3.34% | 103.34 |
| 14-Sep-04 | 3.39 | 109.00 | \$30,425 | 1.62% | \$3,429 | \$33,855 | 3.39% | 103.39 |
| 15-Sep-04 | 3.39 | 111.00 | \$30,086 | 1.63% | \$3,475 | \$33,561 | 3.36% | 103.36 |
| 16-Sep-04 | 3.39 | 108.50 | \$30,510 | 1.63% | \$3,520 | \$34,030 | 3.40% | 103.40 |
| 17-Sep-04 | 3.39 | 107.61 | \$30,661 | 1.67% | \$3,566 | \$34,227 | 3.42% | ** |

On September 17, 2004, the final settlement price for the expiring volatility futures was 107.61. The gain on the short futures position, F_{P&L}, was \$30,661 ([288.50 – 107.61] x \$50 x 3.39). Additionally, the cumulative interest income, I_{Cumulative}, was \$3,566. The total P&L for the Trading Period was \$34,227, corresponding to a Period Return of 3.42%.

Stringing Together Trading Periods: The VARB-X Roll

As one contract expires, a new three-month variance futures contract is deemed sold at the opening bid price, which marks the beginning of a new Trading Period. On September 17, 2004, the amount of available capital was \$1,034,227, the initial \$1 million investment plus the total P&L from the previous Trading Period.

The opening bid price of CBOE S&P 500 Three-Month Variance Futures expiring in December was 239.50. As before, after applying the VARB-X risk guidelines, the strategy is deemed to have sold 3.7 contracts. As shown below, on September 17, the variance futures closed at 235, resulting in a futures gain of \$832.50, a Period Return of 0.08% relative to the available capital from the end of the previous trading period.

The VARB-X value on September 17, 2004, VTY_{Roll}, is based on both the final Period Return from the old Trading Period (3.42%) and the first Period Return from the new Trading Period (0.08%):

$$\begin{aligned}
 \text{VTY}_{\text{Roll}} &= [\text{VTY}_{\text{Period Init}} \times (1 + \text{Period Return}_{\text{Old}})] \times (1 + \text{Period Return}_{\text{New}}) = \\
 &= [100.00 \times (1.034227)] \times (1.000805) = \\
 &= 103.4227 \times 1.000805 = \mathbf{103.51}
 \end{aligned}$$

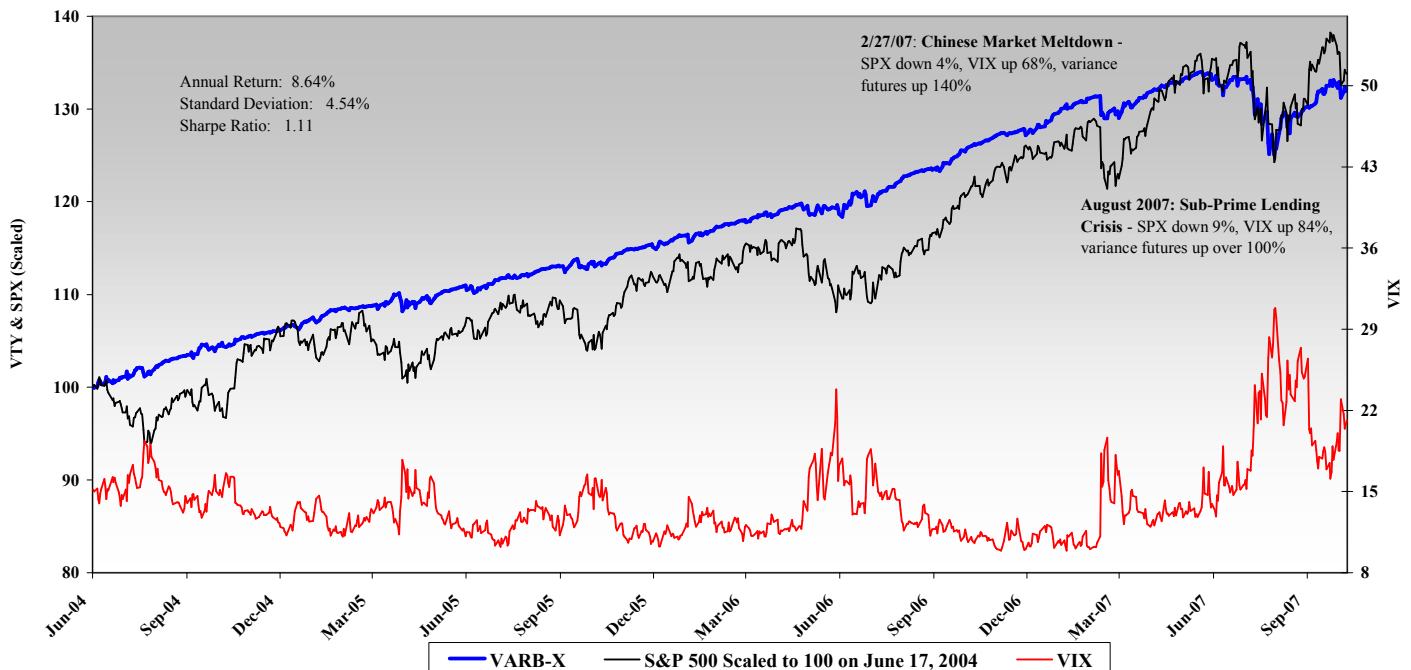
| Date | Number of Short Volatility Futures | Futures Price | Futures P&L (F _{P&L}) | T-Bill Rate | Interest (I _{Cumulative}) | Total P&L | Period Return | VTY |
|-----------|------------------------------------|---------------|-------------------------------------|-------------|-------------------------------------|-----------|---------------|---------------|
| 17-Sep-04 | 3.7 | 239.50 (O) | \$833 | 1.67% | | | | 103.51 |
| | | 235.00 (C) | | | | | | |
| 20-Sep-04 | 3.7 | 236.00 | \$648 | 1.66% | \$144 | \$791 | 0.08% | 103.50 |
| 21-Sep-04 | 3.7 | 223.00 | \$3,053 | 1.68% | \$192 | \$3,244 | 0.31% | 103.75 |
| 16-Dec-04 | 3.7 | 117.50 | \$22,570 | 2.16% | \$4,953 | \$27,523 | 2.66% | 106.17 |
| 17-Dec-04 | 3.7 | 120.60 | \$21,997 | 2.15% | \$5,015 | \$27,012 | 2.61% | ** |

On December 17, 2004, the final settlement price for the expiring variance futures was 120.60. The gain on the short futures position, F_{P&L}, was \$21,997 ($[239.5 - 120.60] \times \50×3.7), and the interest income was \$5,015. The total P&L for the Trading Period was \$27,012, a Period Return of 2.61% ($\$27,012 / \$1,034,227$).

VARB-X Benchmark Performance

As shown in the following chart, the CBOE S&P 500 VARB-X Benchmark has increased over 32% since inception more than 3 years ago, compared to a 34% increase in the S&P 500 Index. At the same time, the standard deviation of the VARB-X Benchmark has been 4.54% compared to 11.38% for the S&P 500. The Sharpe Ratio, a standardized measure of return per unit of risk, for the VARB-X Benchmark is 1.11, almost 2 1/2 times greater than the Sharpe Ratio for the S&P 500.

CBOE S&P 500 VARB-X Benchmark
June 2004 through October 2007



Source: CBOE Research Dept, Bloomberg

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VARB-X risk/return characteristics compare favorably with other major equity indexes (Nasdaq-100[®] and Russell 2000[®]), as well as another popular strategy benchmark, the CBOE S&P 500 BuyWrite Index (BXMSM). While VARB-X outperformed only BXM; none of the other benchmarks had a lower standard deviation, and none had a higher Sharpe Ratio.

| | VARB-X | S&P 500 | Nasdaq-100 | Russell 2000 | BXM |
|-----------------------|---------------|--------------------|-------------------|---------------------|------------|
| Annual Return | 8.64% | 9.06% | 12.31% | 10.90% | 8.29% |
| Std. Deviation | 4.54% | 11.38% | 15.77% | 17.16% | 7.72% |
| Sharpe Ratio | 1.11 | 0.48 | 0.55 | 0.42 | 0.60 |

As shown in the following table, Trading Period Returns have ranged from a low of -2.50% in Q3 2007 to a high of 3.6% in Q3 2006. Both returns correspond to periods of volatile market activity in August 2007 and May 2006 that resulted in higher realized variance (thus a lower Futures P&L for the expiring contract), as well as higher levels of implied variance (thus a higher sale price for the new volatility futures).

| Trading Period | Available Capital | Number of Short Variance Futures | MAX Futures Daily Gain | MAX Futures Daily Loss | Futures P&L | Interest Income | Total P&L | Trading Period Return | Ending VARB-X Level |
|-----------------------|--------------------------|---|-------------------------------|-------------------------------|------------------------|------------------------|----------------------|------------------------------|----------------------------|
| Q3 2004 | \$1,000,000 | 3.39 | | | | | | | |
| Q4 2004 | \$1,034,227 | 3.70 | \$5,424 | (\$7,967) | \$30,661 | \$3,566 | \$34,227 | 3.42% | 103.42 |
| Q1 2005 | \$1,061,238 | 3.99 | \$4,440 | (\$4,810) | \$21,997 | \$5,015 | \$27,012 | 2.61% | 106.12 |
| Q2 2005 | \$1,088,503 | 4.09 | \$2,494 | (\$3,392) | \$20,740 | \$6,525 | \$27,265 | 2.57% | 108.85 |
| Q3 2005 | \$1,108,939 | 4.56 | \$6,646 | (\$9,918) | \$12,667 | \$7,769 | \$20,436 | 1.88% | 110.89 |
| Q4 2005 | \$1,131,465 | 4.44 | \$3,534 | (\$4,560) | \$13,306 | \$9,220 | \$22,526 | 2.03% | 113.15 |
| Q1 2006 | \$1,154,616 | 4.65 | \$4,773 | (\$5,883) | \$12,443 | \$10,708 | \$23,151 | 2.05% | 115.46 |
| Q2 2006 | \$1,180,707 | 4.91 | \$3,255 | (\$8,951) | \$13,571 | \$12,520 | \$26,091 | 2.26% | 118.07 |
| Q3 2006 | \$1,193,426 | 4.19 | \$4,787 | (\$9,452) | (\$1,213) | \$13,931 | \$12,718 | 1.08% | 119.34 |
| Q4 2006 | \$1,236,440 | 4.85 | \$9,323 | (\$12,256) | \$28,146 | \$14,868 | \$43,015 | 3.60% | 123.64 |
| Q1 2007 | \$1,278,771 | 5.24 | \$4,486 | (\$2,910) | \$27,005 | \$15,326 | \$42,331 | 3.42% | 127.88 |
| Q2 2007 | \$1,297,349 | 4.78 | \$5,764 | (\$20,829) | \$2,460 | \$16,117 | \$18,578 | 1.45% | 129.73 |
| Q3 2007 | \$1,338,194 | 5.18 | \$6,095 | (\$7,170) | \$25,071 | \$15,775 | \$40,846 | 3.15% | 133.82 |
| Q3 2007 | \$1,304,805 | 4.04 | \$20,591 | (\$33,411) | (\$49,485) | \$16,096 | (\$33,389) | -2.50% | 130.48 |

The largest daily trading loss was realized on August 9, 2007, a day on which the S&P 500 Index dropped almost 3%, and VIX rose by more than 23%. The price of September 07 variance futures rose 35% on that day, resulting in a one-day trading loss of \$33,411, or 2.5% of available capital!

Through September 21, 2007, the end of the most recently completed Trading Period, the VARB-X Benchmark had recorded a profit, excluding transaction costs, of over \$300,000, a return of 30% on the original capital allocation. Interest income of \$147,000 accounted for 48% of the total strategy gain. The gain from selling realized volatility futures totaled \$157,000, accounting for 52% of the VARB-X strategy performance.

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Finally, a word of caution. The compelling risk/return characteristics of volatility arbitrage strategies in general, and the VARB-X Benchmark in particular, reflect compensation for being short a potentially very risky asset – few investments have the potential to move 35% in a single day. Despite the seemingly attractive returns suggested by the VARB-X Benchmark, it is important to remember that, since June 2004, market conditions have been particularly conducive to selling volatility. U.S. stock market volatility has generally been low relative to historical levels, and there have been few market “shocks”.

In 2007, however, volatility appears to be on the rise again. Since February, the market has had daily moves of 2% or more 12 times. In the 30 months prior to February 2007, the market moved by more than 2% only twice. In addition, the CBOE Volatility Index[®] (VIX[®]) made a multi-year high on August 16, 2007, during the height of the Sub-Prime Lending Crisis, and continues to reflect high sustained levels of implied volatility that haven’t been seen in several years.

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