VIX: An Empirical Analysis of a New Futures Market

Keith Black, CFA, CAIA

Ennis Knupp + Associates

What is VIX?

- The CBOE Volatility Index measures the implied volatility of S&P 500 index options at a 30 day time horizon
- VIX is negatively correlated to the returns on the S&P 500, as investors pay more for index options during a sharp market decline.

Literature Review

- Daigler and Rossi, Journal of Investing, 2006
  - A portfolio of VIX and SPX provides diversification benefits from 1992 to 2002.
  - Adding 10% to 20% VIX reduces portfolio volatility.
  - Risk falls faster than return
- Black, Journal of Trading, 2006
  - Hedge funds and SPX have negative skewness and excess kurtosis, 1994 to 2005.
  - 11.87% VIX and 88.13% SPX restores normal skewness to an equity portfolio, while reducing volatility.

Literature Review

- Dash and Moran, Journal of Alternative Investments, 2005
  - Adding 5-10% VIX to a hedge fund portfolio reduces downside risk.
- Brooks and Kat, Journal of Alternative Investments, 2002
  - Hedge funds have negative skewness and excess kurtosis.
  - The purchase of S&P 500 put options can reduce downside risk and higher moments exposures.

Literature Review

- Bilson and Cernauskas, 2004
  - Tests the interdependence between currency prices and interest rates.
  - Similar methodology can be used for VIX and SPX.

The Problem?

- Each of the prior studies used cash VIX, an untradeable asset.
- VIX Futures started in March 2004, so we can now analyze three years of futures market data, and compare VIX futures to VIX cash.

Empirical Cash Returns

- Annalized daily returns, Mar 2004-Mar 2007

	Mean	StDev	Skewness	Kurtosis
SPX	8.86%	10.48%	-.19	.26
VIX	-8.05%	95.92%	2.16	19.02
SPX+ VIX	12.38%	6.91%	1.90	16.19

	Terminal Wealth	Min Day Return	Max Day Return
SPX	128.93%	- 3.47%	2.16%
VIX	77.78%	-25.91%	64.22%
SPX+ VIX	141.79%	- 1.38%	4.56%

Empirical Futures Returns

- Annualized daily returns, Mar 2004-Mar 2007
- Use nearest term futures contracts

	Mean	StDev	Skewness	Kurtosis
SPX	7.19%	10.51%	-.43	1.92
VIX	-66.44%	56.65%	1.90	43.39
SPX+ VIX	-4.65%	8.16%	0.44	22.00

	Terminal Wealth	Min Day Return	Max Day Return
SPX	123.09%	- 3.94%	2.13%
VIX	3.81%	-31.65%	41.81%
SPX+ VIX	86.73%	- 1.63%	1.27%

Initial Impressions

- VIX Cash and VIX futures have very different behavior
  - Correlation of daily change(Cash VIX, VIX F1) = 0.692
  - Correlation of daily change(Cash VIX, VIX F2) = 0.748
- The large risk premium prevents cost effective hedging of equity portfolios
  - Monthly risk premium –4.87% to hold VIX futures relative to VIX cash
  - Three year terminal wealth of cash VIX 77.78% vs. VIX futures 3.81%
- Futures are less volatile than the cash
  - Stdev(VIX F1)/Stdev(VIX Cash) = 59.1%
  - Stdev(VIX F2)/Stdev(VIX Cash) = 33.2%

The Cash-Futures Basis

- VIX Cash and Futures are Mean Reverting
- Traders are reluctant to sell VIX Futures at very low levels or buy VIX Futures at very high levels
- Change in Basis can overwhelm change in cash
- In four weeks, VIX Cash could +0.65 and VIX futures could –0.55 if settlement at 11.50%
- January 18, 2007 VIX Cash = 10.85%
- Futures Prices

Feb 2007	12.05	Mar 2007	12.90
April 2007	13.44	May 2007	14.01
June 2007	14.64	Aug 2007	15.08
Nov 2007	15.75	May 2008	16.47

Interdependence of VIX and SPX

- Correlation of daily change in VIX cash and SPX cash = -0.795
- Correlation of daily change in front month futures of VIX vs. SPX = -0.651
- Largely a coincident relationship

Testing for Interdependence

- $R_{s,\,t} = \alpha_s + \beta_{1s} X_{s,\,t-1} + \beta_{2s} X_{v,\,t-1} + \varepsilon$
- $R_{v,\,t} = \alpha_v + \beta_{1v} X_{s,\,t-1} + \beta_{2v} X_{v,\,t-1} + \varepsilon$
  - Where X_s is the difference in price between the front and second contract of the SPX futures, and X_v is the price difference between the front and second contract of the VIX futures. The markets are independent if β_{2s} and β_{2v} are not significantly different from zero.

Testing for Interdependence

- $R_{s,\,t} = \alpha_s + \beta_{1s} X_{s,\,t\text{-}1} + \beta_{2s} X_{v,\,t\text{-}1} + \varepsilon$
- $R_{v,\,t} = \alpha_v + \beta_{1v} X_{s,\,t\text{-}1} + \beta_{2v} X_{v,\,t\text{-}1} + \varepsilon$
- $\beta 1s = .041$ (p=0.58) $\beta 2s = .013$ (p=0.004) $R^2 = .011$
- $\beta 1v = .130$ (p=0.74) $\beta 2v = -.121$ (p=0.000) $R^2 = .033$
  - VIX Futures Calendar Spread helps predict both SPX and VIX futures daily returns

Testing for Interdependence

- $R_{s,t} = \alpha_s + \beta_{1s} X_{s,t-1} + \beta_{2s} X_{v,t-1} + \beta_{3s} R_{S,t-1} + \beta_{4S} \text{VIX Cash}_{,t-1} + \varepsilon$
- $R_{v,t} = \alpha_v + \beta_{1v} X_{s,t-1} + \beta_{2v} X_{v,t-1} + \beta_{3V} R_{V,t-1} + \beta_{4V} \text{VIX Cash}_{,t-1} + \varepsilon$
- $\beta 1s = .325$ (p=0.000) $\beta 2s = .028$ (p=0.000)
- $\beta 3s = .017$(p=0.644) $\beta 4s = .0008$ (p=0.000) R^2=.050
- $\beta 1v = -.682$ (p=0.15) $\beta 2v = -.177$ (p=0.000)
- $\beta 3v = -.140$ (p=0.000) $\beta 4v = -.002$ (p=0.003) R^2=.070
  - VIX level and calendar spread predict SPX futures return
  - VIX level, calendar spread, and yesterday's VIX return predict SPX futures return

Conclusion

- In a low volatility environment, it is expensive to hold VIX futures.
- The futures-cash basis is large, as the market anticipates higher future volatility
- There can be substantial benefits to short futures positions in a continued low volatility environment.
- When the level and shape of the volatility curve changes, the volatility risk premium also changes.
- Average VIX futures price = 15.90
- Average VIX cash price = 14.11
- Average futures-cash basis = 1.79