

Peculiarities of Volatilities

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About Me

- Ph.D. in theoretical physics.
- Previously, researcher at IBM T. J. Watson Lab in machine learning, researcher/trader for Morgan Stanley, Credit Suisse, and various hedge funds.
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 - *Quantitative Trading: How to Build Your Own Algorithmic Trading Business* (Wiley 2009).
 - *Algorithmic Trading: Winning Strategies and Their Rationale* (Wiley 2013).
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Volatility Prediction

- Predicting volatility: That's Easy!
- Success in predicting realized volatility does not imply success in predicting implied volatility.
- Can arbitrage between predicted realized volatility and implied volatility.

Volatility Prediction

- “There are **many thousands** of papers on forecasting volatility using a host of increasingly sophisticated, even Nobel-Prize-winning, statistical techniques.” – Ahmad & Wilmott, 2005.
- One of the latest, incredibly complicated but brilliant paper*: Gatheral, *et al*, 2014, based on “fractional Brownian Motion”.

GARCH

- Mercifully, good old GARCH can work pretty well for us practical traders.
- GARCH(p, q): if $r(t)$ is log return from $t-1$ to t ,

$$r_t = m_t + \sigma_t \epsilon_t,$$
$$\sigma_t^2 = \omega + \sum_{i=1}^p \alpha_i \sigma_{t-i}^2 + \sum_{i=1}^q \beta_i r_{t-i}^2$$

where m_t is expected return, and ϵ_t is a Gaussian random variable with zero mean and unit variance.

- σ_t^2 is the conditional variance of r_t .
- Simply put: “predicted variance is a linear function of past predicted variances and past realized squared returns.”

GARCH

- We need to estimate $p, q, \omega, \alpha_i, \beta_i$ using maximum likelihood estimation (with penalty on model complexity) on some training data.
- Not to worry: MATLAB, R, Python all have ready-made toolboxes/packages galore for this.
- Try this on SPY (stock index), USO (oil futures), GLD (gold), AAPL (single stock), and EURUSD (currency).

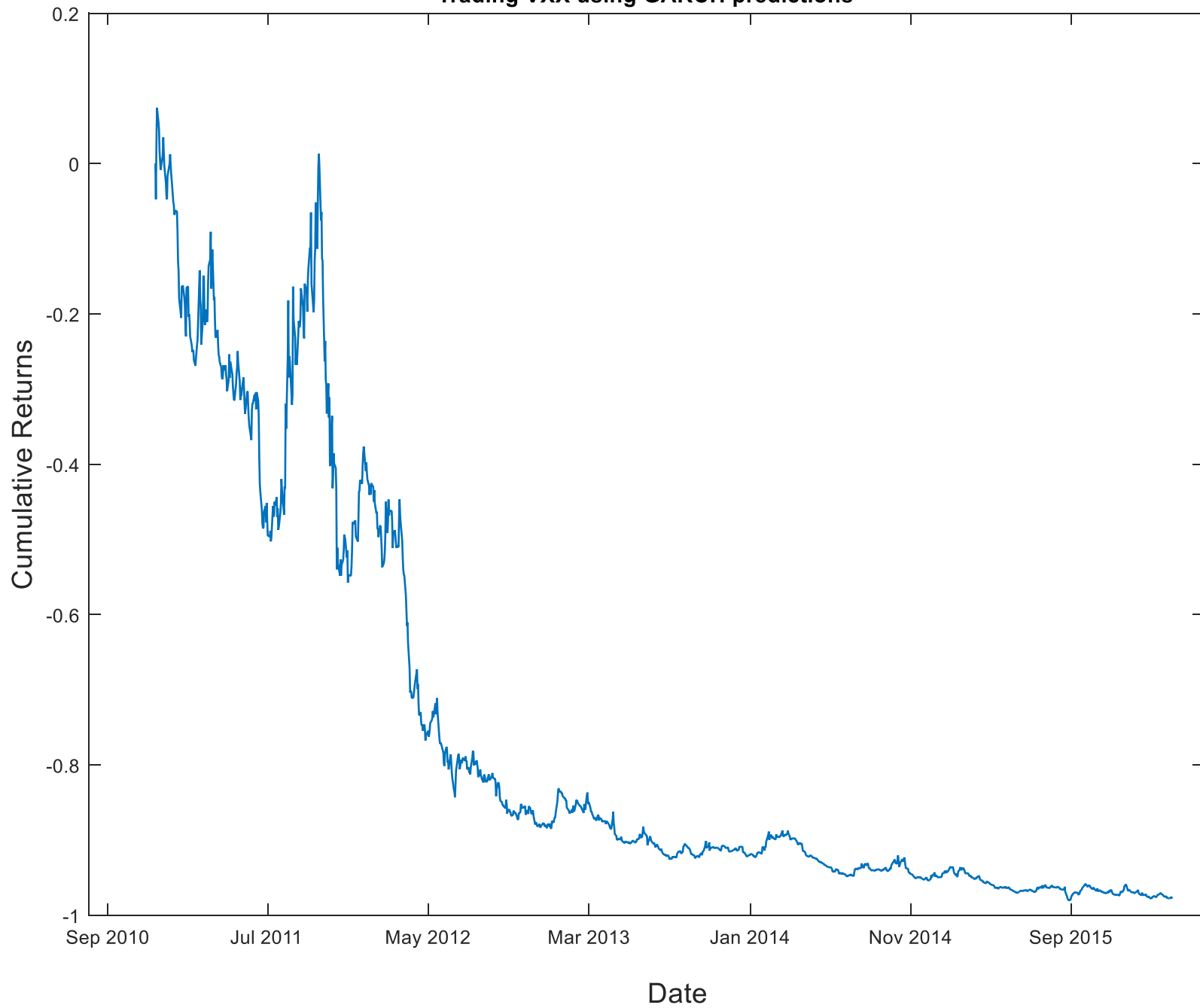
GARCH: predictive accuracy

- Out-of-sample (2010/11/30-2016/03/11) accuracy in predicting *sign* of 1-day volatility change:
 - SPY: 66%
 - USO: 67%
 - GLD: 59%
 - AAPL: 60%
 - EURUSD: 62%
 - If we have that accuracy in predicting sign of 1-day *price* change, we would be rich!

Trading volatility?

- But wait ... couldn't we trade volatility via VXX, VXV, VXZ, XIV, XVZ, VX future, ...?
 - Note my omission of VIX in above list.
- Intuitive strategy: GARCH predicts **increase** in realized volatility → **Buy** VXX. Vice versa.
- Result?

Trading VXX using GARCH predictions



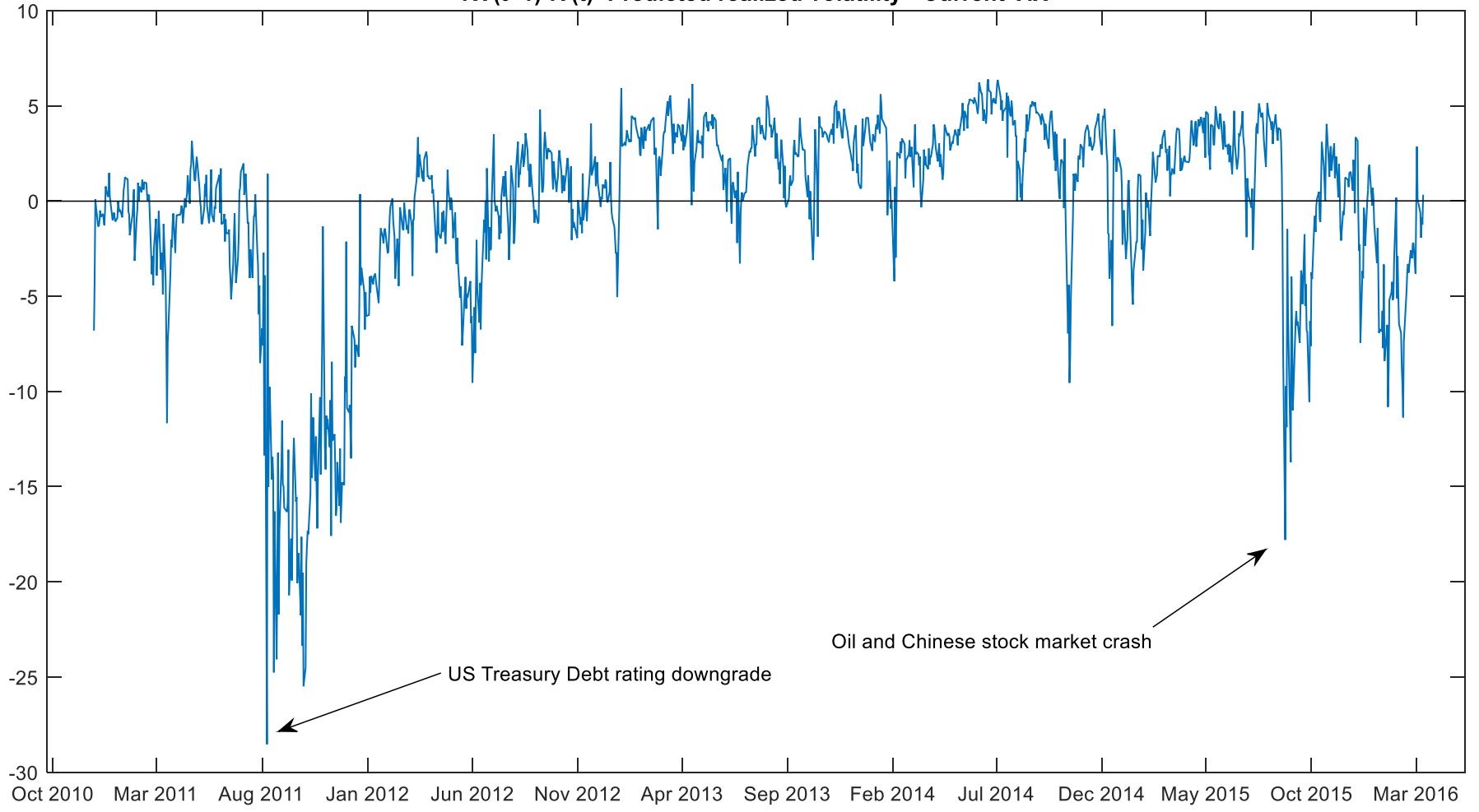
Implied \neq Realized Volatility

- VIX index and realized volatility move in same direction only 51% of days.
 - Almost **zero** correlation between signs of **implied** and **realized** volatility change!
- In fact, on 56% of days with positive returns, VIX and realized volatility move in **opposite** direction.
 - Less demand to buy portfolio insurance when market goes up?

Trading Volatility

- Predicted change in realized volatility won't help us predict change in implied volatility.
- But $RV(t+1)-IV(t)$ (as opposed to $RV(t+1)-RV(t)$) can!
 - $RV(t+1)$ is the GARCH-predicted realized volatility for next period.
 - $IV(t) \equiv VIX(t)$ is the current implied volatility
- Strategy: $RV(t+1)-VIX(t) > 0 \rightarrow$ **Buy VXX**. Vice versa.
 - i.e. Expect $RV(t+1)$ to be better predictor of $VIX(t+1)$ than $VIX(t)$!

$RV(t+1)-IV(t)=\text{Predicted realized volatility} - \text{Current VIX}$



Trading Volatility

- Result: CAGR=26%, but Sharpe ratio=0.7 only.
 - (2010/11/30-2016/03/11).
- Similarly, Ahmad & Wilmott, 2005 suggested
 - $RV(t+1) - IV(t) > 0 \rightarrow$ **Buy** option and delta-hedge till expiry \rightarrow Profit! (No vice versa here.)
 - Supposed to work for any options, not just index options, that can be modeled by Black-Scholes equation.

VIX vs VXX (or VX)

- We suggested trading the ETN VXX (which reflects returns of VX futures).
- We cannot trade the underlying volatility index VIX itself.
- Trading SPY \approx trading stock index SPX

but

Trading VXX $\not\approx$ trading volatility index VIX!

VIX vs VXX (or VX)

- VIX is the weighted average price of a portfolio of OTM SPX options with tenor of 23-37 days.
- But the portfolio composition can change minute-to-minute!
 - See www.cboe.com/micro/vix/vixwhite.pdf
- E.g. if $VIX(t) = \$20$, and $VIX(t+1) = \$21$, \Rightarrow portfolio we held at t has appreciated \$1 by $t+1$.

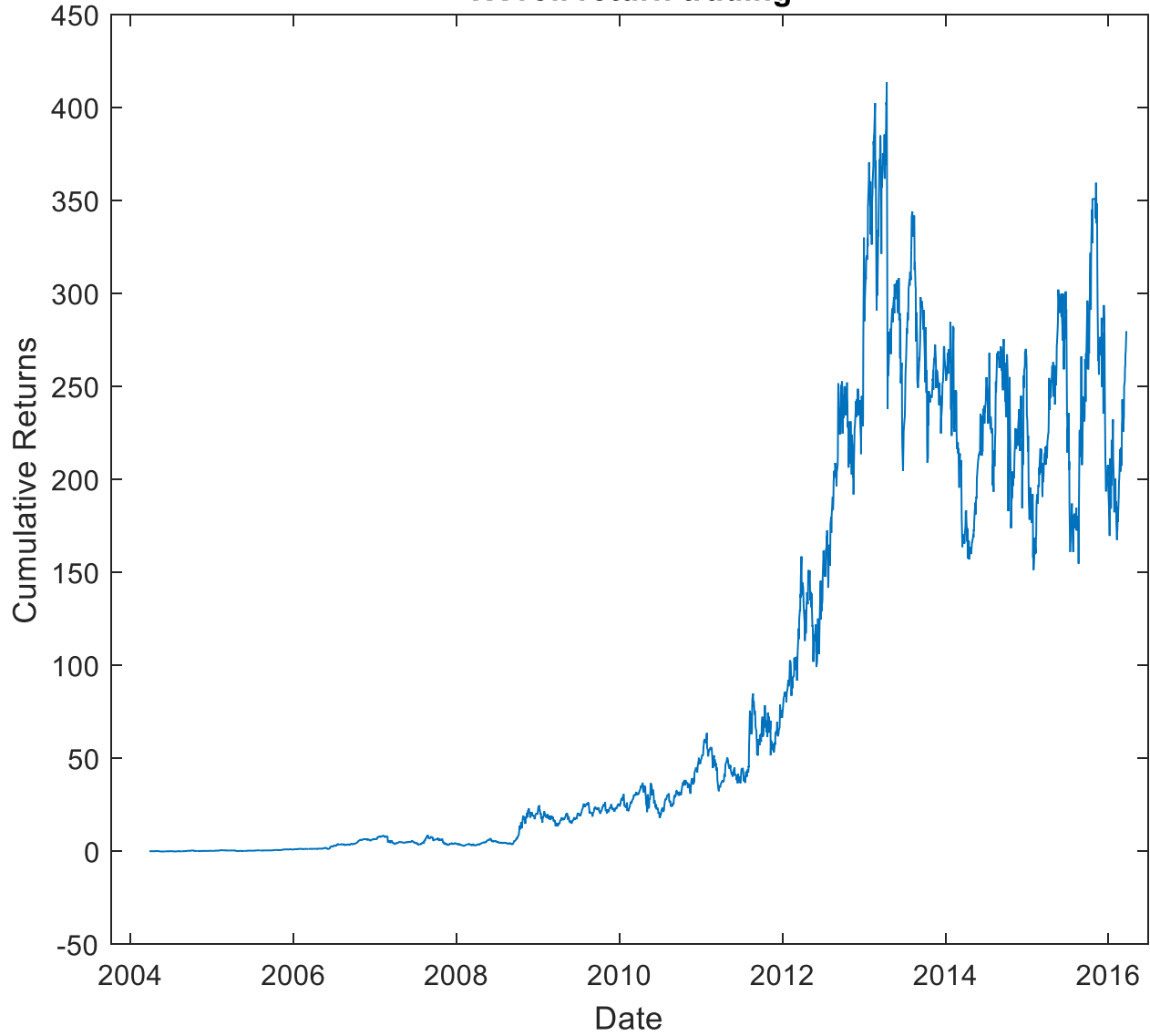
Time decay of options premium

- Even if implied volatility remains constant in time, market value of VIX portfolio will still decline.
 - Time decay of options premium.
 - Negative “theta”.
- Negative theta of SPX options \Rightarrow **negative “roll return”** of VXX or VX futures (when market condition remains constant).

Roll returns of VX

- $\text{Sign}(\text{Roll return of VX}) = \text{Sign}(\text{VX future} - \text{VIX index})$ is a trading signal.
- Roll return of $\text{VX} > 0 \rightarrow$ **Buy** VX. Vice versa.
- Result: CAGR=60%, Sharpe ratio=1.
– (2004/03/26-2015/08/28).

VX roll return trading



VX roll return strategy

- Note where the returns started to falter: 2013.
 - Just after the paper (Simon & Campasano, 2012) describing this strategy was published!
- Trading of VX have changed prices of SPX options themselves?
- Is VIX still a good predictor of future realized volatility due to this arbitrage activity?
 - If not, what is it useful for?

Thank you for your time!

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