A Practical Look at Volatility in Financial Time Series

MATH 287C - Advanced Time Series Analysis

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Outline

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What is Volatility?

- Volatility is peculiar in that we know it exists, but we can't really measure it.
- Conventional definitions rely on some distribution assumption on the returns, after which volatility is defined as the standard deviation σ of the returns (to make things nicer we'll define it as)

Naive Measure

Include plot of rolling standard deviations on absolute returns
Describe why this is an unsatisfying measure

Stylized Facts

Describe stylized facts. Show plot of SP500 returns to reinforce these facts.

GARCH

Popular method to model volatility Show formulas and how it's trained. For the purposes of this talk we'll focus on GARCH(1,1) models.

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NoVaS Transformation

Include definition of NoVaS transformation and how it's derived.
Include algorithm for Simple NoVaS, which is the one we'll be focusing on for the purposes of this talk

SP500

pre-NoVas SP500 returns plot

SP500

pre-NoVas SP500 returns histogram

SP500

pre-NoVas SP500 returns q-q plot

SP500

post-NoVas SP500 returns plot

SP500

post-NoVas SP500 returns histogram

SP500

post-NoVas SP500 returns q-q plot

pre-NoVas BTC returns plot

BTC

pre-NoVas BTC returns histogram

BTC

pre-NoVas BTC returns q-q plot

BTC

post-NoVas BTC returns plot

BTC

post-NoVas BTC returns histogram

BTC

post-NoVas BTC returns q-q plot

Treasury Futures

pre-NoVas Treasury Futures returns plot

Treasury Futures

pre-NoVas Treasury Futures returns histogram

Treasury Futures

pre-NoVas Treasury Futures returns q-q plot

Treasury Futures

post-NoVas Treasury Futures returns plot

Treasury Futures

post-NoVas Treasury Futures returns histogram

Treasury Futures

post-NoVas Treasury Futures returns q-q plot

SP500 not perfect tranform with NoVaS

Simply show an imperfect transformation to make the point that financial time series over long periods are not necessary stationary (only locally stationary) and thus we should use time-varying versions of NoVaS where the window size isn't too big.

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One-Step Ahead Prediction

Define the volatility prediction problem. Outline that you're using squared returns Y_t^2 as a noisy proxy for Volatility What loss function should you use? Will use a window size of 250 days which is approx. 1 year

Infinite Kurtosis?

Do financial returns have infinite kurtosis? If this is the case you, predicting under L2 is incorrect. Instead you should L1 loss where the median is optimal

Infinite Kurtosis Plot SP500

Infinite Kurtosis Plot BTC

Infinite Kurtosis Plot Treasury Futures

Prediction Intervals

Steps for deriving prediction intervals - same for GARCH and NoVaS

SP500 Feb 2018 One Step Ahead Prediction

Plot predicting SP500 Feb 2018 Volatility spike, along with prediction intervals Shows that Simple NoVaS is better than GARCH(1,1)

Outline

Can predict $sigma^2$ using NoVaS under special conditions

Talk about the conditions under which you can actually predict $sigma^2$, plot the ACF to confirm that transformed series is uncorrelated and independent.

RV(t+1)-IV(t)

Outline strategy that if RV(t+1)-IV(t) ¿ 0 you buy VXX and vice versa.

Strategy Results

Cumulative returns plot, legend contains CAGR and Sharpe Ratio