Volatility Arbitrage

MATH 5010 Introduction to the Mathematics of Finance
Instructor: Mikhail Smirnov
Semester:Spring 2018

Technology Tool: R, Excel
Rehearsal Date: May 1, 2018
Rehearsal Time: 5:40 pm
Rehearsal Place: Uris Hall
Rehearsal Attendee: All group members
Guest Listener: Wanxia Chen, Yingting Yu

Group 15:
Chong Liang
Jiun Ying Chen
Mengxue Wang
Xiaojie Wei
Ziyue Wang

Introduction

What is “Volatility Arbitrage”

- Volatility arbitrage is a trading strategy that attempts to profit from the difference between the forecasted future price-volatility of an asset and the implied volatility of options based on that asset.

Breaking Down “Volatility Arbitrage”

- Options pricing is affected by the volatility of the underlying asset, if the forecasted and implied volatilities differ, there will be a discrepancy between the expected price of the option and its actual market price.
- A volatility arbitrage strategy can be implemented through a delta-neutral portfolio consisting of an option and its underlying asset

Implied Volatility vs. Forecasted Volatility

Implied Volatility:

- The Black-Scholes-Merton Formula

$$C(S_0, t) = S_0 N(d_1) - K e^{-r(T-t)} N(d_2)$$

$$d_1 = \frac{\ln \frac{S_0}{K} + \left(r + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}} \qquad d_2 = d_1 - \sigma\sqrt{(T-t)}$$

Forecasted Volatility (Historical Volatility):

- Realized volatility of the underlying asset over a previous time period
- Measuring the standard deviation from the mean during that time period

Delta Neutral

Delta Neutral Portfolio:

- Portfolio value remains unchanged when small changes occur in the value of the underlying security.

$$call\Delta = \frac{\partial c}{\partial S} = e^{-\delta\tau} N(d_1) > 0$$

Delta Hedge:

- The process of setting or keeping the delta of a portfolio as close to zero as possible
- Buying or selling an amount of the underlying asset that corresponds to the delta of the portfolio
- Keeping the portfolio delta neutral

Data Selection

Data source: Wharton Research Data Services (WRDS) & Bloomberg

Stock traded: SPY ETF

Option traded: SPY ETF Call Option (American option)

- Reduce firm-specific volatility

Training data: 2015.10.23 - 2016.12.31

Test data: 2017.01.01 - 2017.12.31

Strategy Signal

When **Implied volatility < Historical volatility,** the option is underpriced and will rise in the future since the volatility will revert to the historical mean.

When **Implied volatility > Historical volatility,** the option is overpriced and will fall in the future.

Spread (difference between implied volatility and historical volatility) narrows

Strategy Signal

Daily Spread = Historical volatility - Implied volatility

If Spread > Average(spread) + 0.5*STDEV(spread) (spread > 0):

Long 1 SPY ETF ATM call, short Delta units underlying SPY ETF

If Spread < Average(spread) - 0.5*STDEV(spread) (spread < 0):

Short 1 SPY ETF ATM call, long Delta units underlying SPY ETF

Otherwise: No Action

93 Trading signals (Long spread: 27 & Short spread: 66)

Implementation

01/17/2017	● SPY implied volatility = 9.835 Historical Volatility = 5.3864 ● Volatility Spread = -4.4486 < Signal = -3.54 Action: **Short** ● Strategy: short an ATM SPY Call option with strike $226 at $2.7 ● Delta = 0.53 Long 53 shares of SPY at $226.25
Duration	● Dynamic re-hedge
Expiration 02/15/2017	● Stock price = 234.92 ● Settle option and sell the remaining stock ● P&L = payoff on day 1 - re-hedge cost + payoff of closing position at expiration = $903.6 ● Total cost is $34269 Return =2.64%

Trading Strategy Backtest

Return

At time t, the strategy return

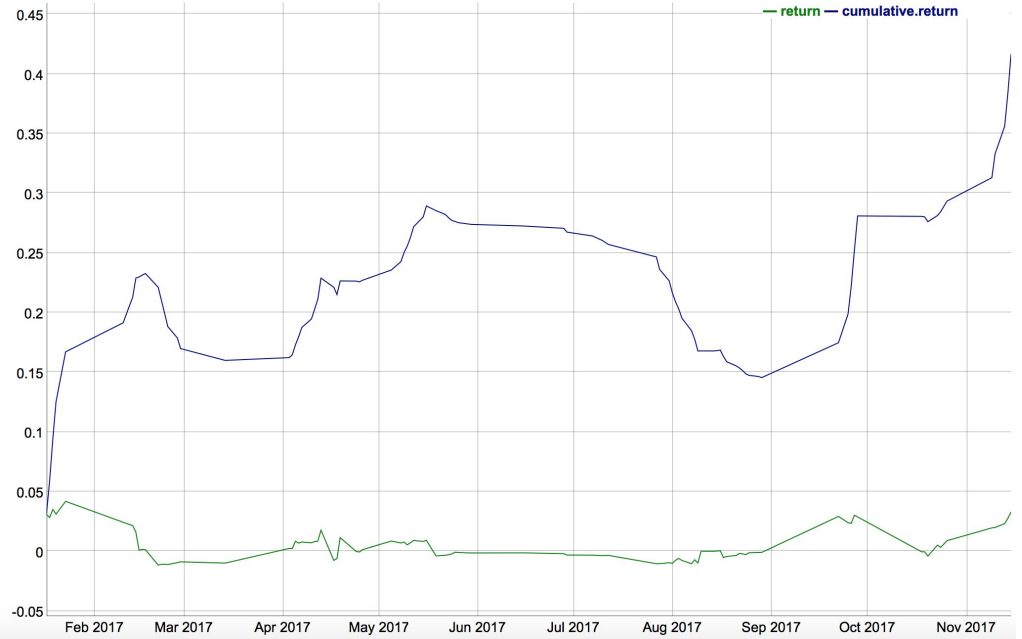
- Long call option, short underlying stock
  - $(P\&L)_t = 100(-C_0 + (S_t - K)_+ + \Delta(S_0 - S_t))$
- Short call option, long underlying stock
  - $(P\&L)_t = 100(C_0 - (S_t - K)_+ - \Delta(S_0 - S_t))$

$C_0 : call\ option\ price\ at\ trading\ day$
$S_0 : equity\ price\ at\ trading\ day$
$S_t : equity\ price\ at\ expiration\ date$
$K : strike\ price\ at\ trading\ day$
$\Delta : stock\ units\ to\ long/short\ in\ the\ strategy$

Trading Strategy Backtest

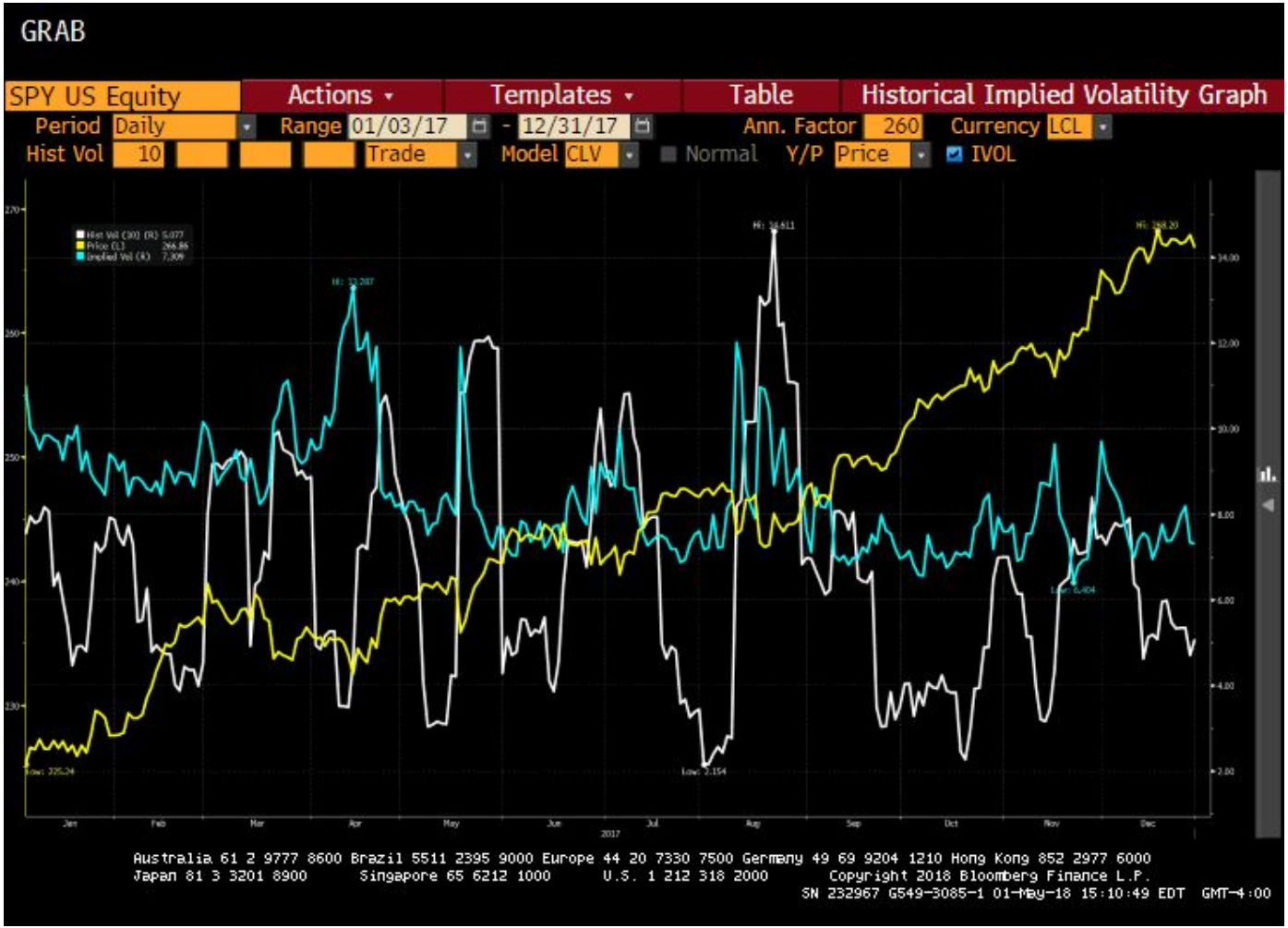
Return

- Daily Return of the strategy on a delta-hedged option position
  - 39 days out of 93 trading days, the return is less than or equal to 0.
- Annualized Return:
  - 10.96%
- Cumulative Return until expiration (12.31.2017)
  - 41.67%
- Annualized Sharpe Ratio (Rf = 2.5%)
  - 0.68



Risk

- Annualized standard deviation: 12.45%


GRAB
SPY US Equity
Actions
Templates
Table
Historical Implied Volatility Graph
Period Daily
Range 01/03/17 - 12/31/17
Ann. Factor 260
Currency LCL
Hist Vol 10
Trade
Model CLV
Normal
Y/P Price
IVOL
Implied Volatility
Historical Volatility
Australia 61 2 9777 8600 Brazil 5511 2395 9000 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000
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Limitations/Assumptions

There are several assumptions a trader must make, which will increase the complexity of a volatility arbitrage strategy:

- Transaction Cost
  - In our strategy, we assume that there is no transaction costs in buying or selling the stock or the option.
- Operation Cost
  - The investor must be right about whether implied volatility is really overpriced or underpriced
  - The investor must be correct about the amount of time it will take for the strategy to profit or time value erosion could outpace any potential gains.
  - The investors have to make the decision about re-hedge frequency, which will greatly impact P&L in volatility arbitrage.

References

"Delta Neutral." *Wikipedia*, Wikimedia Foundation, 10 Apr. 2018, en.wikipedia.org/wiki/Delta_neutral.

"Volatility Arbitrage." *Investopedia*, Investopedia, 19 Jan. 2018, www.investopedia.com/terms/v/volatility-arbitrage.asp.

"Options delta hedging with no options at all" *Faculty of Economic Sciences, University of Warsaw*, 2014.

Q&A

Thank You