Quantitative Trading

A lecture for Oregon State University

By: Avi Thaker

Lecture Highlights

- About Me / What I do?
- What is Quantitative Trading?
- Common Trading Strategies
- Predicting the 2016 Presidential Election

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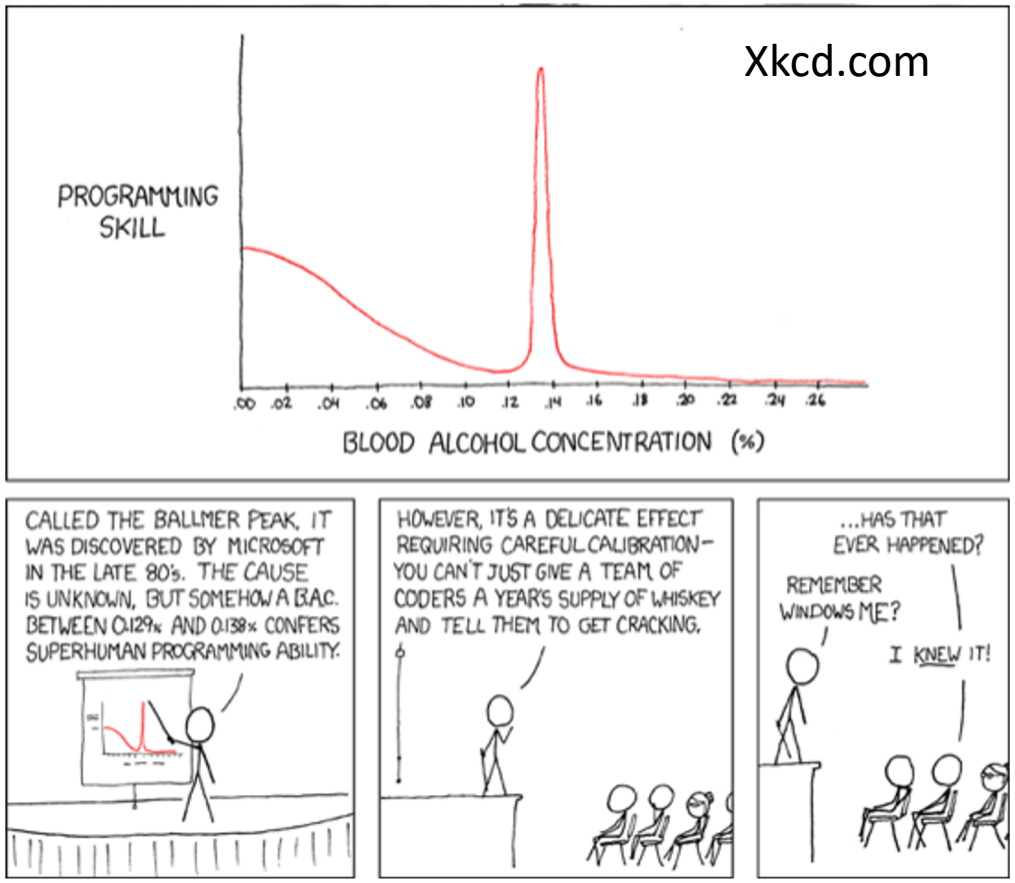
About Me

- Senior Data Scientist - GSK
  - Build better drugs using AI
- Data Scientist - Microsoft
  - Deep learning for customers
  - Implemented a semantic knowledge graph for Ads
- Trader
  - Fully automated trading systems
    - Research Driven Process
    - Crypto and Equity Markets

GlaxoSmithKline

HARVEY MUDD COLLEGE

Microsoft



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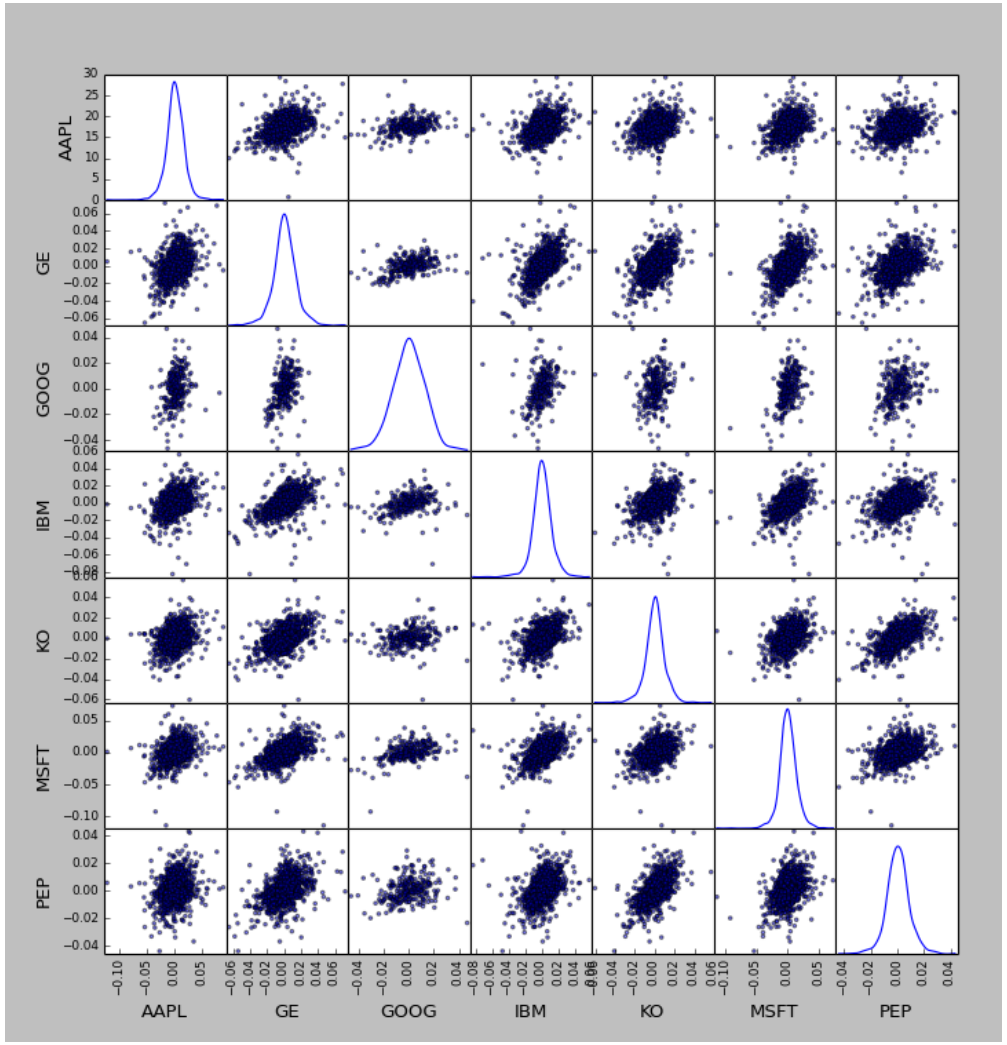
What I do - Distributions and Returns



Goal is to analyze distributions and returns to see how they may interact with one another.

If INTC and AMD diverge should you buy one and sell the other?

```
pd.scatter_matrix(rets, diagonal='kde', figsize=(10, 10));
```

https://finance.yahoo.com/news/boston-stock-exchange-partners-tzero-141455388.html

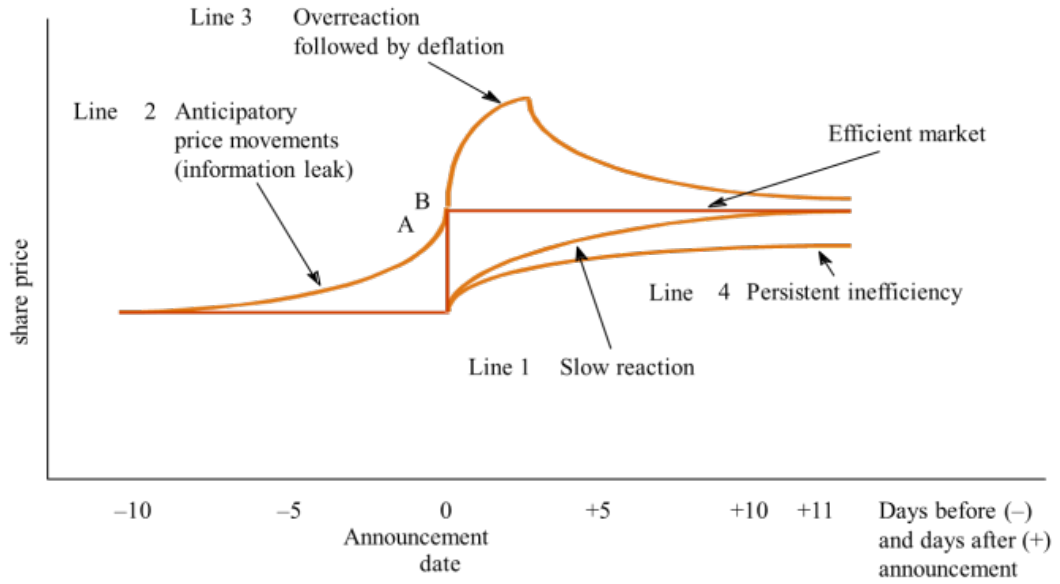
What is Quantitative Trading?

Motivation

- Computers can process larger amounts of data than humans and make decisions faster than humans
- Algorithms do what they are told, takes the human emotion out of trading
- ***Trillions*** of **$$$** traded daily - highly paid employees
- Bleeding edge of sciences; math, engineering, computer science, etc.

The Efficient Market Hypothesis

- Impossible to “beat the market”
  - Market efficiency causes prices to incorporate and reflect all relevant information
    - Prices adjust quickly to new information
    - Prices should reflect all available information
  - Securities always trade at their fair value
  - The only way to obtain higher returns is to purchase riskier investments
  - Cannot predict trends, history does not indicate future
- The market is becoming increasingly more efficient
- Warren Buffett? Citadel? Virtu?
  - *When filing for its IPO in March 2014, it was disclosed that during five years Virtu Financial made profit 1,277 out of 1,278 days, losing money just one day*.

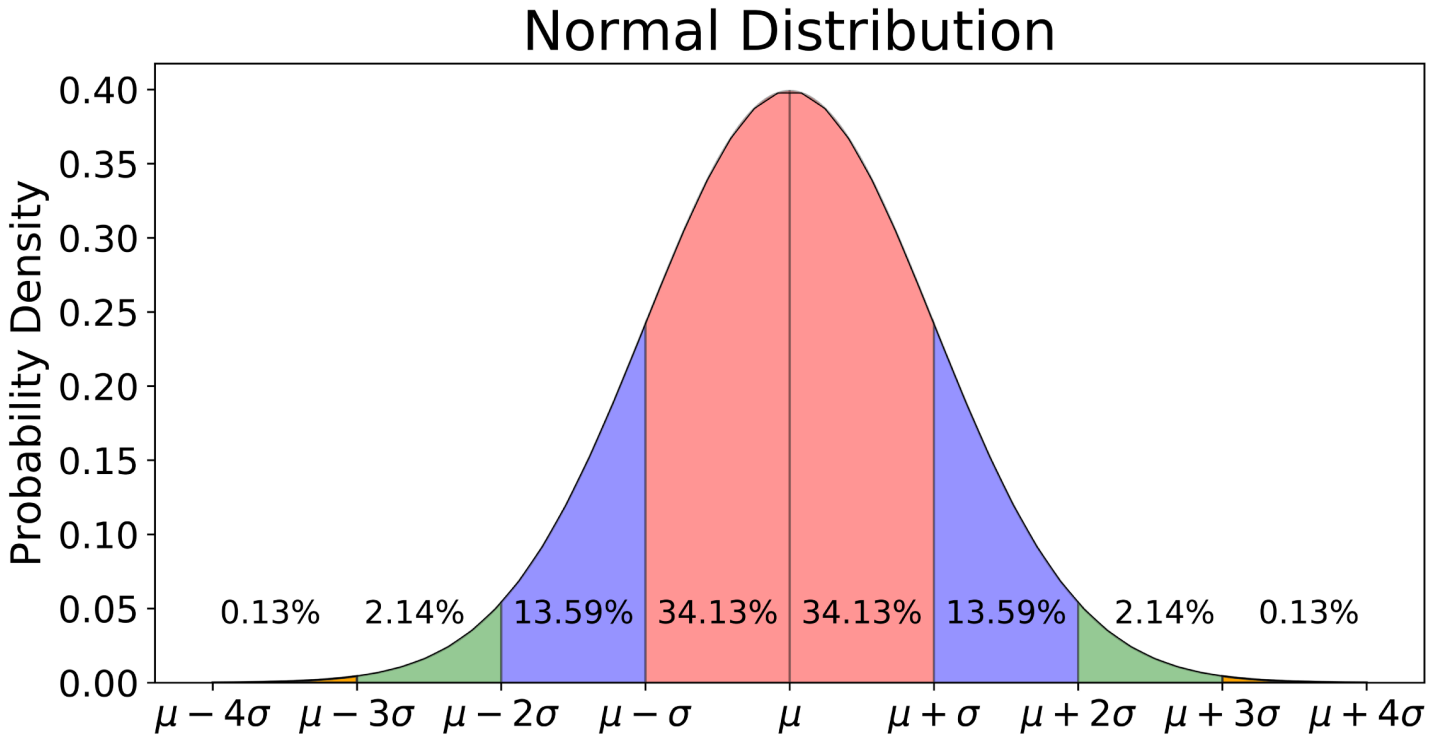


Statistical Sampling

- Some investors are simply lucky
- If you were to have a bunch of monkeys throw darts at a wall and use that to pick stocks you will have some major outperformers.

"In statistical terms, I figure I have traded about 2 million contracts, with an average profit of $70 per contract (after slippage of perhaps $20). This average is approximately 700 standard deviations away from randomness."

~ The Education of a Speculator



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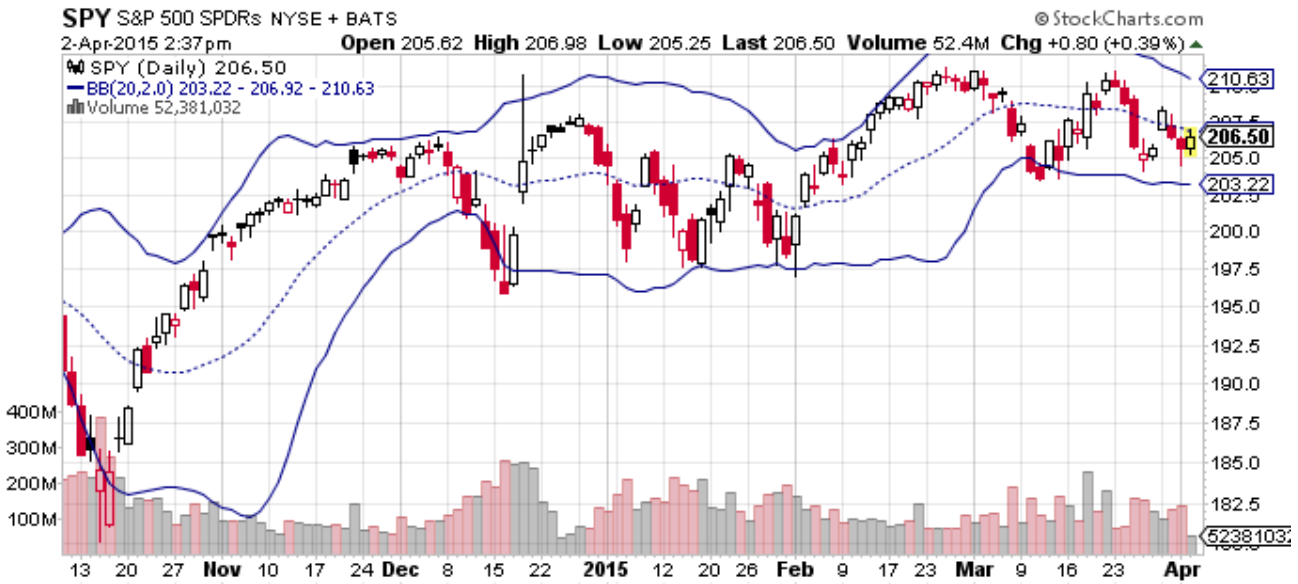
Quantitative Trading

- The implementation and execution of trading strategies in a systematic and disciplined function.
- Components
  - Strategy Identification
  - Strategy Backtesting
  - Execution System
  - Risk Management



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Kinds of Strategies

- Arbitrage
- Alpha Taking – Predicting the market
  - Mean reverting
  - Momentum
- Market Making
- Index/Pairs Trading
  - Can be part of any of the above
- Other

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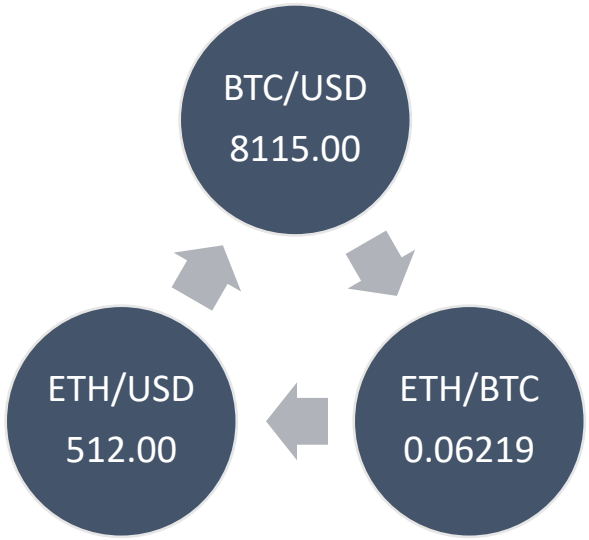
Arbitrage

Inter Exchange Arb (Triangle)

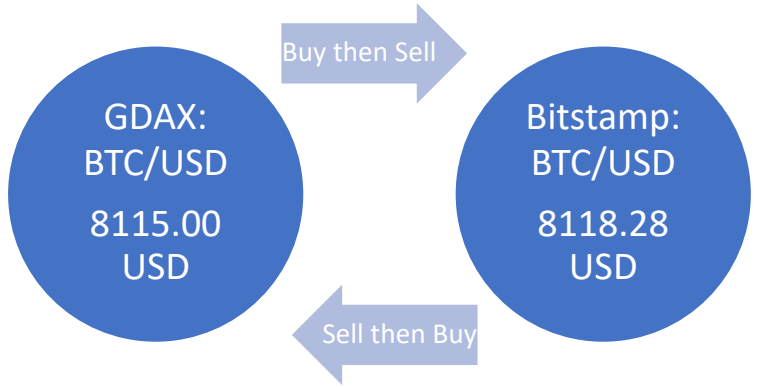


8115 USD -> 1 BTC
1 BTC -> 16.079 ETH
16.079 ETH -> 8232.83 USD
Net: 117.83 USD

Cross Exchange Arb

`Console output Crypto`

[0.0404%, 'BTC/USD', <ccxt.gdax.gdax >, <ccxt.bitstamp.bitstamp>]
[0.0332%, 'ETH/USD', <ccxt.gdax.gdax>, <ccxt.bitstamp.bitstamp>]



Buy BTC on GDAX transfer it to Bitstamp
Sell BTC for USD on Bitstamp
Net: 3.28 USD

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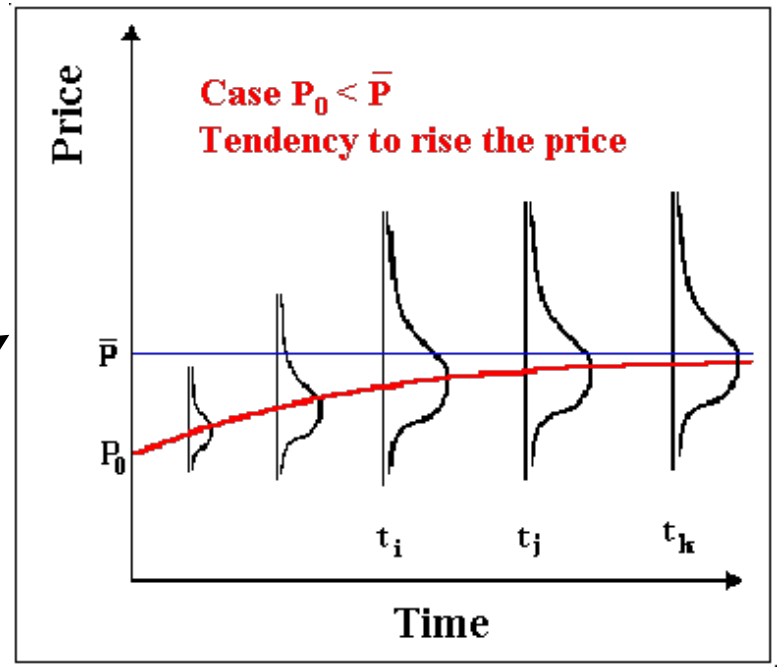
Alpha Taking

- Believes the product will move in one direction
- Mean Reverting – price reverts back to a “average” price, Bollinger Bands
  - Stochastic Math
- Trend following / Momentum
  - Price will move in one direction
  - Impulse response filters



http://marcoagd.usuarios.rdc.puc-rio.br/revers.html

Stockcharts.com

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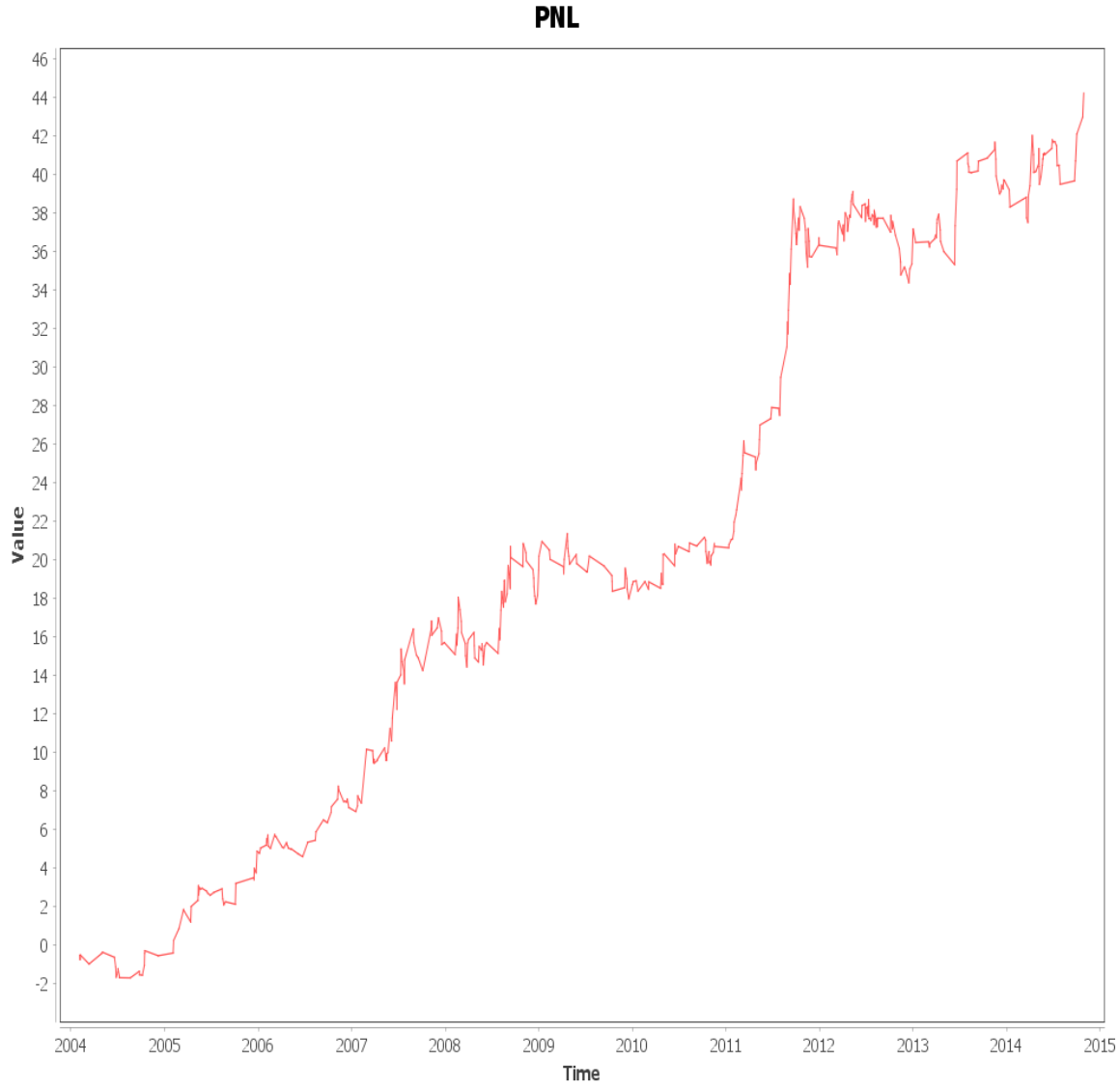
Backtesting a Strategy/Risk

- Provide evidence of profitability
  - Curve fitting/ optimization bias
  - In-sample vs out-of-sample
  - Forward looking bias
- Risk tolerance

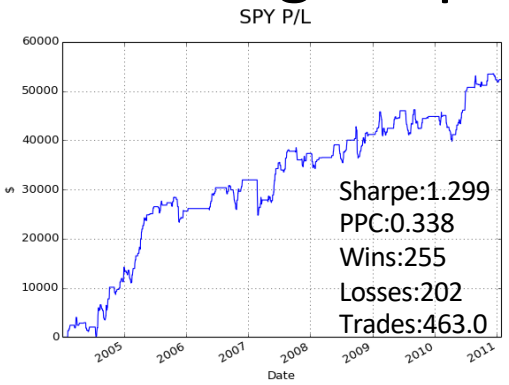
Key Statistics

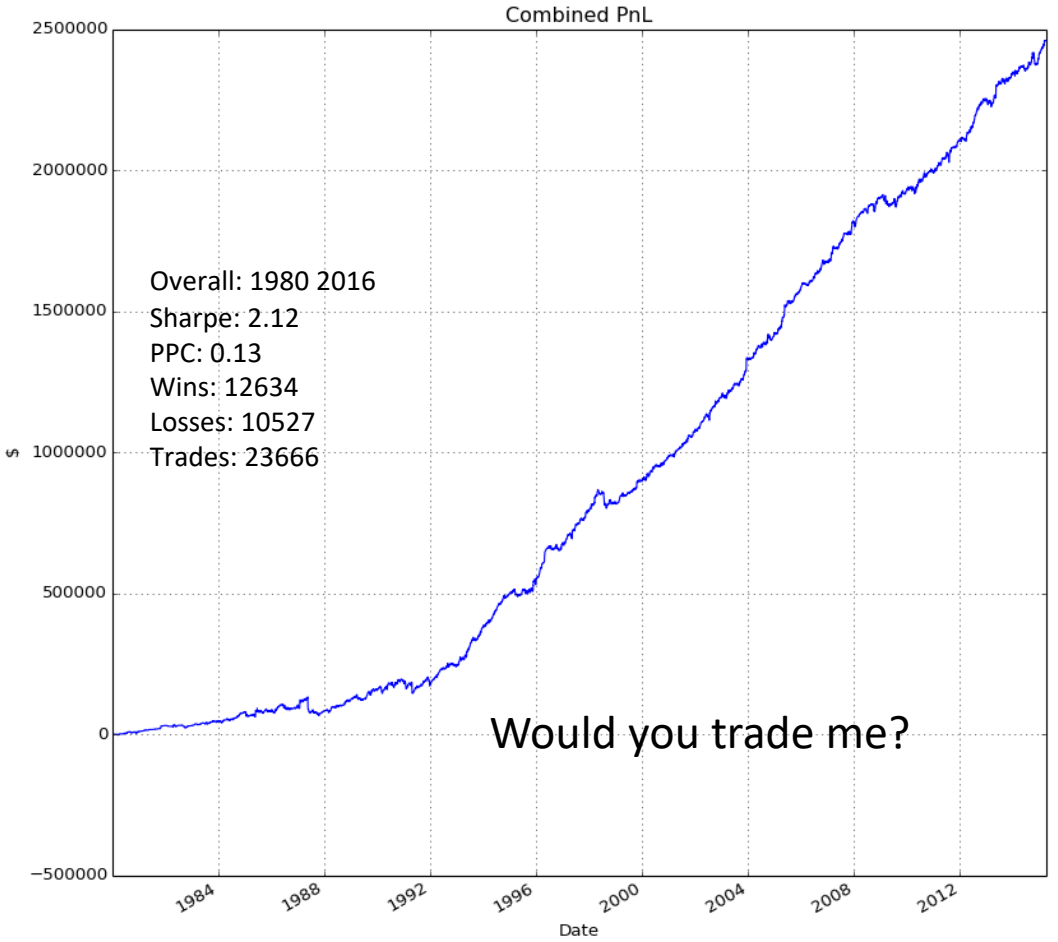
Average wins	:: 0.637 USD
Average loss	:: -0.438 USD
# Wins	:: 214
# Losses	:: 210
# Neutrals	:: 3
Win Rate	:: 0.501
PPC	:: 0.104USD
# Traded	:: 427.0
Ann. Sharpe	:: 2.335



Backtesting a Strategy

- Does the strategy work across many assets?
- How many years does it work for?
- Does it escape the bid-ask bounce?
- Risk Tolerance?
  - Maximum Drawdown?
- Fees? Trading frequency?



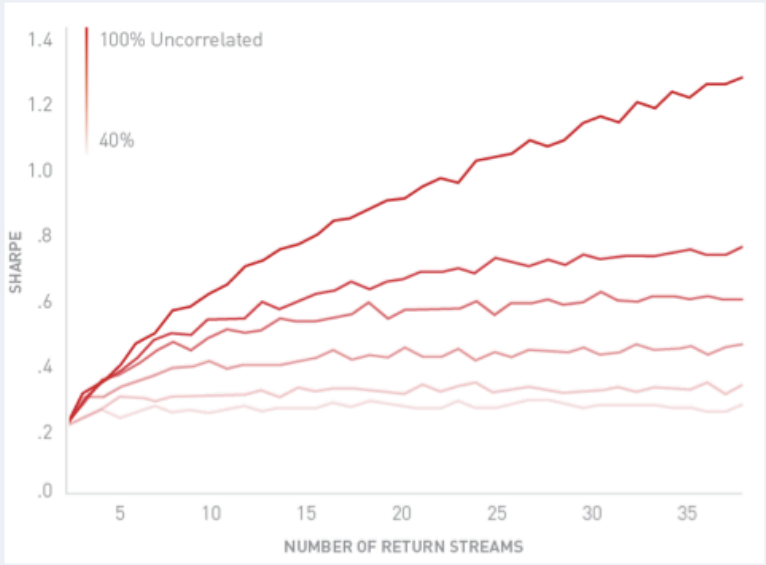


In Sample: SPY 2004-2010

Out of Sample: Assets Randomly Selected:
ADBE XLNX BBBY CFN EMC ADP AFL DE T SPLS DG ADS
ALL MET CL PX WYN

Correlation and Risk

Achieving High Portfolio Sharpe Ratio from holding Low Sharpe Ratio, but uncorrelated, individual algos



Simulation Setup:

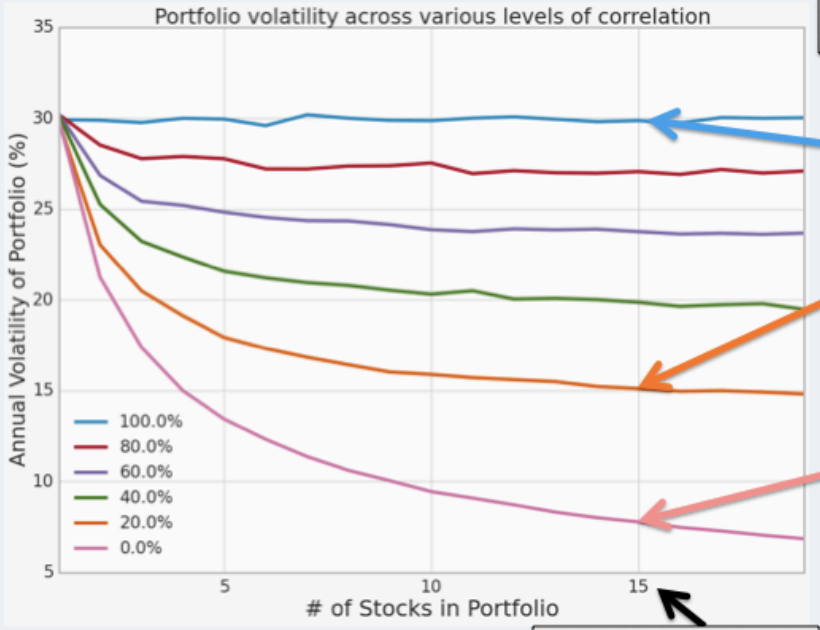
- Each algorithm individually has a Sharpe Ratio of only 0.2
- Hold X strategies across varying correlation assumptions

Results

Sharpe Ratio increases dramatically as you add more uncorrelated algorithms to your portfolio

Quantopian

Investing in uncorrelated algorithms can reduce overall portfolio risk by 50% - 75%



Assume each algo in a portfolio has 30% volatility

If they are 100% correlated, then entire portfolio also has 30% volatility…

…But, if they are only 20% correlated, overall portfolio volatility is reduced by half to 15%

…And…perfect *uncorrelation* reduces annual volatility to *only 8% !*

Only need to hold 15 algos in the portfolio

Quantopian

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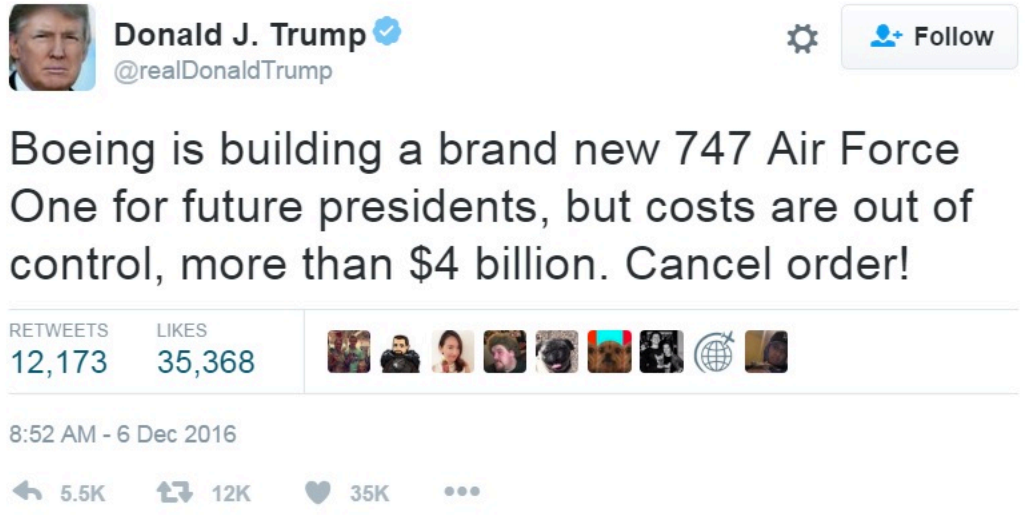
Limit Order Execution

For an order to be executed, a trade must cross below your buy, or a trade happens at your price, when you have been filled in the queue

Other: News Sentiment

- Thesis:
  - Twitter and other news sources (Reuters, etc.) can give me an information advantage
- Execution
  - Train an ML model to understand Donald Trumps Tweets, trade the resulting market sentiment
- Example:
  - https://www.kaggle.com/c/two-sigma-financial-news



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Other: Drone Car Counting

- Thesis:
  - Storefront business's financial performance strongly correlated with number of visitors
- Execution:
  - Use image processing to count the number of cars over time in parking lots
  - Possible to forecast better than market

https://www.youtube.com/watch?v=HK9r3qFmA70

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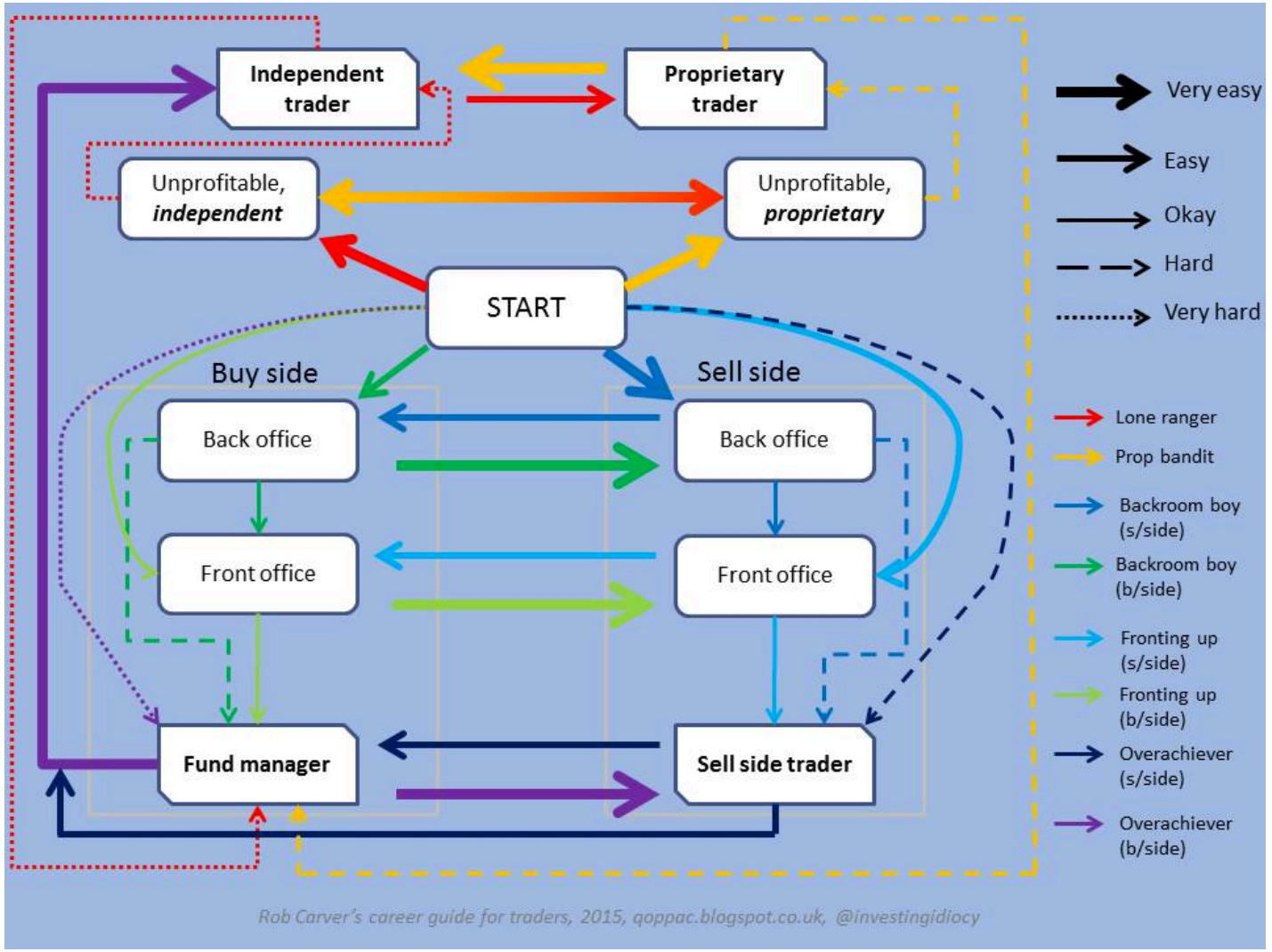
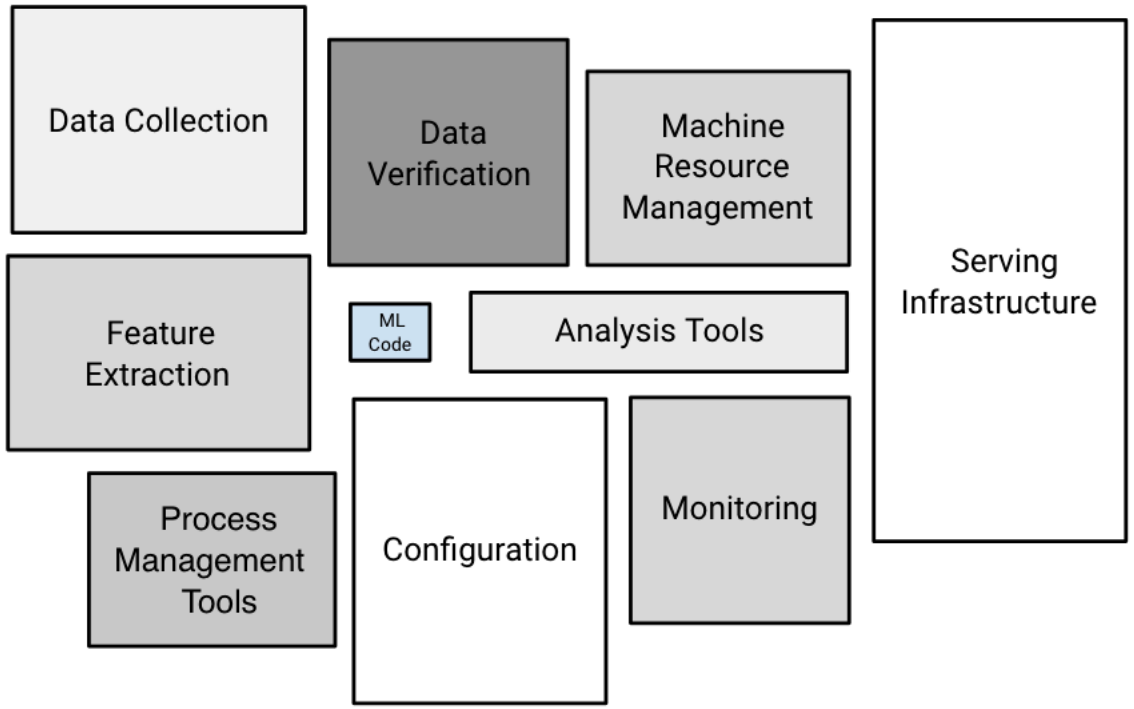
Getting Started

A Visual Guide

- Get started trading!
- Proof is in the pudding
- High Sharpe Ratio
- Quantitative and programming skills



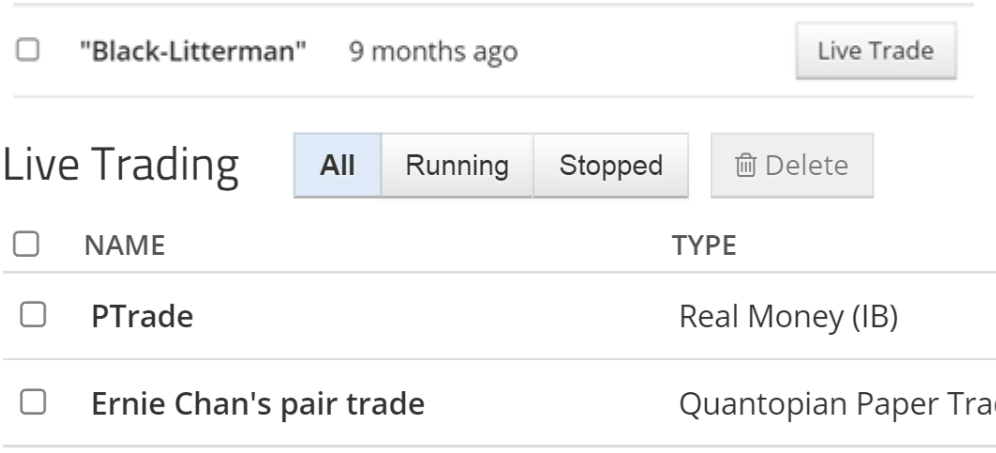
ML/DL is Only a Small Fraction of the Work



https://developers.google.com/machine-learning/crash-course

Quantopian

- A sample momentum algorithm from Quantopian.
- Very simple coding interface to use, and push to live trading with IB, or paper trade
  - This system can directly trade with your Interactive Brokers account
  - Must give privileges, have cash, etc.

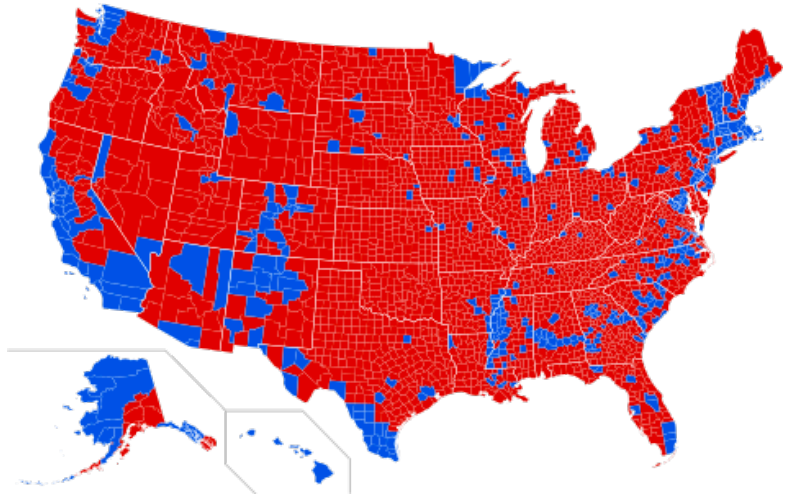



```python
def initialize(context):
    # Trading AAPL
    context.aapl = sid(24)

    # In these two lines, we set the maximum and minimum we want our algorithm
    # to go long or short our security
    context.max_notional = 1000000.1
    context.min_notional = -1000000.0

def handle_data(context, data):
    #This function runs on each frame of the data, each tick/frame is 1 min

    # 3 day volume weighted price
    vwap = data[context.aapl].vwap(3)
    # We need a variable for the current price of the security
    price = data[context.aapl].price

    # How long or short our position is at this minute.
    notional = context.portfolio.positions[context.aapl].amount * price

    # You can use the record() method to track any custom signal. The record graph
    # will track up to five different variables. Here we record the portfolio cash value
    record(cash = context.portfolio.cash)

    # If the price of the security is .5% less than the 3-day volume weighted average
    # price AND we haven't reached our maximum short, sell 100 shares
    # command and sell 100 shares.
    # If the stock is .5% higher than the 3-day average AND we haven't reached our
    # maximum long, buy 100 shares
    if price < vwap * 0.995 and notional > context.min_notional:
        order(context.aapl,-100)
        log.info("Selling %s" % (context.aapl))
    elif price > vwap * 1.005 and notional < context.max_notional:
        order(context.aapl,+100)
        log.info("Buying %s" % (context.aapl))
```

Predicting the Election

Overview

- Use a DNN and features to predict the Trump election and the expected market reaction
- Python utilizing Tensorflow
- https://github.com/athaker/econ_136
- Identify the sources of data and the resulting outputs
- What features do you think are most important to the model?



Candidate	Party	Electoral Votes	Popular Votes
Donald J. Trump	Republican	**304**	62,980,160
Hillary R. Clinton	Democratic	227	**65,845,063**
Gary Johnson	Libertarian	0	4,488,931
Jill Stein	Green	0	1,457,050
Evan McMullin	Independent	0	728,830

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Appendix

General Tips

- Be creative and develop your own way of trading
- Develop a thesis and test it
- Deep understanding of what you are doing and why
- This is not a get rich quick scheme
  - Finding alpha is difficult
- At scale this is like any other business
- Build your own backtester/execution environment
- Data In -> Data Out

- Performance
  - Out of sample performance is generally ½ of in sample performance
  - Live trading performance is generally ¼ of in sample performance
  - Due to curve fitting, unexpected slippage, etc.
- Make sure you account for ***transaction fees*** and ***slippage*** and ***order sizes***
- Visualize

Appendix: Sharpe Ratio

$$Sharpe = \frac{r_p - r_f}{\sigma_p}$$

$$r_p = portfolio\ return$$

$$r_f = risk\ free\ rate$$

$$\sigma_p = standard\ deviation\ of\ return$$

- Measures risk adjusted performance
  - Risk vs. Reward
- Higher is usually better
- Risk free rate sometimes assumed to be 0
- Usually annualized and volatility taken as standard deviation
  - Monthly: Volatility sampled monthly * sqrt(12)
  - Daily: Volatility sampled daily * sqrt(252)
  - Minutely: Volatility sampled minutely * sqrt(390*252)

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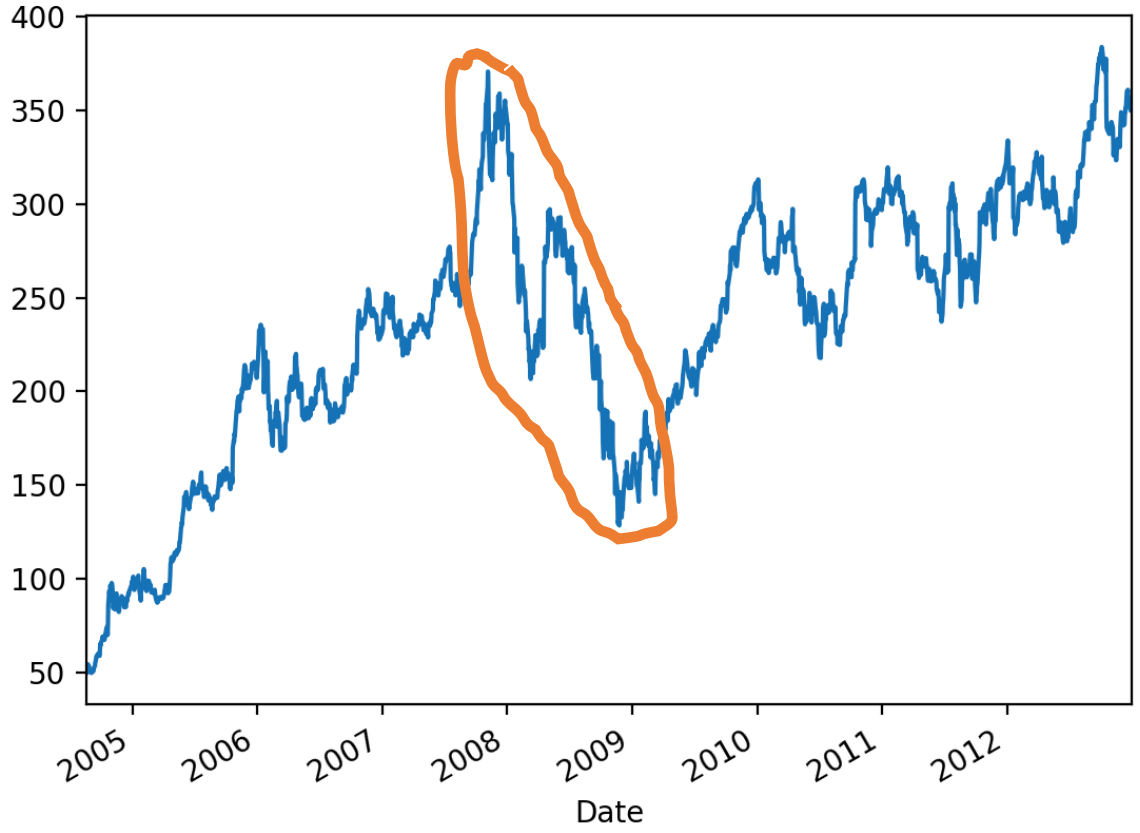
Appendix: Drawdown

- The measure of the largest drop from peak to bottom (in percentage)
  - It is a pain index measure
- Extremely important to measure the duration of the drawdown
  - Do you want to be losing money for years?

$$D(T) = \max_{t \in (0,T)} \{X(t) - X(T)\}$$

$$\mathrm{MDD}(T) = \max_{t \in (0,T)} [\max_{t \in (0,\tau)} \{X(t) - X(\tau)\}]$$

- Where $X = (X(t), t \geq 0)$ is a random process
- Simply put maximum drawdown is:
  - (Peak value before largest drop – lowest value before new high) / Peak value before drop



Appendix: Tradeable AUM

- Not all strategies are created equal
- Strategy A might be able to trade $1,000,000 without incurring large slippage but trading $100,000,000 it might incur much more slippage and kill the strategy
  - Market making – your ability to capture the inside bid offer decreases with size
  - High frequency strategies
  - Some momentum strategies
- Sharpe ratios and AUM tradable are usually inversely correlated
  - There are some exceptions
- Note that these numbers are artificial

Thank you Aaron Rosen for your feedback