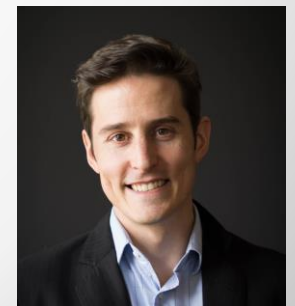


QUANTCONNECT

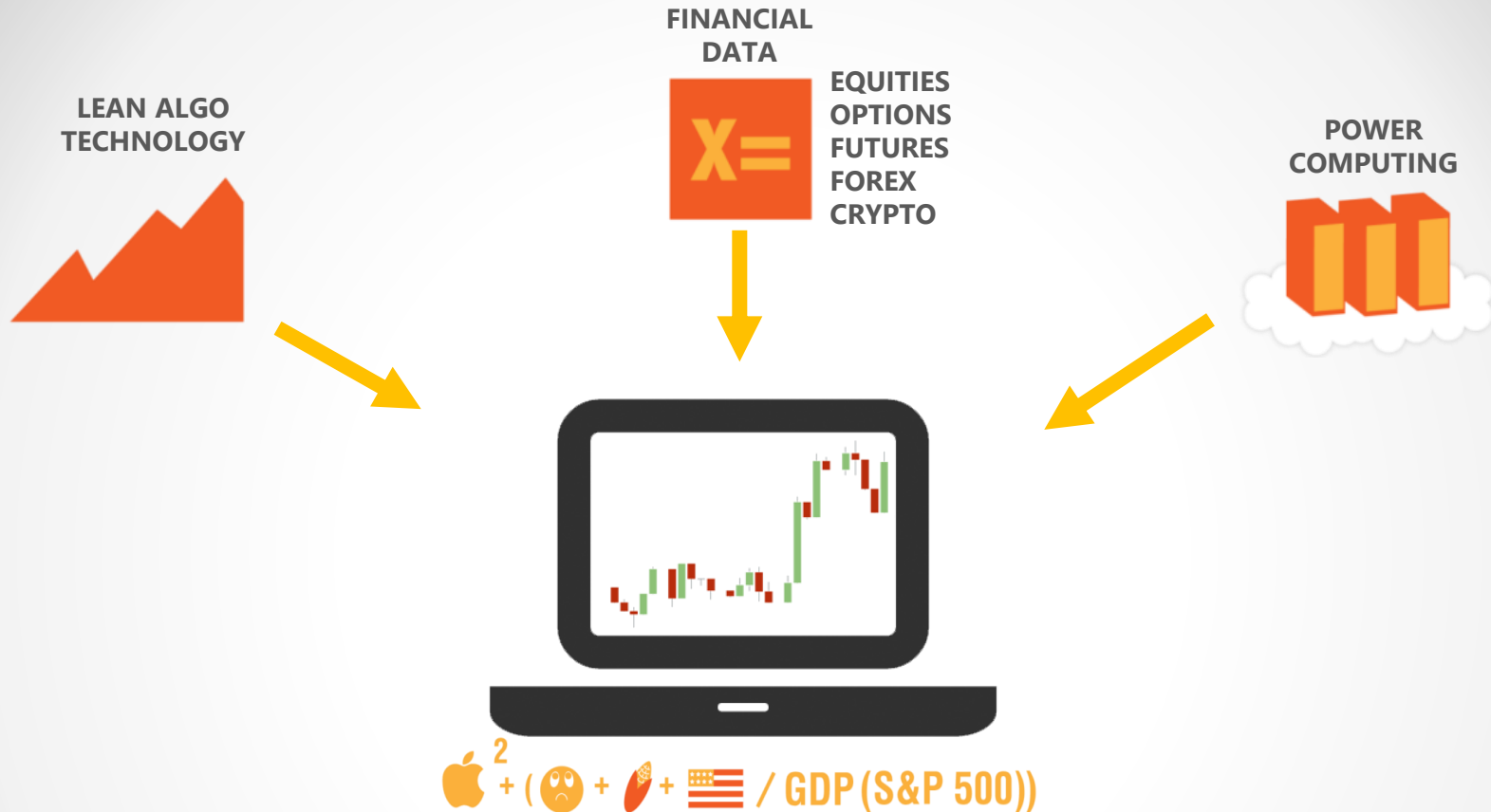
Momentum Based ETF Portfolio Rebalancing *Optimizing Portfolio Construction For Optimal Sharpe Ratio*



Jared Broad
CEO and Founder



What is QuantConnect?



We've built a web algorithm lab where thousands of people test their ideas on financial data we provide; for free.

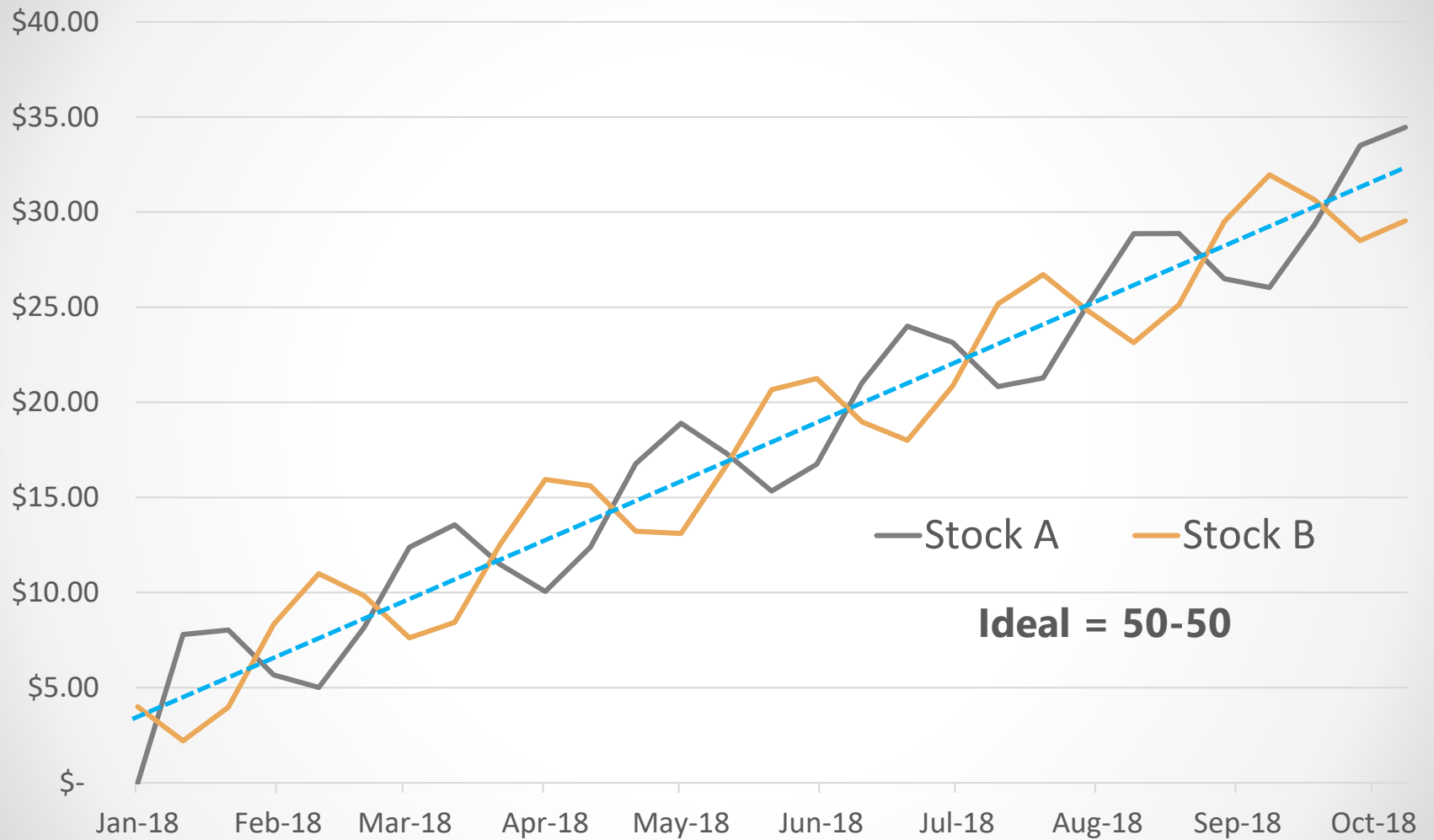
- Basics of Mean Variance Portfolio Construction
- Defining Optimization Function
- LEAN Algorithm Framework
- Implementing Our Model
- Testing and Researching
- Summary

Reduce volatility, increase returns by calculating optimal weight allocation of a portfolio for minimum volatility.

Core Idea:

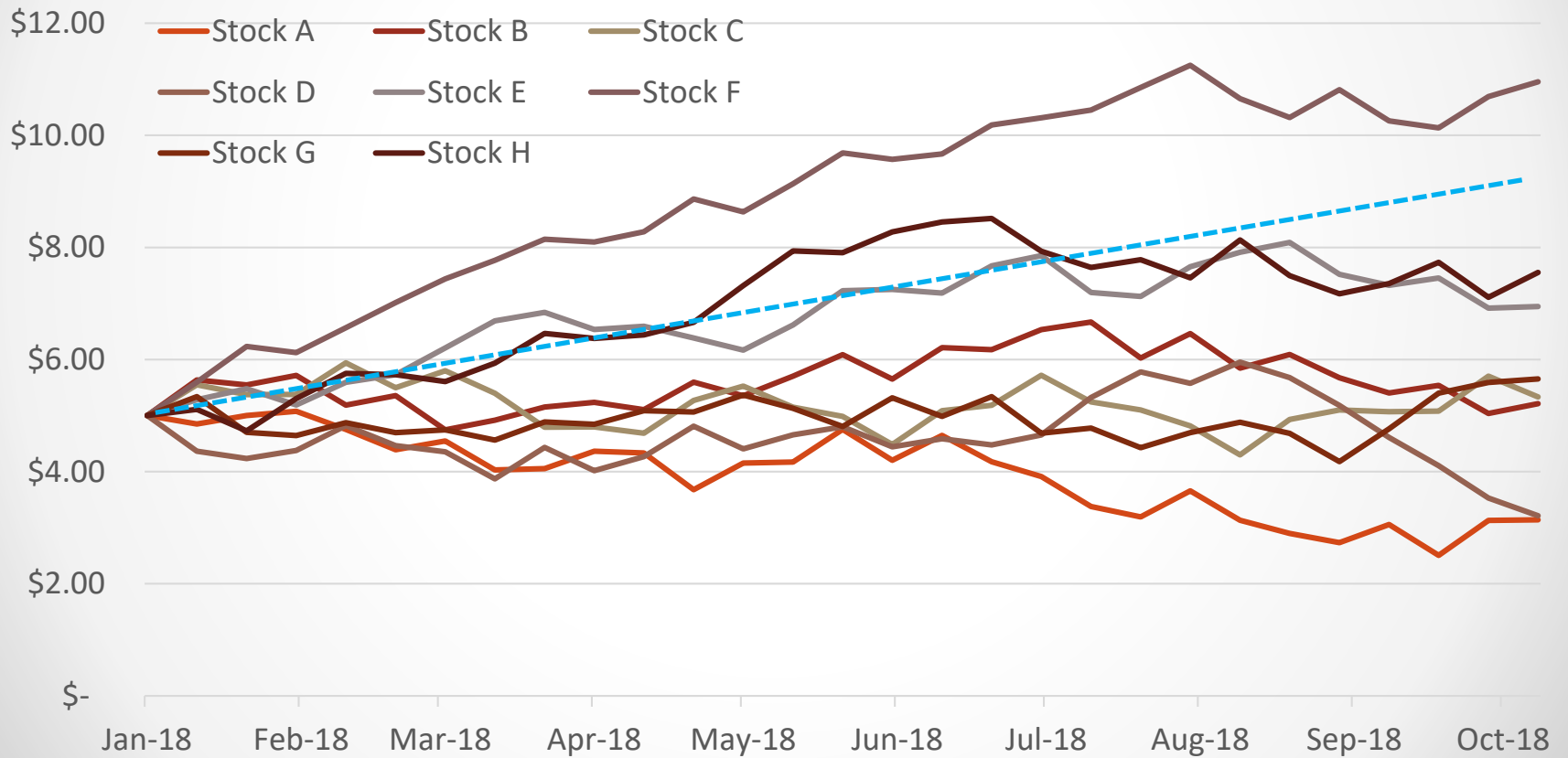
- 1) Create an estimate of returns and volatility.
- 2) Build portfolio of assets; allocating to each by weight.
- 3) Optimize weights to minimize the volatility in portfolio.

Classic Mean Variance Portfolio Construction



Classic Mean Variance Portfolio Construction

Most real world applications have portfolios of many assets. We are seeking to find best balance of hundreds of assets.



Optimizers experiment with portfolios; seeking to minimize the *objective* function.

Classic Mean Variance Optimization the objective function seeks to *minimize expected volatility*.

We will seek to optimize *Sharpe Ratio* instead of volatility; seeking to minimize objective function:

$$x = \min\left(\frac{\textit{Annual Portfolio Return}}{\textit{Var}}\right)$$

This approximates the traditional Sharpe Ratio function and serves as our weighting target.

Build your Alphas with the full power of the

QuantConnect Framework

The QuantConnect Framework bakes in key quantitative finance concepts, giving you a well defined scaffolding to design your alpha.



Portfolio Selection *

Curate your asset universe



Alpha Creation *

Derive your asset signals



Portfolio Construction

Form position sizing



Execution Module

Intelligently execute



Risk Management

Monitor ongoing risk

* Only Portfolio Selection and Alpha Modules are required for Alpha Streams™

Assumptions and Limitations

- ❖ Mean Variance Optimization requires expected returns and we provide historical values. We're making an assumption these returns will continue in the future.
- ❖ Most variance approximations assume a normal distribution.
- ❖ Any estimation error in the return prediction magnified.
- ❖ The resulting portfolios can be concentrated and nonsensical. In practice its more common to use Black-Litterman method.

```
1 from datetime import timedelta
2 import numpy as np
3
4 from CustomMacdAlphaModel import CustomMacdAlphaModel
5 from CustomExecutionModel import CustomExecutionModel
6 from CustomPortfolioConstructionModel import CustomPortfolioConstructionModel
7 from CustomFundamentalPortfolioSelectionModel import CustomFundamentalPortfolioSelectionModel
8 from MaximumDrawdownPercentPerSecurity import MaximumDrawdownPercentPerSecurity
9
10 class CustomFrameworkModelsAlgorithm(QCAAlgorithmFramework):
11
12     def Initialize(self):
13
14         # Set requested data resolution
15         self.UniverseSettings.Resolution = Resolution.Minute
16
17         self.SetStartDate(2013,10,7) #Set Start Date
18         self.SetEndDate(2013,12,31) #Set End Date
19         self.SetCash(100000) #Set Strategy Cash
20
21         self.SetPortfolioSelection(CustomFundamentalPortfolioSelectionModel())
22         self.SetAlpha(CustomMacdAlphaModel(timedelta(minutes = 10), timedelta(minutes = 30), 0.01))
23         self.SetPortfolioConstruction(CustomPortfolioConstructionModel())
24         self.SetExecution(CustomExecutionModel())
25         self.SetRiskManagement(MaximumDrawdownPercentPerSecurity(1.01))
26
27     def OnOrderEvent(self, orderEvent):
28         if orderEvent.Status == OrderStatus.Filled:
29             self.Debug("Purchased Stock: {}".format(orderEvent.Symbol))
```

Backtest

Summary

Total Trades	Drawdown	Net Profit	Sharpe Ratio
270	12.9%	34%	0.555

- ❖ Using portfolio construction techniques we can automatically assign weights to our portfolio assets.
- ❖ This reduces the number of variables we manually define; can improve returns and lower volatility.

Next Steps – Investigate more robust portfolio construction techniques! (E.g. Black-Litterman).

QUANTCONNECT

www.quantconnect.com

Thank you.



Appendix

Research Environment - x

QuantConnect Corporation [US] | <https://www.quantconnect.com/research/notebook/106/MyResearch.ipynb>

QUANTCONNECT Research BETA Pricing Data Community Algorithm Lab Research Documentation Jared Broad

File Edit View Insert Cell Kernel Help Not Trusted Python 2

```
In [14]: # For EURUSD
bbdf = qb.Indicator(bb, "EURUSD", 360, Resolution.Daily)
bbdf = bbdf.drop('standarddeviation', 1)
bbdf.plot()
```

Out[14]: <matplotlib.axes._subplots.AxesSubplot at 0x7efce87ea250>

```
In [ ]: # Example with ADX, it is a bar indicator
adx = AverageDirectionalIndex("adx", 14)
adxdf = qb.Indicator(adx, "SPY", 360, Resolution.Daily)
adxdf.plot()
```

Out[15]: <matplotlib.axes._subplots.AxesSubplot at 0x7efce8439650>

```
private List<String> _universeSymbols = new List<String>();

public override void Initialize() {
    // this sets the resolution for data subscriptions added by our universe
    UniverseSettings.Resolution = Resolution.Second;
    UniverseSettings.FillForward = true;

    // set our start and end for backtest mode
    SetBrokerageModel(BrokerageName.InteractiveBrokersBrokerage);
    SetStartDate(2017, 08, 18);
    SetEndDate(2017, 08, 24);

    var spyEquity = AddEquity("SPY", Resolution.Second, Market.USA, true, 0, true);
    // Schedule events
    Schedule.On(DateRules.EveryDay("SPY"), TimeRules.AfterMarketOpen("SPY", 5), () => {
        OpenPositions();
    });
    Schedule.On(DateRules.EveryDay("SPY"), TimeRules.AfterMarketOpen("SPY", 15), () => {
        ClosePositions();
    });
    Schedule.On(DateRules.EveryDay("SPY"), TimeRules.BeforeMarketClose("SPY", 1), () => {
        canPoll = false;
        List<OrderTicket> stopTickets = Transactions.GetOrderTickets(x => x.OrderType == Orders.OrderType.StopMarket).ToList();
        foreach (OrderTicket stopTicket in stopTickets ?? Enumerable.Empty<OrderTicket>())
        {
            Debug(String.Format("Cancelling stop order for {0}", stopTicket.Symbol));
            stopTicket.Cancel();
        }
        Debug("Finished Cancelling stop orders for the day");
    });
    DebugMessages
    // DEMO
    {
        define local
        Debug local
        decimal local
        Decimal local
        default keyword
        using var client = new WebClient();
        {
            // handle live mode file format
            if (LiveMode)
            {
                // fetch the file from dropbox
                String file = client.DownloadString(url);
                // if we have a file for today, break apart by commas and return symbols
                if (file.Length > 0)
                {
                    file = file.Replace("\r\n", "");
                    _universeSymbols = file.ToCsv();
                    _universeSymbols.ForEach(Debug);
                    return _universeSymbols;
                }
            }
            // no symbol today, leave universe unchanged
        }
    }
}
```


Going Live, Deploying to Live Trading



Live: Clone of FX Combiner x

QuantConnect Corporation [US] | https://www.quantconnect.com/terminal/#openLive/615470

Terminal Upgrade Mode LIVE Data Community Algorithm Lab Research Documentation Bernard Blazquez

Dashboard

\$2.21 Unrealized -\$0.00 Fees \$0.00 Net Profit 2.81 % Return \$132.08 Equity \$132.10 Holdings \$259.79 Volume

Zoom 10m 1h 1d 1w All

Jul 26, 2017
Equity: \$131.4445

Market Status Time
Equity Open 18:24:02 EDT
Forex Open 18:24:02 EDT

Select Chart
Strategy Equity
Benchmark
Select Stockplot

Status
Running

Server Statistics
CPU : 79.1%
RAM : 320 Mb / 512 Mb
Host : QC-COLO-1-9f0ca110
Up Time : 57d 01:35:09

Clone of: FX Combined Momentum and Correlation
QuantConnect - LEAN v2.4.0.0.1773

Portfolio Holdings

Symbol	Average Price	Quantity	Market Price	Market Value	Unrealized
GBPUSD	\$1.29897	100	\$1.32102	\$132.102	\$2.20

Orders

Id	DateTime	Symbol	Fill Price	Quantity	Type	Operation	Status
4	2017-09-01 09:31:05	USDCAD	\$CAD	-136	Market	Short	Invalid
3	2017-09-01 09:31:05	GBPUSD	\$1.29897USD	100	Market	Long	Submitted
2	2017-08-01 09:31:05	USDCAD	\$CAD	-132	Market	Short	Invalid

Console