# Statistical Arbitrage Pairs Trading

A presentation series by Hudson & Thames

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# PRESENTATION SERIES PLAN

- Distance Approach In Pairs Trading
- Simulating Cointegrated Pairs and Minimum Profit Optimization
- Introduction to Copula-Based Pairs Trading Strategy
- Applying Machine Learning to Statistical Arbitrage

25 Minutes per Presentation

5 Minutes Q&A after each Presentation

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# ABOUT ME

- Quantitative Research Team Lead at Hudson & Thames
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# DISTANCE APPROACH IN PAIRS TRADING

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# PLAN OF THE PRESENTATION

01 **PAIRS TRADING FIELD**
Classification of approaches and history

02 **DISTANCE APPROACH**
Where the pairs trading started

03 **IMPLEMENTATION AND RESULTS**
How to use the tools and what results can be obtained

04 **UPSIDES AND DOWNSIDES**
What can be done to improve the results of the original method

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# PAIRS TRADING CONCEPT

## FINDING A PAIR

Two securities whose prices have moved together historically

## MONITOR THE SPREAD

Monitor the spread between prices in a subsequent period

## TRADE

If the prices diverge and the spread widens, short the winner and buy the loser

## VARIATIONS

Multiple ways to use the concept. Possible extensions to multivariate frameworks

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# PAIRS TRADING APPROACHES (according to C. Krauss)

- DISTANCE
- COINTEGRATION
- TIME SERIES
- STOCHASTIC CONTROL
- OTHER
  - MACHINE LEARNING
  - COPULA
  - PRINCIPAL COMPONENT ANALYSIS

Completion Status in ArbitrageLab

(as of January 2021)

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# BASELINE DISTANCE APPROACH (by Gatev et al.)

- Picking securities
- Price normalization
- Euclidean distance calculation
- Pair selection
- Position entry/exit logic
- Examples
- Upsides of the strategy
- Downsides of the strategy

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## Preparation

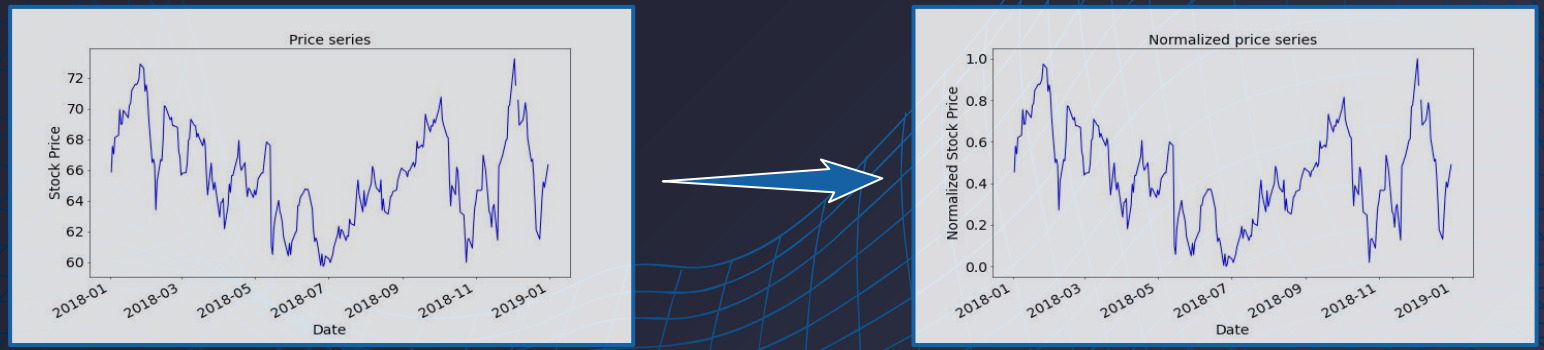
- Picking liquid U.S. stocks (period 1962-2002)

## Pairs Formation Period I

- Normalizing all stocks prices
  (or cumulative total return index)

$$P_{normalized} = \frac{P - min(P)}{max(P) - min(P)}$$

- And saving the normalization values $min(P)$ and $max(P)$

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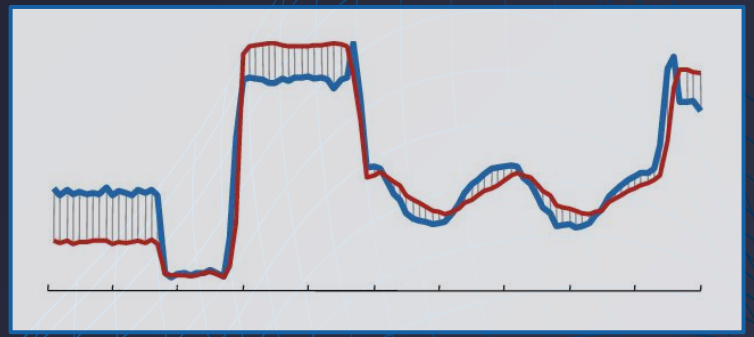
# Pairs Formation Period II

- Calculating distances between each pair of normalized prices

$$SSD = \sum_{t=1}^{N} (P_t^1 - P_t^2)^2$$

(Euclidean square distance - SSD)

- Picking top n pairs with smallest distances



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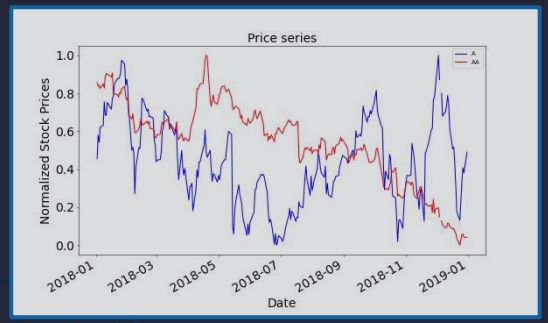
## Pairs Formation Period III

- Calculating historical spread volatility for picked pairs





$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N - 1}}$$

## Trading Period I

- Normalizing stocks prices in the trading period using saved values

$min(P)$ and $max(P)$

- Calculating pair spreads in the trading period

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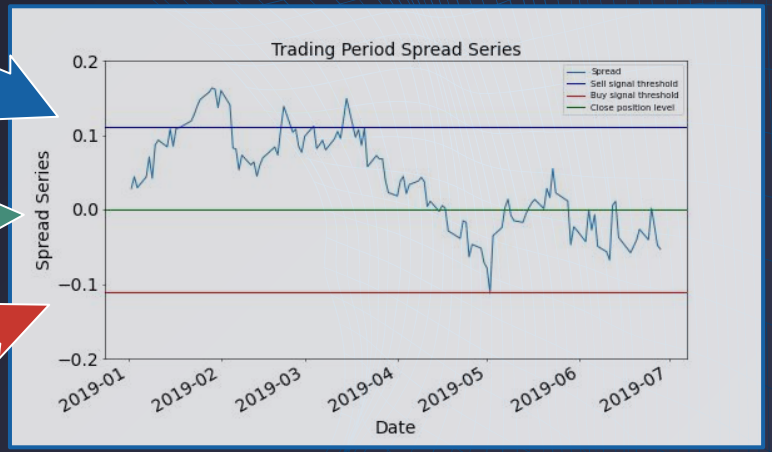
# Trading Period II

- Generating trading signals

If the spread value exceeds two historical deviations, generate a **sell** signal

**Close** open position when spread crosses the zero mark

If the spread value is below minus two historical deviations, generate a **buy** signal

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## Strategy Usage

| 12 months pairs formation period | 6 months trading period |
| --- | --- |

Picking top 20 pairs of stocks

Using 2 historical deviations threshold to enter a trade

## Strategy Variations

- Pairs formation / trading period duration
- Number of chosen pairs
- Sensitivity of the signal generation
- Weights in the portfolio of pairs
- Weights of assets in each pair

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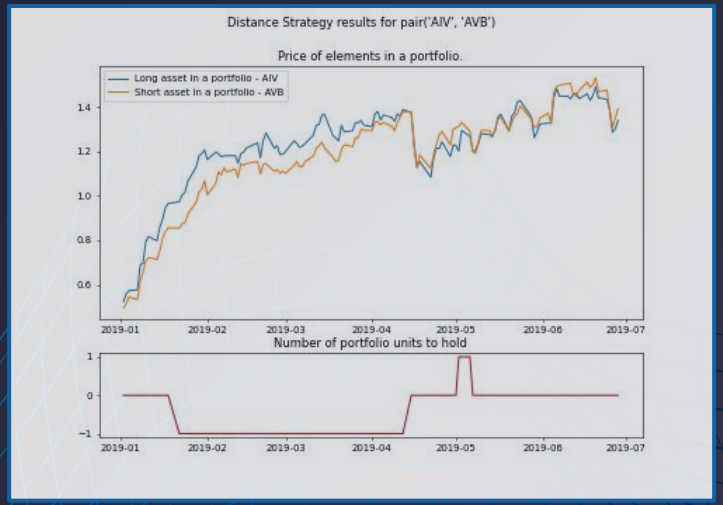
# SHOW ME THE CODE

```python
# Importing packages
import pandas as pd
from arbitragelab.distance_approach.basic_distance_approach import DistanceStrategy

# Getting the dataframe with price time series for a set of assets
data = pd.read_csv('prices.csv', index_col=0, parse_dates = [0])

# Dividing the dataset into two parts - the first one for pairs formation
data_pairs_formation = data.loc[:'2019-01-01']

# And the second one for signals generation
data_signals_generation = data.loc['2019-01-01':]

# Performing the pairs formation stage of the DistanceStrategy
# Choosing pairs 5-25 from top pairs to construct portfolios
strategy = DistanceStrategy()
strategy.form_pairs(data_pairs_formation, num_top=20, skip_top=5)

# Now generating signals for formed pairs, using (2 * st. variation) as a threshold
# to enter a position
strategy.trade_pairs(data_signals_generation, divergence=2)

# Checking portfolio values for pairs and generated trading signals
portfolios = strategy.get_portfolios()
signals = strategy.get_signals()

# Plotting price series for elements in the second pair (counting from zero)
# and corresponding trading signals for the pair portfolio
figure = strategy.plot_pair(1)
```

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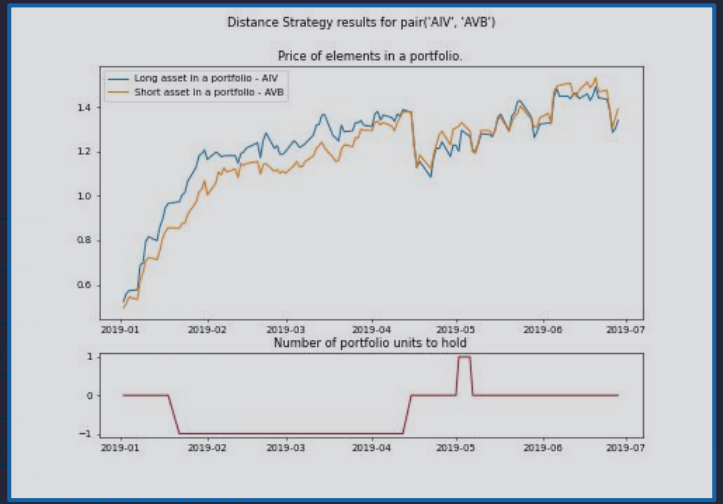
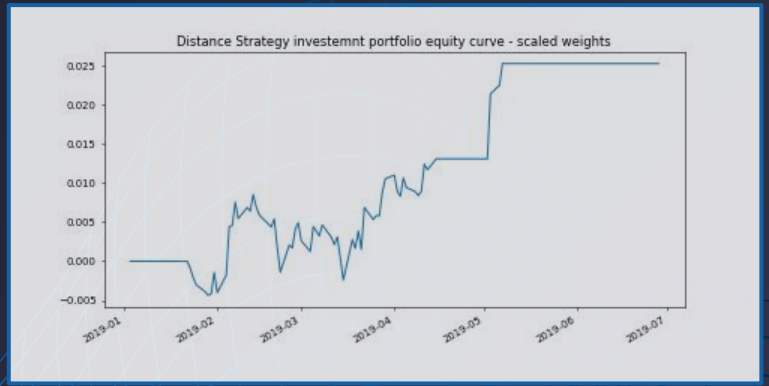
# RESULTS

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# Upsides

- Established pairs trading concept in the literature
- Baseline strategy generated excess returns over a long period
- Method robust to data snooping
- Easy to interpret
- Nonparametric
- Economic model-free

# Downsides

- Using Euclidean squared distance for picking pairs is not optimal (see Krauss et al. 2015)
- No cointegration tests are performed, so observed correlations may be spurious
- 32 percent of all identified pairs based on the distance metric do not converge (see Do and Faff 2010)
- Worse mean reverting behavior compared to cointegration relationships (see Huck 2015)
- Worse volatility properties compared to cointegration relationships (sdd Huck 2015)
- Profitability of the method is declining on tests after 2009 (see Do and Faff 2012)

# Improvements

- Choosing different pair distance measure
- Add high historical spread variance criterion to pairs selection
- Add high historical spread mean reversion criterion to pairs selection

- Limit matching securities within industries (see Do and Faff 2012)
- Favor pairs with high number of zero-crossing in the formation period (see Do and Faff 2012)
- Adding a familywise error rate (see Cummins and Bucca 2012)

# Other Strategies

- Using Pearson correlation (see Chen et al. 2012)
- Moving to quasi-multivariate pairs trading (see Chen et al. 2012)
- Expanding the strategy to high frequency applications (see Nath 2003)

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# THANK YOU!

Does anyone have any questions?

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