

The background of the slide is a dark, semi-transparent image of a financial chart. It features multiple overlapping lines in white, green, and red, which appear to be candlestick or line charts. A prominent blue diagonal line crosses the chart from the bottom left towards the top right. The overall aesthetic is technical and professional, typical of a financial presentation.

Pair Trading

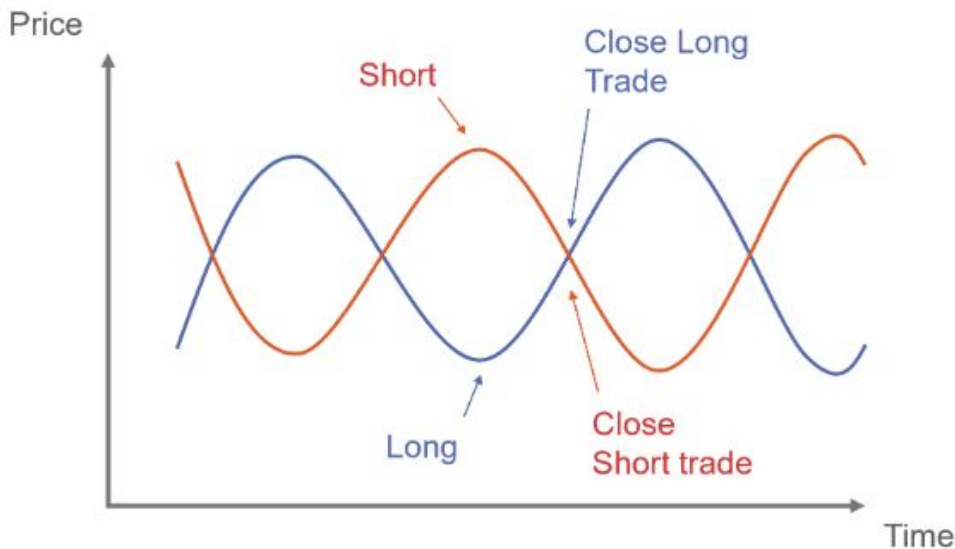
By: Alejandro, Ashkaan and Shrey

Research Question

How Does One Implement “Pair Trading” for The Stocks in S&P 500?

What Does This Mean?

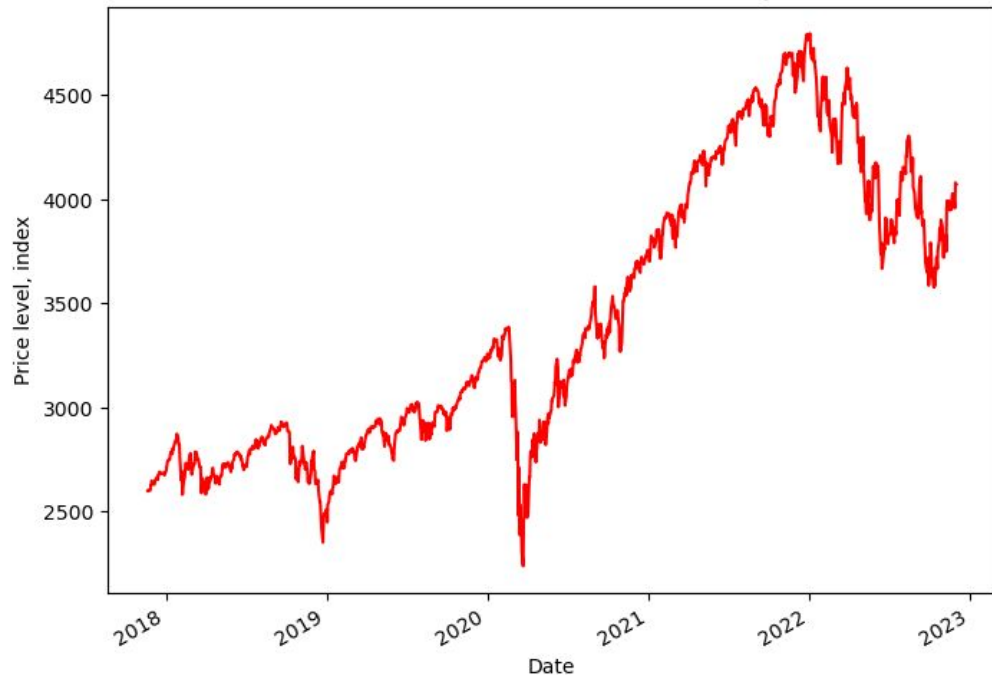
- The goal is to match two stocks (e.g. Pepsi and Coke) that are highly cointegrated. We view these as a pair.
- When the pair's price ratio diverges some number of standard deviations (based on historical data), we trade one stock long and the other short.



General idea of pairs trading

Motivation

S&P500 Index, Performance Over Last 5 years



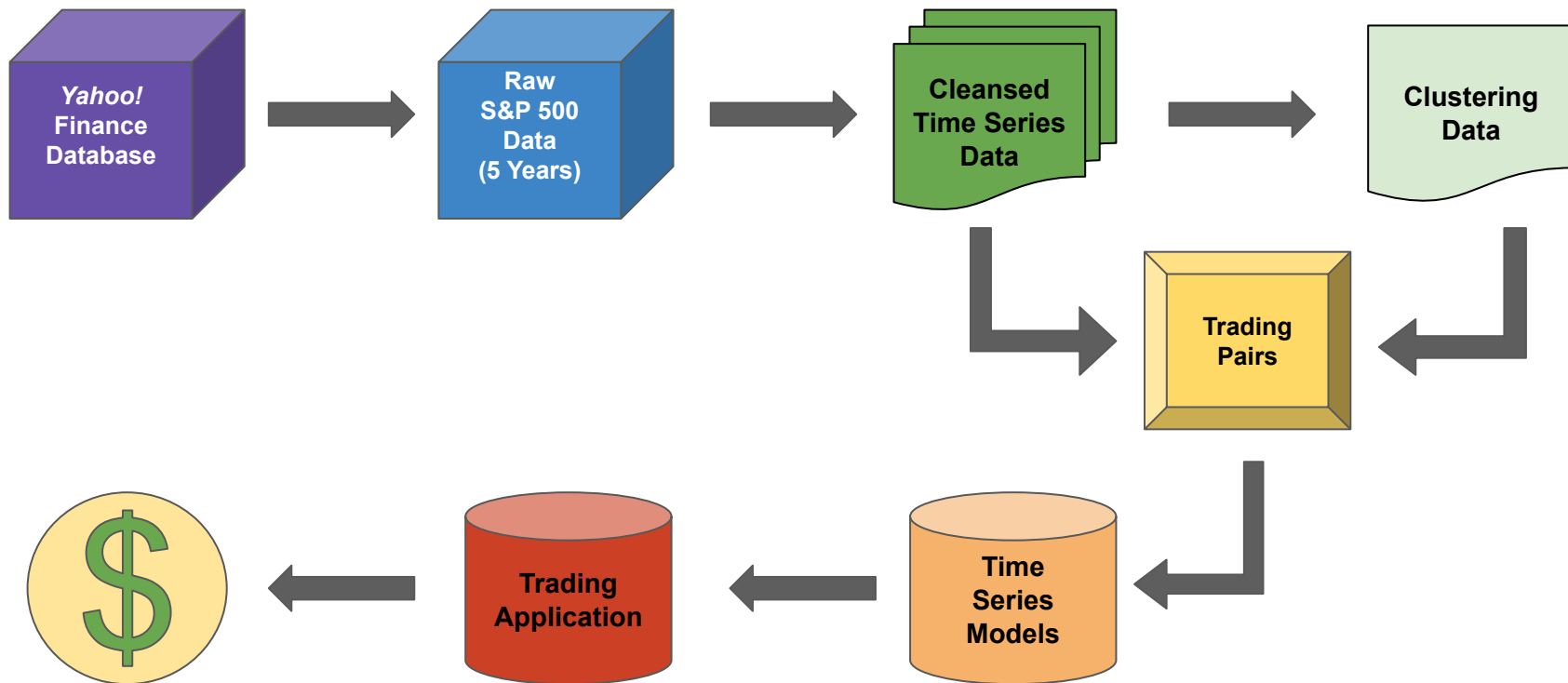
Why Implement a Pair Trading Strategy?

- **S&P 500** index has lost **-17% year-to-date**. Thus, investing at the index level has not been a good strategy.
- Pair trading has the potential to achieve profits through simple and relatively low-risk positions.
- The fluctuation of stock market has been violent over the last few years. We want to show that volatility can be your friend.

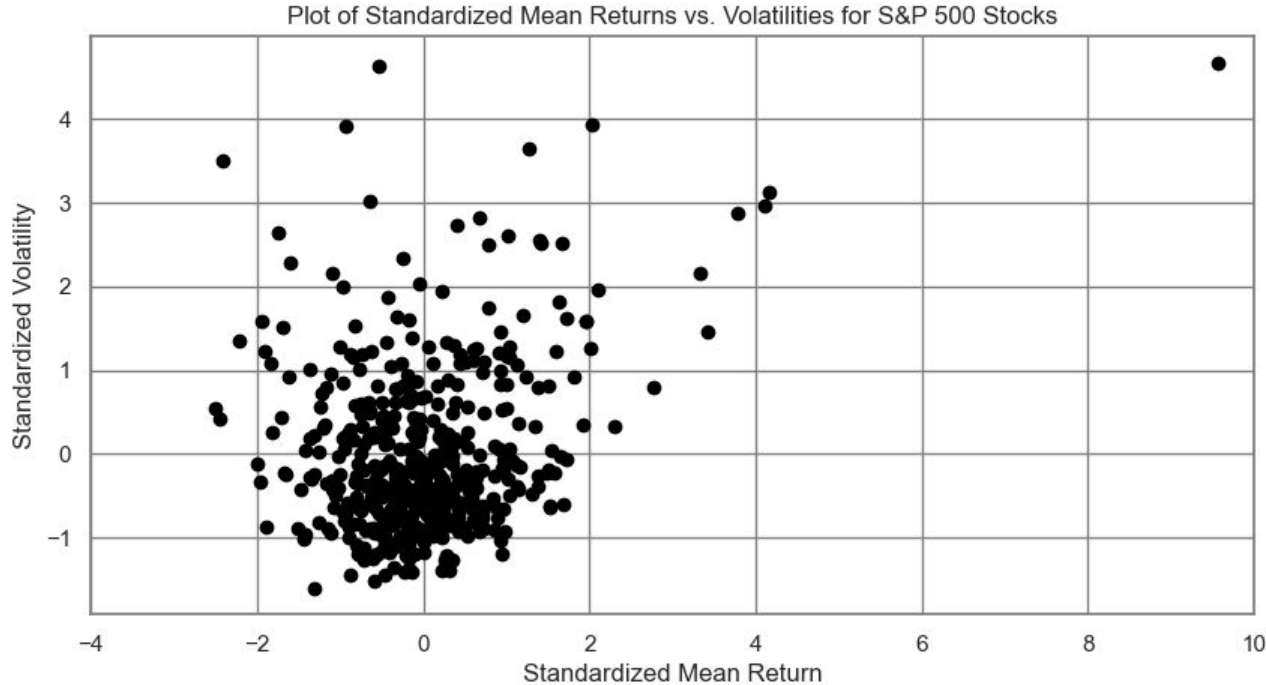
Related Work

- Pairs trading is ***one of the most commonly studied algorithmic trading strategies*** in literature (see ***References***)
- The spread prediction problem is often formulated as a simple distance measurement problem. This approach is outdated due to overly-simplistic assumptions made in the model.
- Various papers have proposed a ***“Kalman Filtering” based approach*** to predict spread. It is one of the most commonly used techniques in pair trading today.
- There has been an interest in ***applying deep learning methods***, like ***LSTM***, for stock price prediction problems.

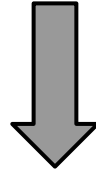
Overall Plan (Workflow)



Preliminary View of Returns vs. Volatilities:



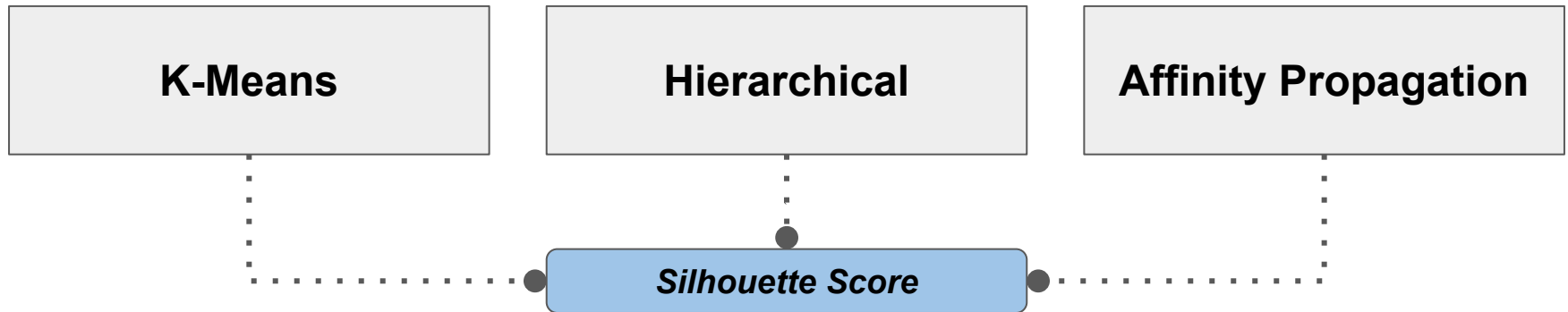
**Large Number of Packed
Stocks Near Center...**



**... Best Clustering
Strategy to Form
Groups?**

Evaluation of Clustering Algorithms and Models

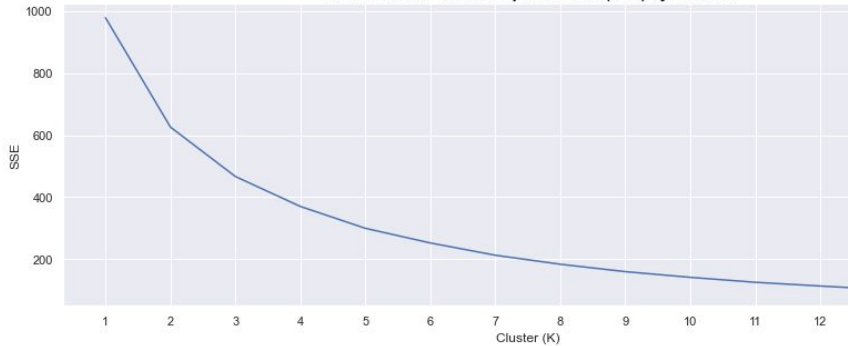
- Why Clustering Analysis?
- Several approaches to clustering exist. [6]
- How to choose?
- $O(n^2)$ algorithms are not practical when $n \rightarrow \infty$



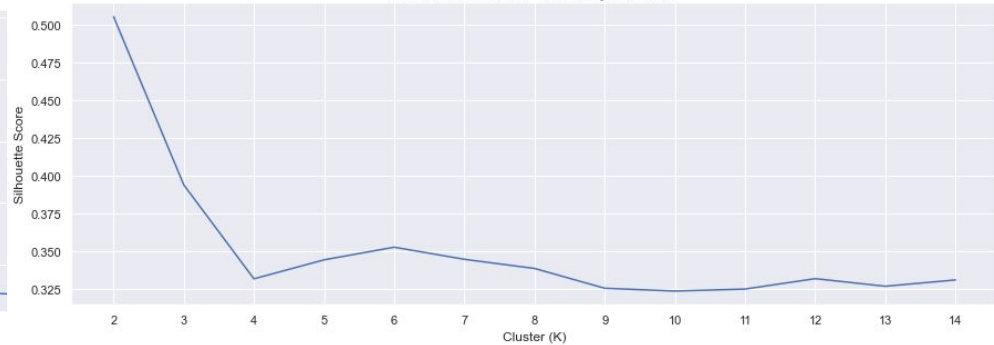
K-Means Clustering

- K-Means has a complexity of $O(n)$
- How to pick the optimal number of clusters (k)?
- Unsupervised Methods:
 - Elbow (Sum of Squared Errors)
 - Silhouette Score

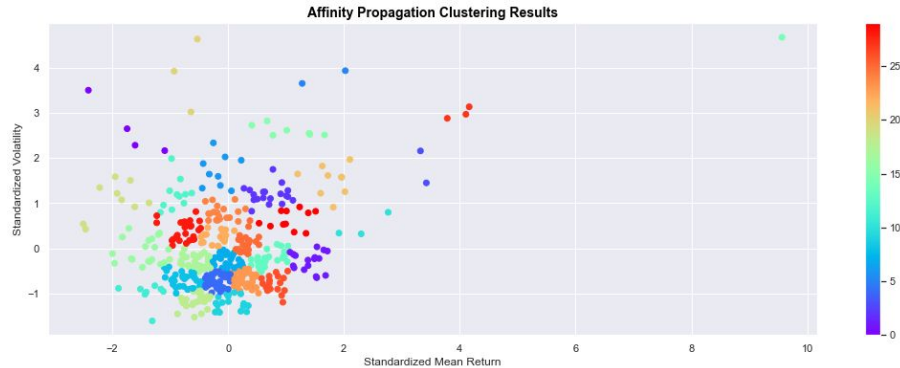
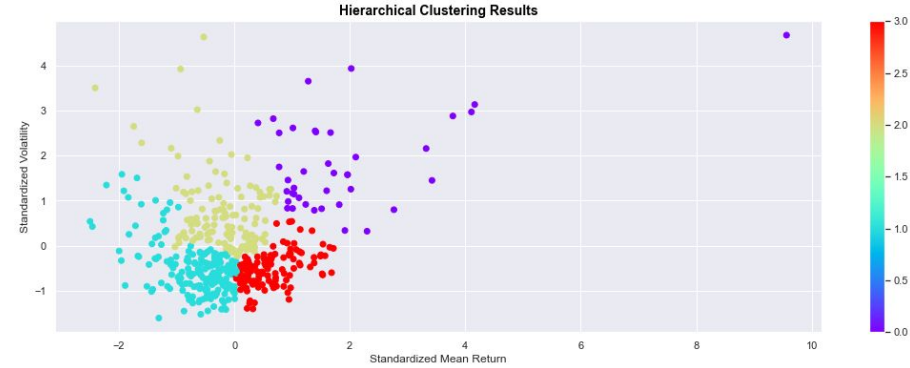
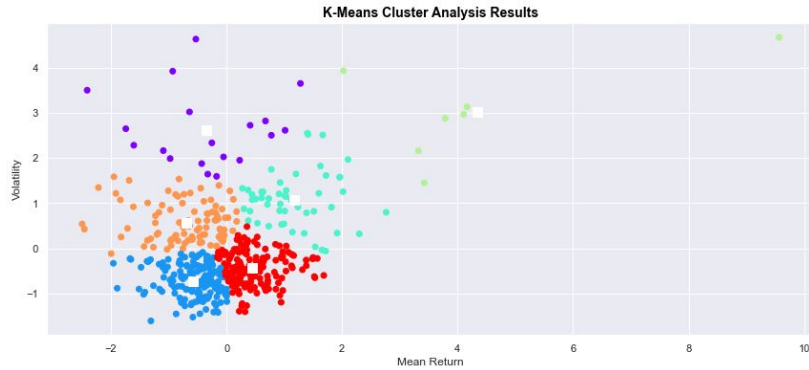
Elbow Method - Sum of Square Errors (SSE) by Clusters



Silhouette Method - Score by Clusters



Results for Clustering Algorithms



Cluster Evaluation & Model Selection Silhouette Scores

K-Means Clustering: 0.33616

Hierarchical Clustering: 0.287473

Affinity Propagation Clustering: 0.34961

Selecting Trading Pairs: Cointegration

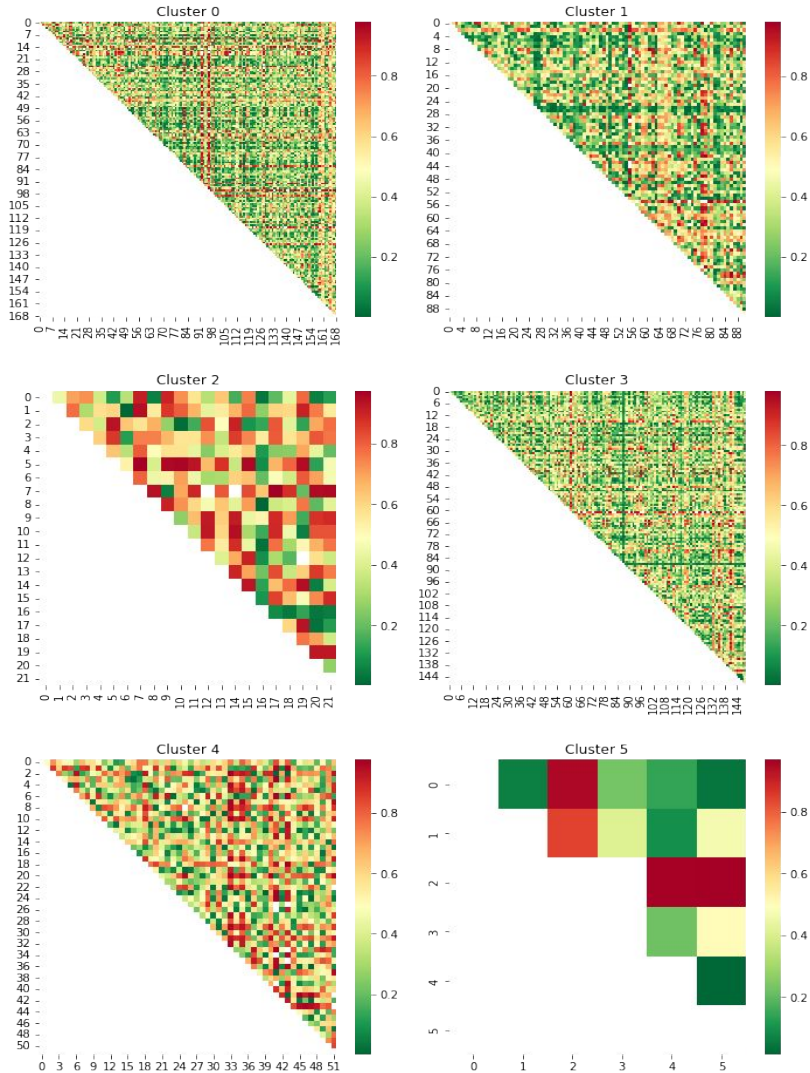


P-Value Heat Maps

***Test for
Statistically
Significant
Cointegration***



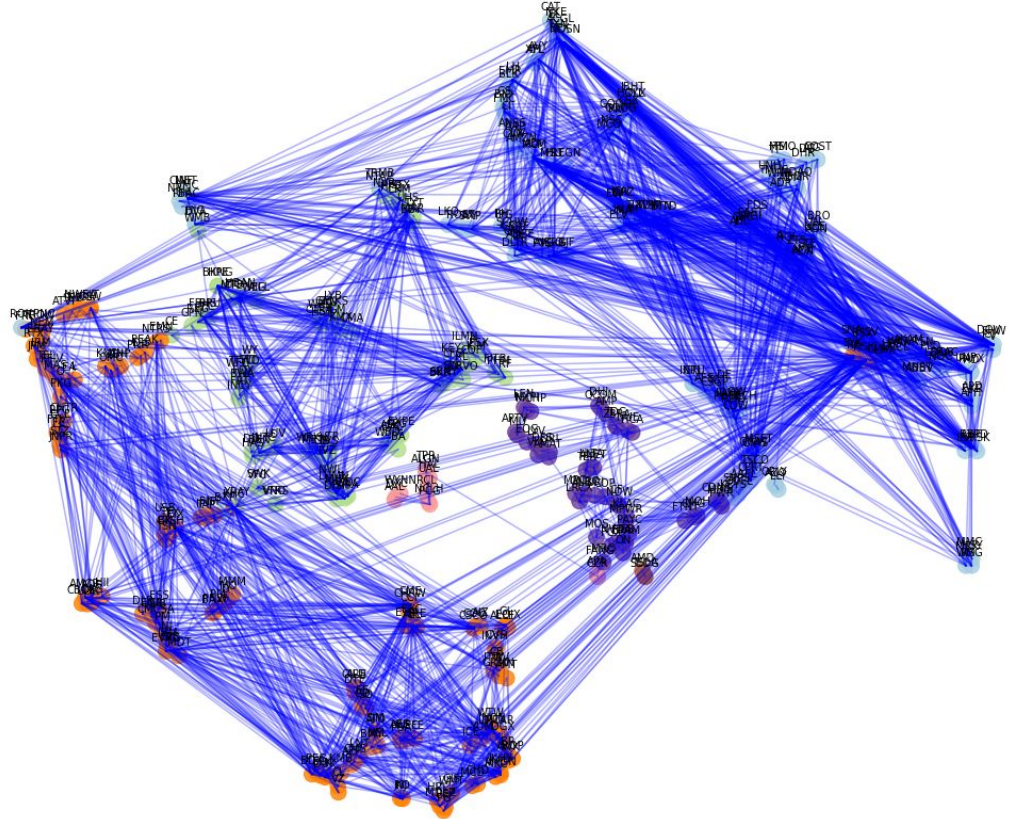
***Requires
 $p \leq 0.02$***



T-Stochastic Neighbor Embedding (TSNE)

***Shows All Pairs
That Passed
CDFT ...***

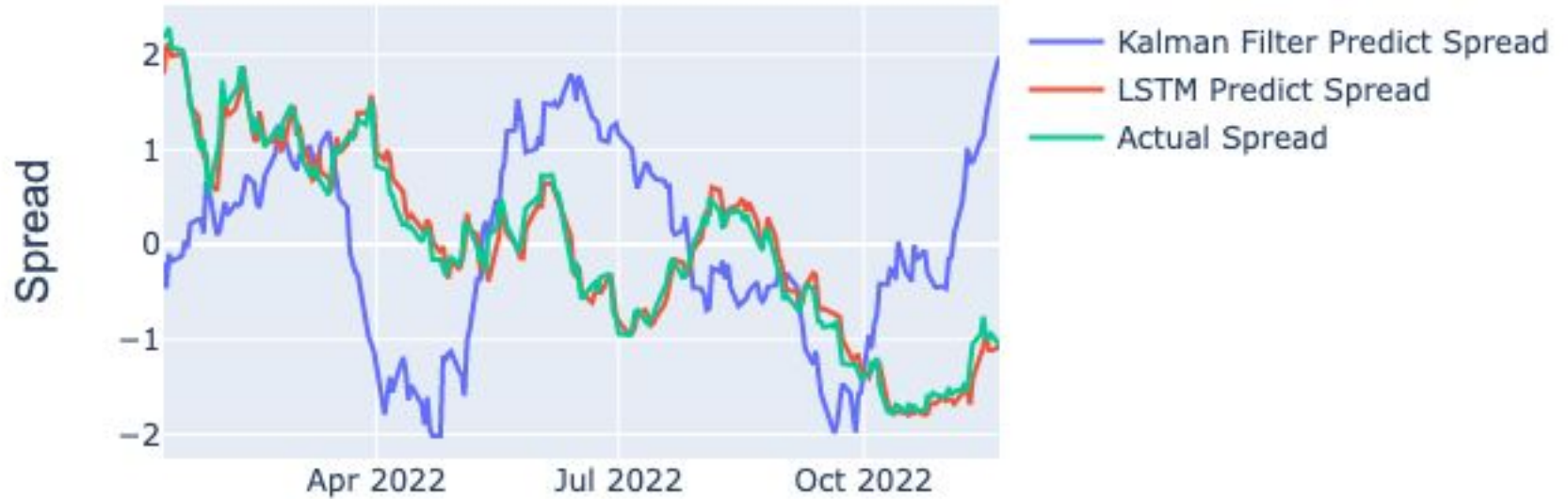
***... Let's
Forecast AMD
and TSLA Pair
Trends!***



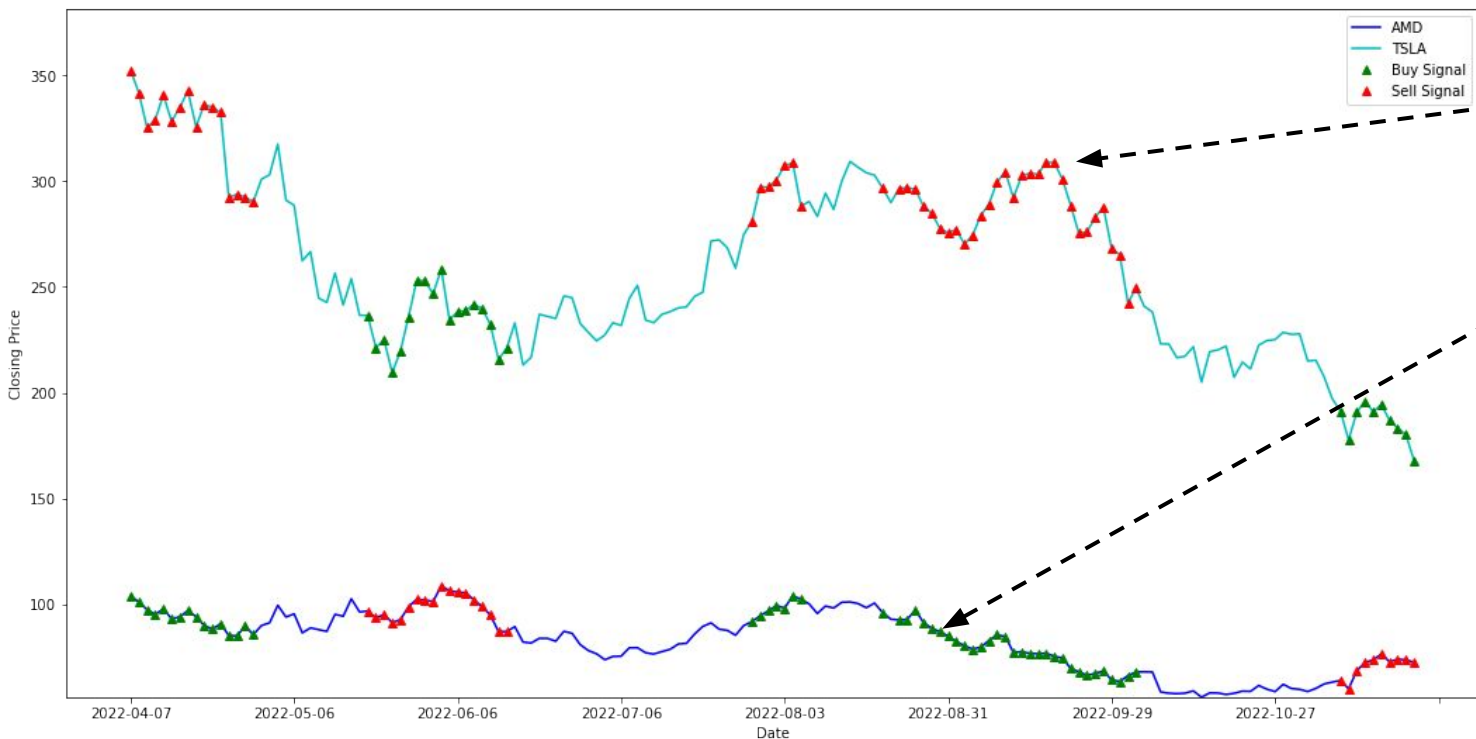
Spread: Closing Price (AMD - TSLA)



Spread Forecasting: AMD vs. TSLA



Applying the Pair Trading Strategy: AMD vs. TSLA



**Follow the Buy
and Sell Signals!**

Profit Earned:

\$1,094,134.40

References

- [1] Vidyamurthy, G. (2004). Pairs Trading: Quantitative Methods and Analysis. John Wiley & Sons.
 - [2] Elliott, R. J., van der Hoek, John, & Malcolm, W. P. (2005). Pairs trading. *Quantitative Finance*, 5(3), 271-276.
 - [3] Gatev, E., Goetzmann, W. N., & Rouwenhorst, K. G. (2006). Pairs trading: Performance of a relative-value arbitrage rule. *Review of Financial Studies*, 19(3), 797-827.
 - [4] Gatev, E., Goetzmann, W. N., & Rouwenhorst, K. G. (1999). Pairs trading: Performance of a relative-value arbitrage rule. Working paper, Yale School of Management's International Center for Finance.
 - [5] M. Avellaneda and J.-H. Lee, "Statistical arbitrage in the US equities market," *Quantitative Finance*, vol. 10, no. 7, pp. 761–782, 2010.
 - [6] Xu, D., Tian, Y. A Comprehensive Survey of Clustering Algorithms. *Annals of Data Science*. 2, 165–193 (2015).
 - [7] Kaur, Simerjot, "Quantitative Trading Strategies Using Deep Learning: Pairs Trading." Stanford University (2018).
- Repo: https://github.com/UC-Berkeley-I-School/moinzadeh_reskala_singhal_w207_final