Analysis of Jim Simons' Trading Strategy

An Insight into Quantitative Trading

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Outline

Mispricing

"The Medallion Fund, managed by Renaissance Technologies, is capped at approximately $10 billion in assets. In comparison, BlackRock's iShares Core S&P 500 ETF holds over $400 billion in assets, and Vanguard's Total Stock Market Index Fund manages more than $1 trillion."

"He did not believe in the efficient market hypothesis and always looked to capture the market inefficiencies using mathematical models"

What is mispricing?

Mispricing refers to the situation where an asset is priced incorrectly compared to its intrinsic value, often due to market inefficiencies or a lack of information.

For example, the index price does not equal the price of a portfolio constructed from the index's constituents.

For example, the put-call parity in options does not always satisfy the equation:

$$C(t) - P(t) = S(t) - K \cdot B(t, T), \tag{1}$$

but

$$C(t) - P(t) = S(t) - K \cdot B(t, T) + \varepsilon_t \tag{2}$$

where $C(t)$ is the call option price, $P(t)$ is the put option price, $S(t)$ is the stock price, K is the strike price, and $B(t, T)$ is the present value of the strike price discounted to time t.

How to Benefit from Mispricing

Strategies to Profit from Mispricing:

- **Arbitrage:**
  - Buy the undervalued asset and simultaneously sell an overvalued equivalent to profit from the price difference.
- **Value Investing:**
  - Identify and purchase undervalued assets, holding them until the market corrects the mispricing.
- **Market Timing:**
  - Take advantage of temporary mispricing caused by market inefficiencies, such as during periods of high volatility or news events.

Example of Taking Advantage from Misprice: Pair Trading

Pair trading involves taking a long position in one asset and a short position in a related asset, exploiting price divergence between the two.

Mathematical Model:

- Let $S_1(t)$ and $S_2(t)$ represent the prices of two correlated assets.
- The spread $X(t)$ between the two assets is given by:

$$X(t) = S_1(t) - \beta S_2(t)$$

  where β is the hedge ratio, often estimated using linear regression.
- Profit is made by betting on the mean reversion of $X(t)$:

$$X(t) \sim \mu_X$$

  where μ_X is the mean of the spread. Traders will buy when the spread is below μ_X and sell when it is above μ_X.

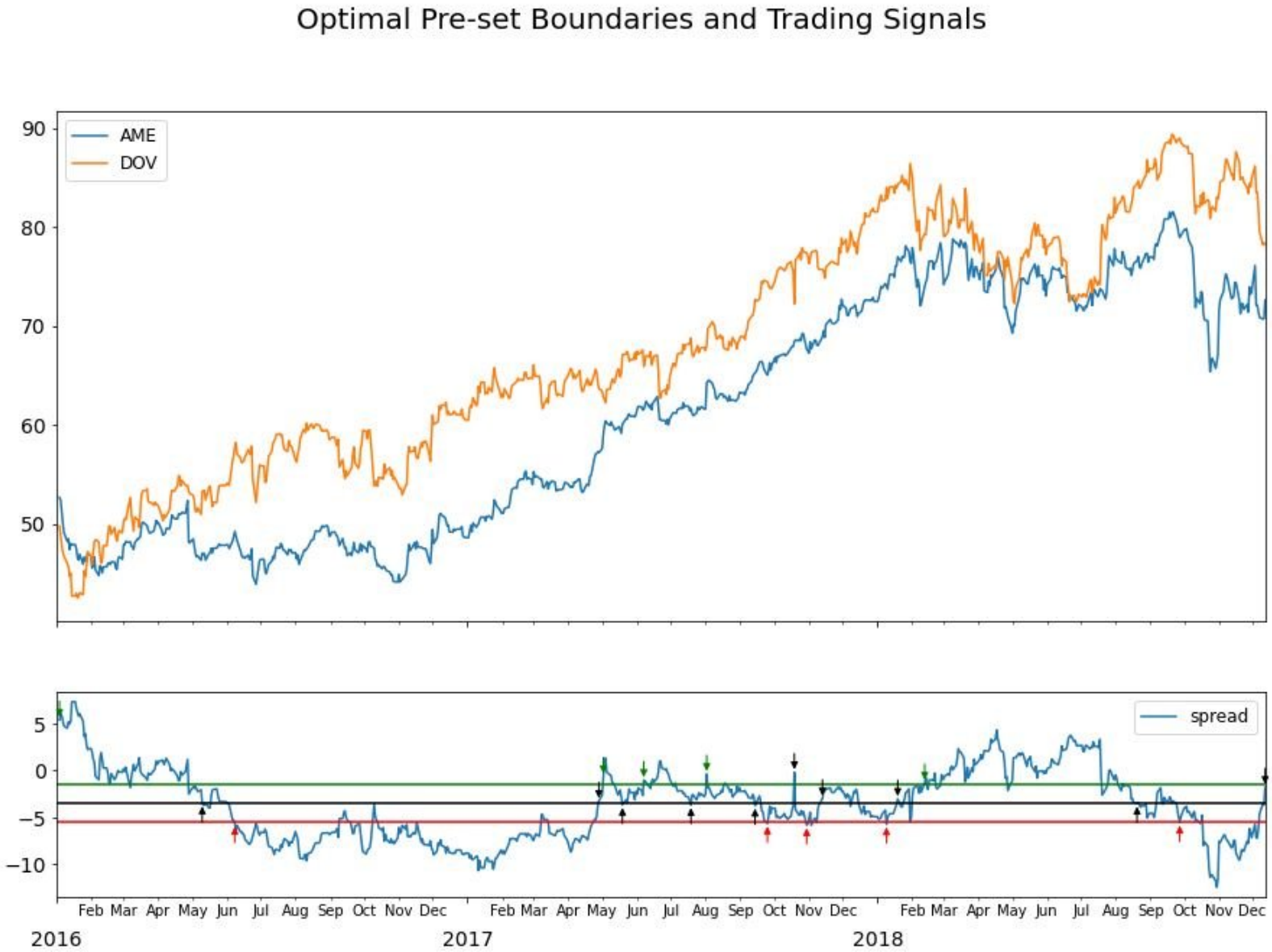

Figure:
https://hudsonthames.org/definitive-guide-to-pairs-trading/

Data Topology

"What if we integrate alternative data to identify mispricing?"

- Minimal Cones, Plateau's Problem, and the Bernstein Conjecture
- Minimal Varieties in Riemannian Manifolds
- Some Cohomology Classes in Principal Fiber Bundles and Their Application to Riemannian Geometry

What is a Manifold?

A **manifold** is a mathematical space that locally resembles Euclidean space, but can have a more complicated global structure.

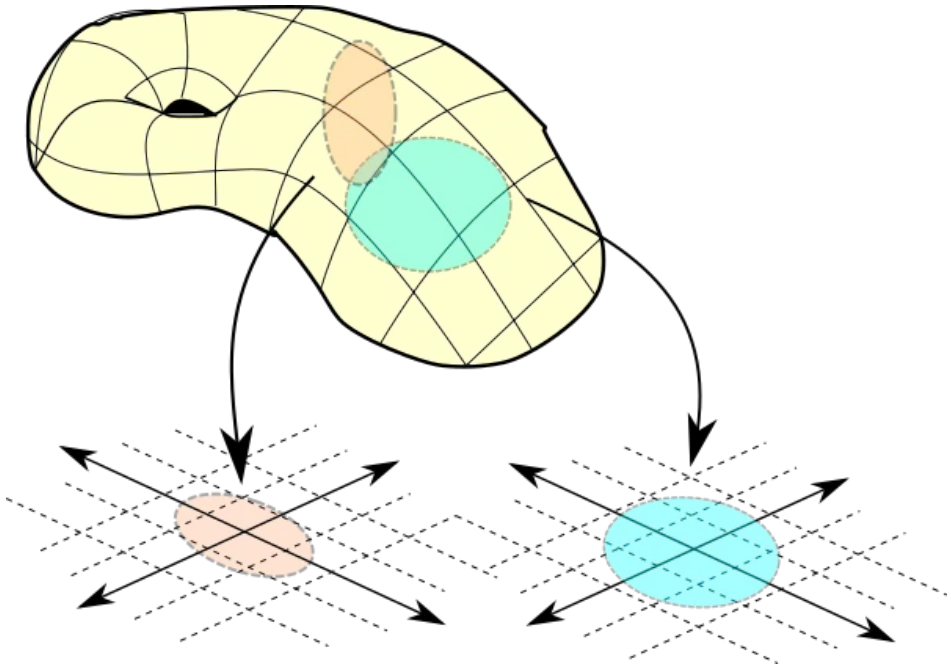

Figure: `https://medium.com/intuition/what-the-heck-is-a-manifold-60b8750e9690`

Data to Manifold

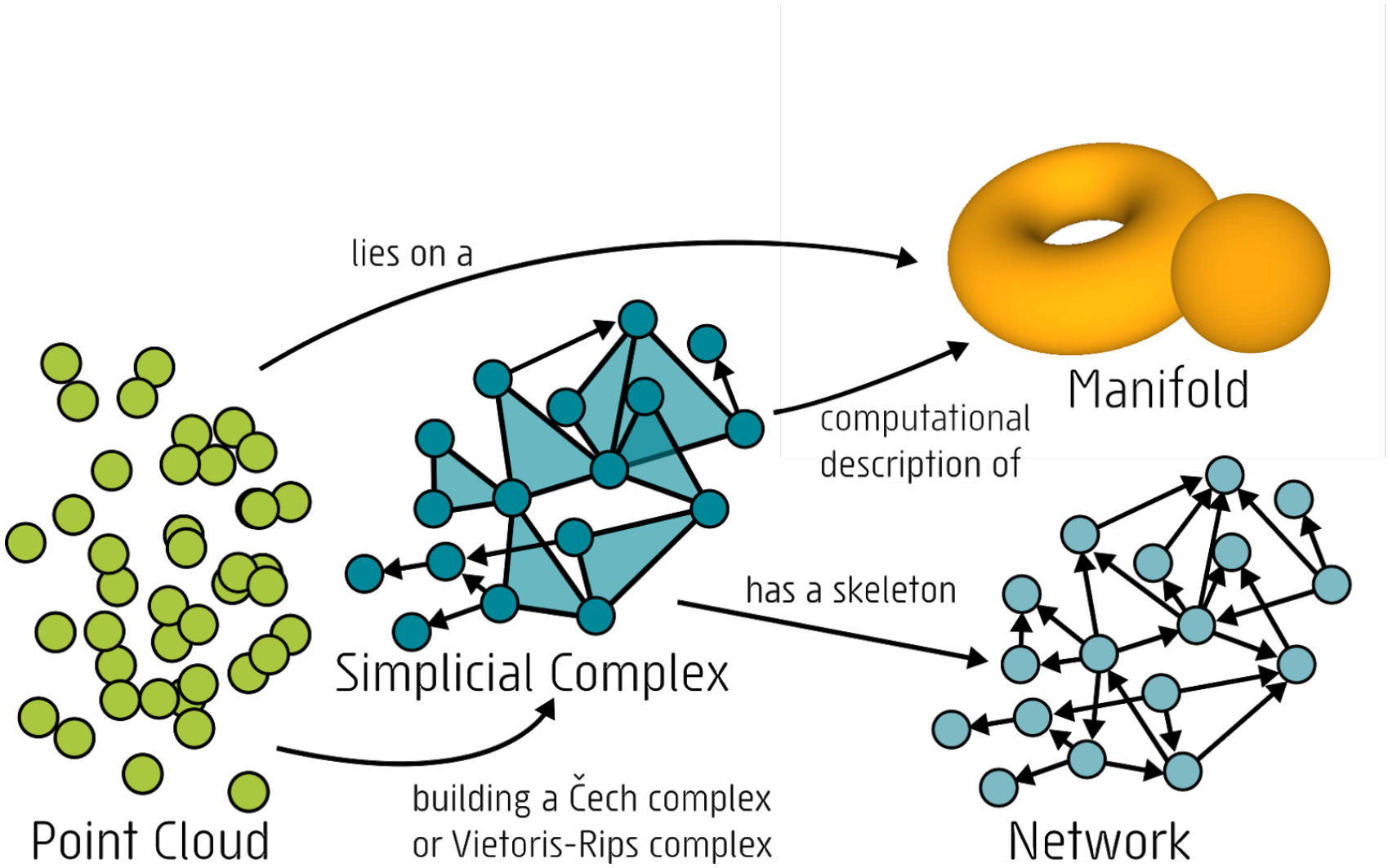

Figure: `https://menchelab.com/higher-order-networks-and-the-topology-of-data`

Misprice in Topological Space?

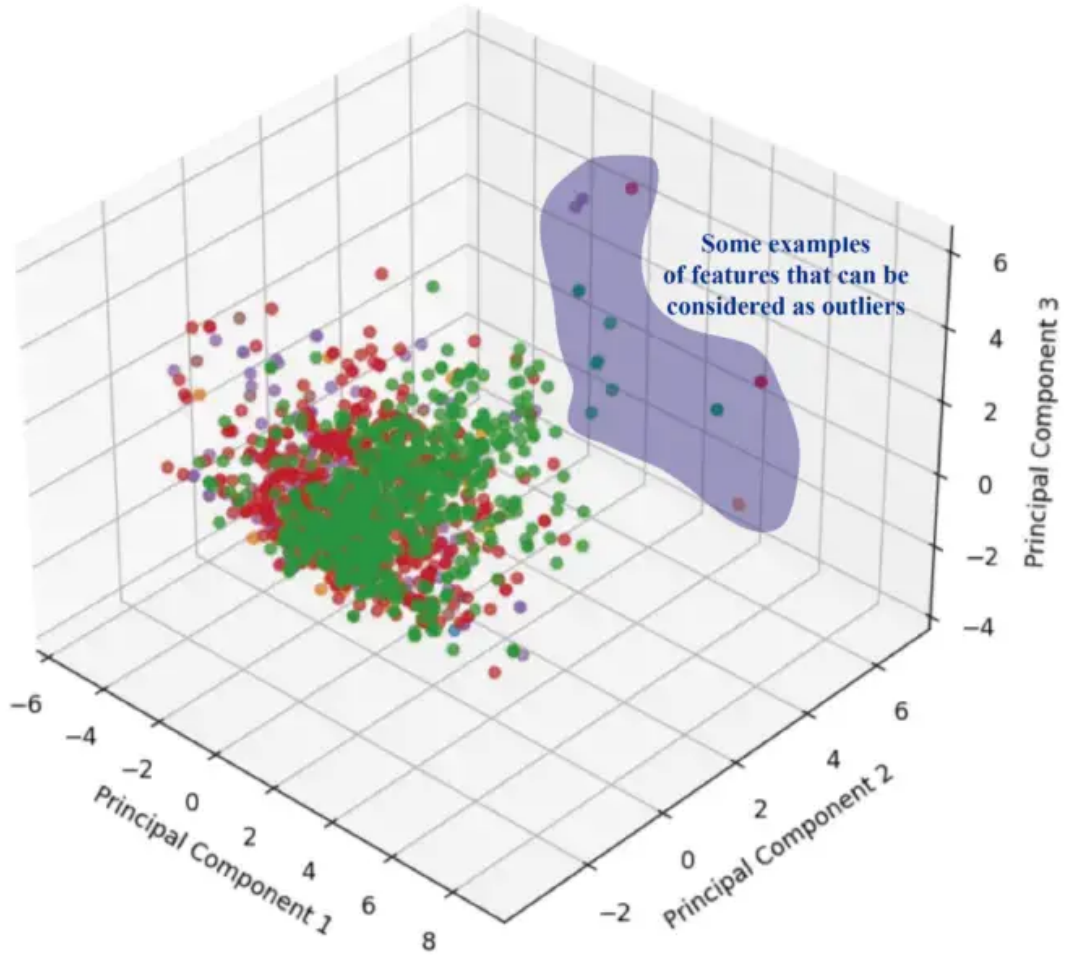

Figure: https://panamahitek.com/en/identification-and-removal-of-outliers-in-machine-learning/

Jim Simons' Research Keywords

Minimal Cones:

- Conical surfaces with minimal area for given boundary conditions.
- Often encountered in higher-dimensional spaces.

Plateau's Problem:

- Classical problem asking for a minimal surface spanning a given boundary curve.
- Inspired by soap films stretched across wireframes.

Bernstein Conjecture:

- States that the only minimal graphs over the entire plane in certain dimensions are flat planes.
- Proven up to dimension 8, with counterexamples in higher dimensions.

Jim Simons' Research Keywords

Cohomology:

- A tool in algebraic topology used to classify spaces based on their "holes" at different dimensions.
- Often encountered in higher-dimensional spaces.

Minimal Surfaces:

A minimal variety generalizes a minimal surface in Riemannian manifolds. A surface is **minimal** if it is a critical point of the area functional, meaning small variations do not decrease its area. This implies that the mean curvature at every point is zero.

Modern Study in Topology and Data

- **Manifold Learning:**
  - Assumes high-dimensional data lies on a lower-dimensional manifold.
  - Examples: Locally Linear Embedding (LLE), Isomap, t-SNE.
  - Used in dimensionality reduction and visualization of complex data.
- **Topological Data Analysis (TDA):**
  - Focuses on the shape and structure of data.
  - Example: Persistent Homology, which captures the connected components, loops, and voids in data at different scales.
  - Applied in image recognition, sensor networks, and genomics.

Pattern Recognition

Simons believed that financial markets have discoverable patterns through mathematical models. He did not believe in the efficient market hypothesis and always looked to capture the market inefficiencies using mathematical models.

The One Piece is Real!!

Pattern Recognition

Pattern recognition is the process of classifying input data into identifiable categories based on key features or patterns within the data.

Does technical analysis using candlestick patterns work for you?

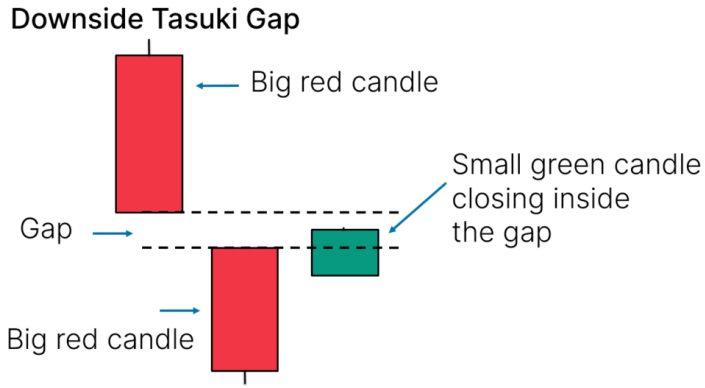

Figure:
`https://www.livingfromtrading.com/blog/candlestick-patterns/`

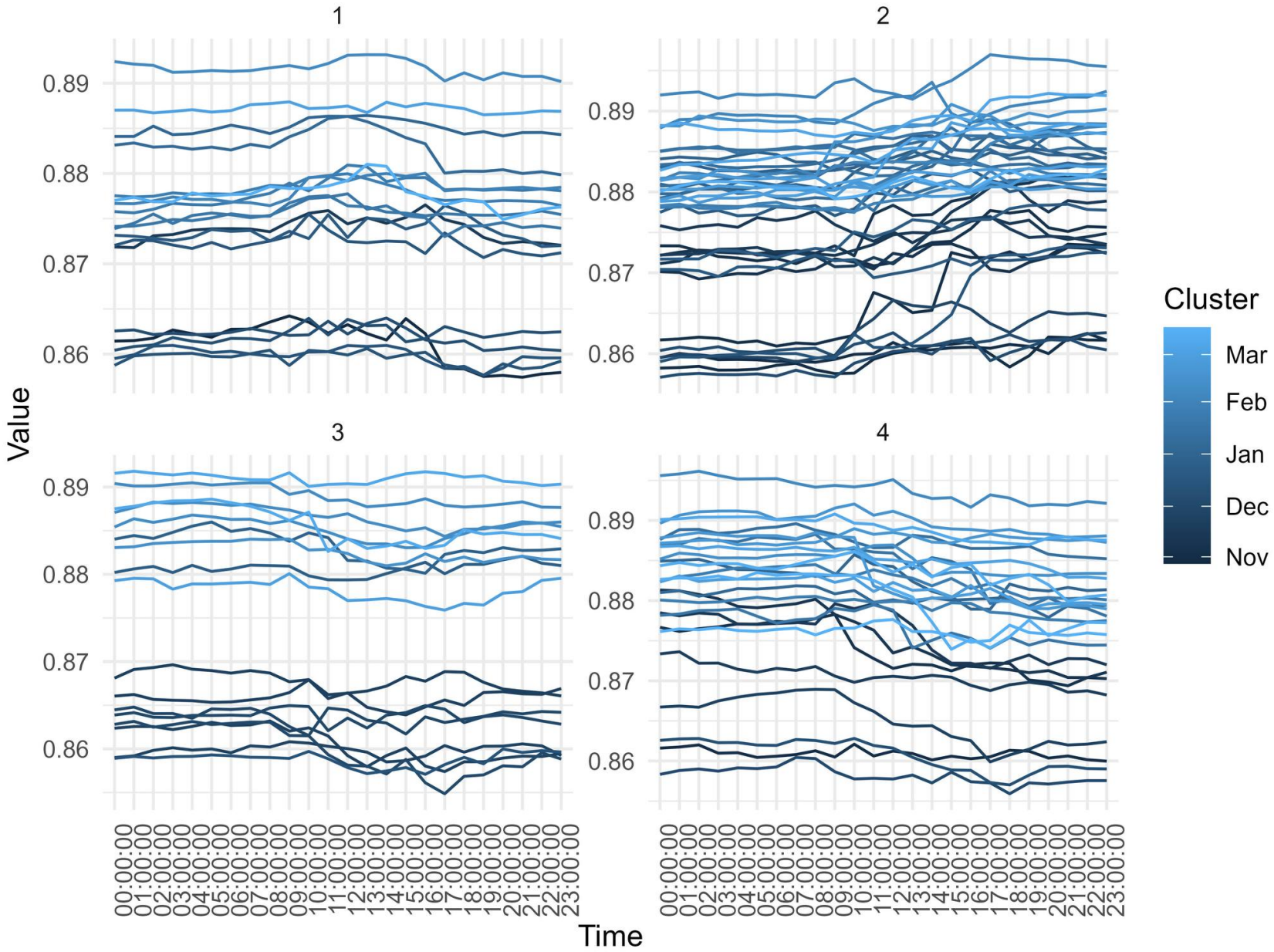

Figure: FX price pattern obtained from trading firm

Stability

The late Jim Simons was arguably the best trader of all-time, achieving 66% average gross annual returns over the span of three decades.

- Stability and gap phenomena for Yang-Mills fields

Stability

Stability generally refers to the property of a system, structure, or solution that remains unchanged or returns to its original state when subjected to small perturbations.

Stability in the context of Yang-Mills fields refers to whether small perturbations of a given Yang-Mills field solution lead to nearby solutions (stability) or diverge (instability).

Stable solutions correspond to local minima of the Yang-Mills functional, meaning that small variations around these solutions do not significantly change the action of the field.

How can the portfolio return be made more stable?

- Selecting assets with a high degree of structural consistency
- Regular portfolio rebalancing