1) INTRODUCTION

The project analyzes and compares two advanced trading algorithms that use statistical arbitrage techniques to take advantage of pricing inefficiencies between stock pairs. These techniques, which are implemented within the Quant Connect framework, are intended to take advantage of the reversion to the mean of stock price spreads by employing various trade execution methodologies.

2) STRATEGIES OVERVIEW

2.1) Trading using Ad-Hoc Bands Strategy Overview

The first approach, "Trading Using Ad-Hoc Bands," finds the top 50 stocks by dollar volume and then looks for pairs that are statistically cointegrated. The approach implies that the historical price relationship between these pairings will continue, opening up opportunities for successful trades when the spread between the prices deviates from historical standards. It uses a Vector Autoregression (VAR) model to assess and predict price correlations. Trading choices are made using predetermined deviation levels, with the intention of capitalizing on inefficiencies. This strategy incorporates tools for liquidating holdings upon reaching a predetermined profit level or at the end of the trading period.

2.2) Trading with Optimal Entry and Exit Signals Overview

The second strategy, "Trading Using Optimal Entry and Exit Signals," builds the pairs trading approach by offering a more advanced mechanism for selecting the best entry and exit positions for trades. This method involves solving a partial differential equation to determine the ideal trading boundaries based on the price spread's mean and standard deviation, as well as the cointegration strength. In comparison to the first method, this one tries for a more dynamic and potentially successful approach to capitalizing on pricing differences. Similarly, it selects a universe of top stocks, detects cointegrated pairs, and predicts prices using a VAR model. However, it has an additional optimization layer for trade execution, which improves its capacity to respond to market conditions.

Both strategies follow a daily rebalance schedule when the market opens and are designed to liquidate all holdings when a profit target is hit or at a predetermined end date. The next sections will assess the performance and consequences of various techniques, providing insights into their effectiveness and efficiency in capitalizing on statistical arbitrage possibilities in financial markets.

3) ALGORITHM INITIALIZATION

3.1) Initialization for Trading with Ad-Hoc Bands

The Trading Using Ad-Hoc Bands technique is set to function between January 1, 2022, and January 1, 2024, with a $100,000 beginning capital. It subscribes to daily data for the top 50 stocks by dollar volume, assuring a concentration on liquidity for efficient execution. This technique employs a simple yet effective approach to identify statistically cointegrated pairs of stocks, as well as a VAR model to handle trades based on ad hoc thresholds that determine when to enter or quit positions. Daily rebalancing is scheduled following market open, using the most recent market data to adjust positions accordingly.

3.2) Initialization for Trading with Optimal Entry and Exit Signals

Similarly, the Trading Using Optimal Entry and Exit Signals approach runs from January 1, 2022 to January 1, 2024 and begins with the same capital amount. It keeps to daily resolution for high-volume equities, but adds an advanced layer by estimating optimal trading boundaries using a mathematical algorithm. This model determines the ideal entry and exit positions for trades based on the spread's mean and standard deviation, as well as the strength of cointegration. This method seeks precision in trading execution, with daily scheduled post-market rebalancing to integrate enhanced tactics based on freshly optimized parameters.

4) PAIR SELECTION

The pair selection procedure for both trading strategies include choosing statistically cointegrated pairs from a universe of the top 50 equities ranked by dollar volume, with a focus on liquidity and minimizing execution risk. The stats models library's cointegration test is used to pick pairs based on their long-term equilibrium relationship, as shown by a p-value threshold of 0.05, ensuring significant statistical cointegration. This selection criterion focuses on the stock pairs' mean-reverting characteristics, where departures from the historical average spread create profitable trading opportunities and serve as the foundation for trading methods.

5) TRADING LOGIC

5.1) Trading Logic for Trading Using Ad-Hoc Bands

In the "Trading Using Ad-Hoc Bands" strategy, the algorithm uses a vector autoregressive (VAR) model to predict future price movements when pairs are identified and considered significant co-integration. for these couples. Based on the results of the model, the strategy defines ad-hoc intervals or thresholds that determine trade entry and exit. Specifically, trades are initiated when the spread between two stocks widens significantly – above established thresholds – indicating a temporary deviation from their historical average price spread. The difference is expected to narrow to the mean when positions are exited. Thresholds are usually set at standard deviations from the average interest margin, and the strategy involves reviewing these ranges daily to decide whether to rebalance the portfolio by adding new positions or liquidating existing ones.

5.2) Trading Logic for Trading Using Optimal Entry and Exit Signals

The "Trading Using Optimal Entry and Exit Signals" strategy adopts a more refined approach, estimating optimal entry and exit locations via a mathematical optimization process that employs partial differential equations to simulate the spread dynamics. This method takes into account the spread's mean and standard deviation, as well as the strength of the cointegration connection, in its computations. The optimization seeks to identify the places where the potential reward from reversion is greatest while risk is minimized. When the spread exceeds these optimally computed bounds, trades are conducted in the anticipation that the spread will return back inside these boundaries, allowing the strategy to profit from these moves. This strategy also involves daily monitoring of the spread against these calculated optimal points to manage and adjust positions accordingly.

Both strategies assume that prices will return to a historical mean, but the "Trading Using Optimal Entry and Exit Signals" strategy uses a more sophisticated mathematical framework to potentially improve trading precision and profitability, as opposed to the simpler threshold-based approach used in the "Trading Using Ad-Hoc Bands" strategy.

6) RISK MANAGEMENT

Both strategies incorporates a profit-taking rule in which all holdings are liquidated if the portfolio's unrealized profit reaches or surpasses 25%. This guideline helps to lock in earnings and minimize return erosion caused by adverse market movements. Furthermore, leverage is set at a fixed level for all securities, thereby standardizing the risk assumed across diverse assets.

7) BACKTEST AND RESULTS

7.1) Exposer Overview Analysis

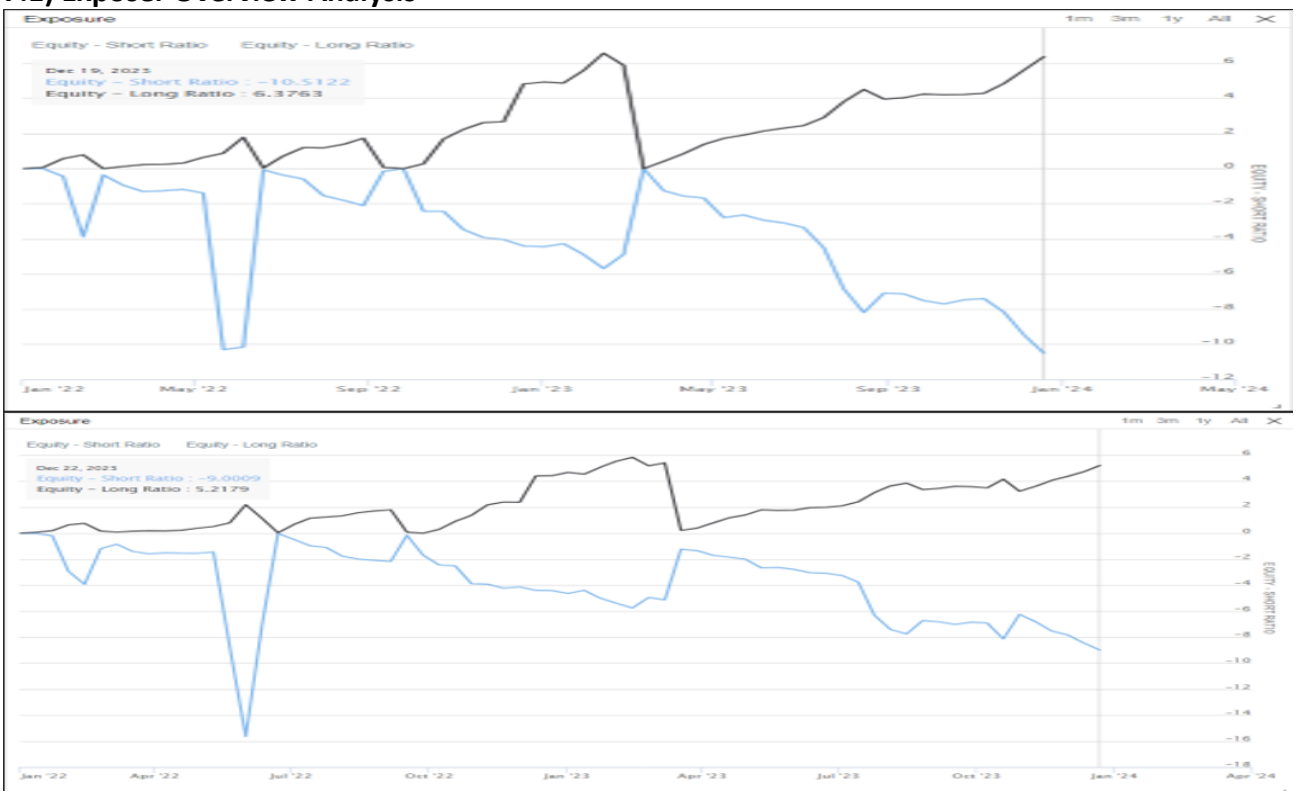

Figure 1: Exposure graphs of Ad-hoc bands strategy and Optimal entry, exit strategy.

The exposure table of the first algorithm shows a more controlled and balanced approach between short and long positions. At no point does the stock's short ratio overwhelmingly dominate the long ratio, suggesting a more conservative and potentially risky strategy. Short and long exposures appear to vary relatively close to each other, which means the algorithm aims to maintain a market-neutral position and balance long and short positions to reduce systematic market risk. This may indicate that ad hoc areas are effective in creating a balance between buying and selling pressure.

In contrast, the second algorithm's exposure chart displays a bolder stance, characterized by deeper forays into short positions and occasionally higher long positions. This approach suggests a strategy that capitalizes on larger price discrepancies and is possibly tuned to react more aggressively to certain market signals. The more pronounced deviations from a balanced exposure reflect a trading logic that may not shy away from taking on directional bets, indicating a possible preference for higher-risk/higher-reward opportunities.

7.2) Strategy Equity Candlestick Chart Analysis

Figure 2: Strategy overall performance of Ad-hoc bands strategy and Optimal entry, exit strategy.

Performance of the First Algorithm (Trading Using Ad-Hoc Bands)

The first chart shows a strategy with a strong upward trend in equity, indicating a series of profitable trades or positions. This strategy achieved a net profit of around $371,985.39, with an impressive 205.24% return on the starting capital. However, it also exhibits significant unrealized losses ($-167,125.27), suggesting that there could be open positions that are currently in a loss state or that the strategy may hold on to losing positions longer. The overall trajectory suggests that while the strategy has been profitable, it is subject to periods of drawdown, which are points where the equity curve dips. The peak in the equity curve followed by a downtrend towards the end could indicate a change in market conditions that the strategy may not have adapted to well.

Performance of the Second Algorithm (Trading Using Optimal Entry and Exit Signals)

The equity curve for the second algorithm shows an even greater overall growth in equity, resulting in a higher net profit of $391,964.01 and a return of 268.62%. The equity movement appears smoother, with fewer dramatic swings than the first method. The reported unrealized losses are large ($-123,738.82), but fewer than those of the first algorithm, implying that the second technique may be better at managing losing positions.

When comparing the two techniques while the first algorithm performed well, the second algorithm exceeded it in terms of both net profit magnitude and equity curve smoothness. The second algorithm's better return and smaller unrealized losses suggest a technique capable of properly balancing risk and reward. It also looks to manage positions in a way that reduces exposure to significant volatility, potentially leading to a more consistent investment growth trajectory.

7.3) Key Performance Metrics and Overview Analysis

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PSR	44.840%	Sharpe Ratio	1.199
Total Orders	933	Average Win	1.42%
Average Loss	-0.83%	Compounding Annual Return	74.980%
Drawdown	62.700%	Expectancy	0.572
Start Equity	100000	End Equity	305243.98
Net Profit	205.244%	Sortino Ratio	1.322
Loss Rate	42%	Win Rate	58%
Profit-Loss Ratio	1.71	Alpha	0.746
Beta	-0.884	Annual Standard Deviation	0.63
Annual Variance	0.397	Information Ratio	1.118
Tracking Error	0.685	Treynor Ratio	-0.855
Total Fees	$2076.99	Estimated Strategy Capacity	$3100000.00
Lowest Capacity Asset	SCHI X8K1670BA1D1	Portfolio Turnover	17.29%

Backtest Logs

2023-12-30 00:00:00 : Unique pairs traded during the backtest: 862

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PSR	53.116%	Sharpe Ratio	1.408
Total Orders	1033	Average Win	1.34%
Average Loss	-0.55%	Compounding Annual Return	92.338%
Drawdown	63.800%	Expectancy	0.722
Start Equity	100000	End Equity	368615.75
Net Profit	268.616%	Sortino Ratio	1.501
Loss Rate	50%	Win Rate	50%
Profit-Loss Ratio	2.42	Alpha	0.851
Beta	-1.281	Annual Standard Deviation	0.615
Annual Variance	0.378	Information Ratio	1.276
Tracking Error	0.686	Treynor Ratio	-0.675
Total Fees	$2437.15	Estimated Strategy Capacity	$4200000.00
Lowest Capacity Asset	SCHI X8K1670BA1D1	Portfolio Turnover	18.42%

Backtest Logs

2023-12-30 00:00:00 : Unique pairs traded during the backtest: 990

Figure 3: Performance Metrics of Ad-hoc bands strategy and Optimal entry, exit strategy

Key Metrics of the First Algorithm (Trading Using Ad-Hoc Bands)

- **Net Profit:** 205.24%
- **Sharpe Ratio:** 1.199, indicating moderate risk-adjusted returns.
- **Sortino Ratio:** 1.322, showing effectiveness in achieving returns with less downside volatility.
- **Alpha:** 0.746, suggesting the strategy generates significant excess returns compared to the benchmark.
- **Beta:** -0.884, indicating an inverse relationship with the market, potentially implying short bias in the market.
- **Annual Standard Deviation:** 0.63, representing the level of volatility experienced by the strategy.
- **Compounding Annual Return:** 74.98%, showing a strong annual growth rate.
- **Drawdown:** 62.78%, indicating the largest drop from peak to trough over the strategy's life.

Key Metrics of the Second Algorithm (Trading Using Optimal Entry and Exit Signals)

- **Net Profit:** 266.616%
- **Sharpe Ratio:** 1.468, slightly higher than the first, suggesting slightly better risk-adjusted returns.
- **Sortino Ratio:** 1.581, comparable to the first, also indicating efficient performance on downside volatility.
- **Alpha:** 0.851, showing an increased ability to generate excess returns over the benchmark.
- **Beta:** -1.281, indicating a stronger inverse relationship with the market.
- **Annual Standard Deviation:** 0.615, showing less volatility than the first algorithm.
- **Compounding Annual Return:** 92.338%, which is better than the first, which is significant considering compounding effects.
- **Drawdown:** 63.86%, While this figure is slightly greater, it is proportional to the increased returns, and such a minor difference may be acceptable given the substantial improvement in annual returns.

Comparing the two strategies, we can observe that both have generated high net profits where 2nd algorithm shows higher compound annual returns, but they do exhibit different risk profiles and trading behaviors:

Risk and Return: Algorithm 2 exhibits a higher net profit and compound annual return than Algorithm 1, with a similar level of risk as indicated by a slight increase in drawdown and a lower annual standard deviation.

Market Sensitivity: Both strategies move inversely to the market, with Algorithm 2 having a stronger negative beta, suggesting a higher defensive stance against market downturns.

Drawdowns: The drawdown for Algorithm 2 is marginally greater than for Algorithm 1, but it is in line with its higher returns.

Trading Activity: Algorithm 2 engages in more trading activity, indicating a dynamic strategy that potentially captures more short-term opportunities, albeit with higher transaction costs.

CONCLUSION

The comparative research reveals that the "Trading Using Optimal Entry and Exit Signals" approach outperforms "Trading Using Ad-Hoc Bands" in terms of returns and compound annual growth. While it has a slightly higher drawdown, it compensates by providing better risk-adjusted returns. The approach also has a higher negative beta, indicating a potential for superior performance in dropping markets. This makes the Optimal Entry and Exit Signals method an appealing option for investors seeking higher profits without increasing their risk exposure. In contrast, the Ad-Hoc Bands strategy takes a more conservative approach, making it ideal for investors who seek lower volatility and more consistent results. Each method provides diverse ways to gain statistical arbitrage, appealing to different investor profiles based on their risk tolerance and return objectives.