Summary:
The provided code implements a pairs trading strategy leveraging Bollinger Bands as a key technical indicator. Upon initialization, the algorithm selects top correlated pairs of ETFs based on historical returns, subsequently initializing Bollinger Bands for each pair to monitor spread dynamics. The initial investment amount is $100000. Bollinger Bands consist of a middle band (SMA) representing the average price and upper and lower bands indicating overbought and oversold conditions. The algorithm generates buy signals when the spread falls below the lower band, signaling an undervalued asset, and sell signals when the spread rises above the upper band, suggesting an overvalued asset. Accordingly, the algorithm enters long and short positions in the respective ETFs to capitalize on the expected mean reversion of the spread. Position management is dynamic, with positions closed upon the spread crossing back above or below the middle Bollinger Band, indicating potential trend reversals. Through continuous monitoring and adherence to predefined trading rules, the algorithm aims to achieve consistent profitability while mitigating risks associated with market fluctuations. The return of the backtest was 3.20% and the net profit was $13518.64.

Aim: to implement a mean reverting pairs trading strategy.
Data: The data for the ETFs is taken using the Quant Connect code. The test is conducted from 01-01-2022 to 31-01-2024.
ETFs used:

SPY - SPDR S&P 500 ETF Trust
DIA - SPDR Dow Jones Industrial Average ETF Trust
IVV - iShares Core S&P 500 ETF
VTI - Vanguard Total Stock Market ETF
QQQ - Invesco QQQ Trust
IWM - iShares Russell 2000 ETF
EFA - iShares MSCI EAFE ETF
IEFA - iShares Core MSCI EAFE ETF
EEM - iShares MSCI Emerging Markets ETF
VWO - Vanguard FTSE Emerging Markets ETF
AGG - iShares Core U.S. Aggregate Bond ETF
VOO - Vanguard S&P 500 ETF

Methodology:

To start with, there is a group of ETFs. The top 3 pairs which have the highest correlation are chosen.
We use the closing price of each asset and conduct a linear regression.
The regression is conducted over a lookback period(this parameter is defined in the code).
We use the intercept and slope in the calculation of the portfolio value. The value of the slope and intercept is updated daily and so in order to get a mean reverting series around zero, we remove the intercept daily.
In this strategy, we keep the hedge ratio dynamic. This helps us detect short term mean reversing behaviors which may not be noticeable in a longer period.

The buy and sell signals are implemented using Bollinger Bands.
Bollinger Bands are used to identify potential buying and selling opportunities based on the deviation of the spread between two assets from its historical average. The algorithm enters positions accordingly, aiming to profit from the mean reversion of the spread between the ETF pairs.
Bollinger Bands consist of three lines:

- Middle Band: This is typically a simple moving average (SMA) of the asset's price over a specified period (in this code, it's 20 days). It represents the average value of the asset over the specified period.
- Upper Band: This is calculated as the sum of the middle band and a specified number of standard deviations (in this code, it's 2 standard deviations) multiplied by the asset's volatility over the same period.
- Lower Band: Similarly, the lower band is calculated as the difference between the middle band and a specified number of standard deviations (2 in this code) multiplied by the asset's volatility over the same period.

The upper and lower bands are the = mean +- standard deviations (z-scores).

Buy and Sell Signals:

Buy Signal:

- A buy signal is generated when the spread between the two assets (ETFs) falls below the lower Bollinger Band. This suggests that the spread is relatively low compared to historical levels, indicating a potential buying opportunity.

- When the spread falls below the lower band, it implies that one asset is relatively undervalued compared to the other. In pairs trading, this could mean that one asset is oversold compared to the other, presenting an opportunity to buy the undervalued asset and sell the overvalued one.
- The algorithm enters a long position in one ETF and a short position in the other ETF, aiming to profit from the expected mean reversion of the spread.

Sell Signal:

- Conversely, a sell signal is generated when the spread between the two assets rises above the upper Bollinger Band. This indicates that the spread is relatively high compared to historical levels, suggesting a potential selling opportunity.
- When the spread rises above the upper band, it implies that one asset is relatively overvalued compared to the other. In pairs trading, this could mean that one asset is overbought compared to the other, presenting an opportunity to sell the overvalued asset and buy the undervalued one.
- The algorithm enters a short position in one ETF and a long position in the other ETF, aiming to profit from the expected mean reversion of the spread.

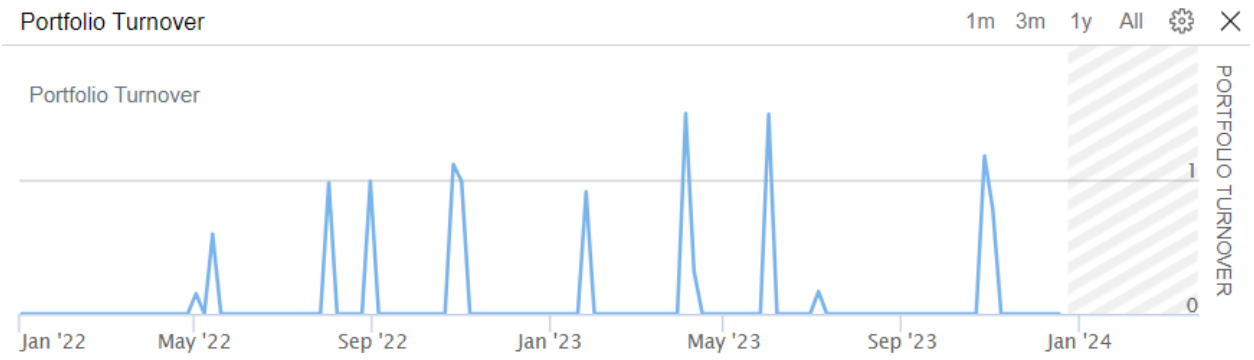
Closing Positions:

- Additionally, the algorithm includes logic to close positions when the spread crosses back above or below the middle Bollinger Band. This indicates a potential reversal in the trend of the spread and suggests closing the existing positions to lock in profits or minimize losses.

In the end we periodically update the invested portfolio to meet the new hedge ratio, by rebalancing it.

Results:

$103,204.15	-$96.51	$185,712.59	$13,518.64	7.970%	3.20 %	$-10,317.76	$5,092,833.58
Equity	Fees	Holdings	Net Profit	PSR	Return	Unrealized	Volume



PSR	7.970%	Sharpe Ratio	-0.224
Total Orders	105	Average Win	1.06%
Average Loss	-0.43%	Compounding Annual Return	1.609%
Drawdown	13.100%	Expectancy	0.618
Net Profit	3.204%	Sortino Ratio	-0.257
Loss Rate	53%	Win Rate	47%
Profit-Loss Ratio	2.45	Alpha	-0.023
Beta	-0.251	Annual Standard Deviation	0.089
Annual Variance	0.008	Information Ratio	-0.038
Tracking Error	0.218	Treynor Ratio	0.08
Total Fees	$96.51	Estimated Strategy Capacity	$50000000.00
Lowest Capacity Asset	VTI S551B7YE6N39	Portfolio Turnover	6.79%

Drawbacks:

The Sharpe ratio of this strategy is -0.224. In this case the risk taken will not be offset by the return.
The total drawdown is 13.1%.
The alpha and beta are negative.
The return is not very high.

Conclusion

The strategy runs perfectly well. However it does not give good returns for the back tested period. The Sharpe ratio is negative which suggests that the strategy is not optimal. The strategy needs a lot more refinement.