Pairs Trading Algorithm for Financial Markets: Logic, Inputs, and Outputs

The Pairs Trading Project is structured across four distinct phases, each implemented in a separate Jupyter notebook:

1. Identifying the Optimal Pair
2. Strategy Formulation
3. Strategy Back-testing
4. Risk Analysis

Each notebook corresponds to a crucial step in the project, facilitating a systematic approach to pairs trading strategy development. Below are the detailed descriptions of each phase:

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1. Identifying the Optimal Pair: "findingPair.ipynb"

Stock Selection

- **Selection Process**: The project commenced by selecting a comprehensive set of 200 stocks listed on the Bombay Stock Exchange (BSE).
- **Data Acquisition**: Data was acquired from Yahoo Finance, covering a period from 2013 to 2023, ensuring a robust dataset for analysis.

Filtering

- **Loss-Making Stocks**: Stocks demonstrating consistent losses throughout the decade were filtered out.
- **Rationale**: This step was essential to align the strategy to make profit even on loss making stocks.

Correlation Analysis

- **Identification of Pairs**: Pairs of stocks with a correlation index exceeding 0.9 were identified. A high correlation indicates a strong relationship between the price movements of the two stocks.
- **Significance**: This step ensures that the selected pairs have a tendency to move together, which is critical for the pairs trading strategy.

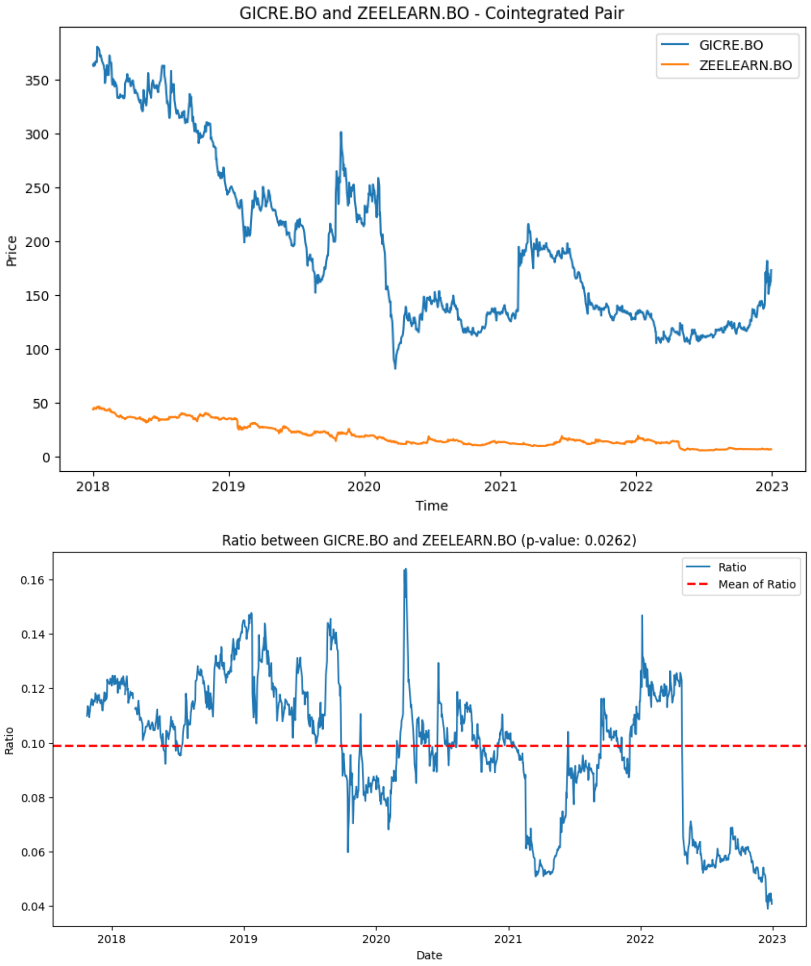
Cointegration Analysis

- **Statistical Tests**: Further analysis was conducted to identify correlated stocks exhibiting cointegration, using statistical tests named Engle-Granger test.
- **Criteria**: Cointegration was confirmed if the p-value was less than 0.05, ensuring the presence of mean reversion characteristics.

- **Importance**: Cointegration ensures that despite short-term deviations, the prices of the stocks tend to revert to a long-term equilibrium, which is a key premise of pairs trading.

Optimal Pair Selection

- **Final Pair**: After rigorous analysis, the optimal stock pair was determined to be "ZEELEARN.BO" and "GICRE.BO".
- **Reasoning**: These stocks exhibited strong correlation and cointegration, making them suitable for the pairs trading strategy.



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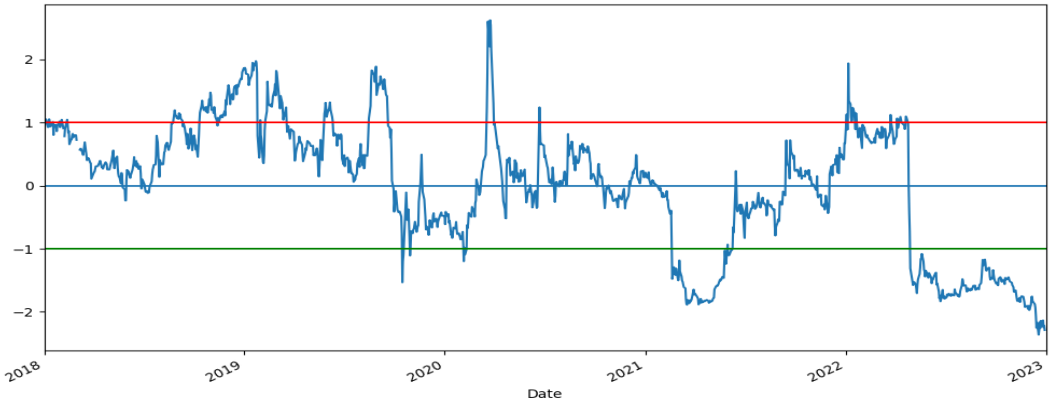
2. Strategy Formulation: "pairTradingStrategy.ipynb"

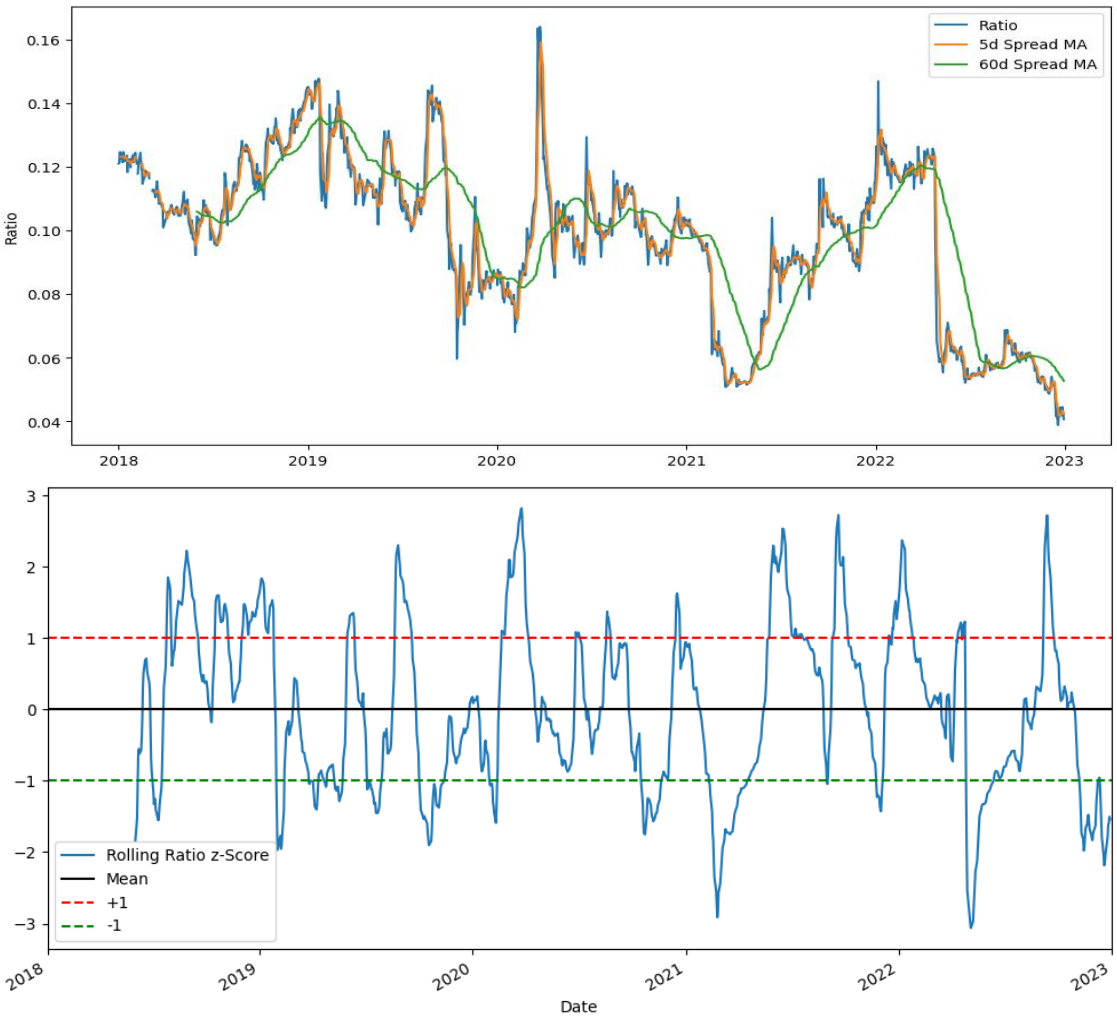
Mean Reversion

- **Observation**: Pronounced mean reversion trends were observed in the ratio graph of the stocks, indicating that the ratio of their prices frequently reverted to the mean.
- **Defining Characteristic**: The ratio of the stocks was chosen as the defining characteristic for the strategy due to its mean-reverting nature.



Z-score Calculation

- **Purpose**: The z-score of the ratio was computed to normalize the ratio and establish trading boundaries.
- **Formula**: The z-score is calculated as (short-term moving average − long-term moving average) / standard deviation.
- **Interpretation**: This z-score indicates how far the current price ratio deviates from its historical mean.



Strategy Development

- **Trading Rules**:
  - **Long Position**: If the z-score fell below -0.6, indicating a negative deviation from the mean, it signaled that ZEELEARN.BO was undervalued relative to GICRE.BO. The strategy involved taking a long position on ZEELEARN.BO and a short position on GICRE.BO.
  - **Short Position**: Conversely, if the z-score exceeded 0.6, suggesting a positive deviation from the mean, it implied that ZEELEARN.BO was overvalued relative to GICRE.BO. The strategy involved taking a short position on ZEELEARN.BO and a long position on GICRE.BO.
  - **Exit Signal**: An exit signal was triggered when the z-score approached 0.25, indicating that the ratio was close to its mean and it was time to close positions.
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User Parameters

- **Customization**:
  - **Window Sizes**: Users could choose the window sizes for the short-term (window1) and long-term (window2) moving averages.
  - **Trading Frequency**: Users could select the trading frequency (e.g., 1 day, 5 days, or 1 week), allowing them to tailor their trading approach according to their preferences.
  - **Parameter Details**:
    - **window1**: Determines the window size for the short-term moving average (ma1), making it more responsive to recent price changes.
    - **window2**: Determines the window size for the long-term moving average (ma2) and the standard deviation (std), providing a broader perspective of the price.

FREQUENCY OF TRADING

```
def trade_strategy_freq(start, end, window1, window2, frequency):
    import yfinance as yf
    import matplotlib.pyplot as plt
    import pandas as pd
    import numpy as np

    intervals = {
        '1d': '1d',
        '1wk': '1wk',
        '5d': '5d',

    }
```

3. Strategy Back-testing: “backTesting.ipynb”

Performance Metrics

- **Assessment Criteria**: The strategy was assessed based on profitability, Sharpe ratio, volatility, and a comparative analysis of returns against the BSE index and NIFTY 50 returns.

  Key Metrics:
- 1.Profitability

  Definition**:** Profitability measures the total returns generated by a strategy.

  Importance: It indicates how much profit or gain an investment strategy has produced over a specific period.
- 2. Sharpe Ratio

  Definition: The Sharpe Ratio evaluates risk-adjusted returns, calculated by dividing the excess return of the strategy over the risk-free rate by its standard deviation.

  Importance: It shows how well the returns compensate for the risk taken, allowing comparison of different strategies on a risk-adjusted basis.
- 3. Volatility

  Definition: Volatility assesses the risk associated with a strategy by measuring the degree of variation in its returns, often represented by standard deviation.

  Importance: It helps gauge the potential risk and stability of an investment strategy, with higher volatility indicating higher risk.

Testing Periods

- **Time Frames**: The strategy underwent rigorous testing over periods of 1, 3, and 5 years.
- **Results**: Consistent profitability was observed, with respectable Sharpe ratios and volatility metrics.

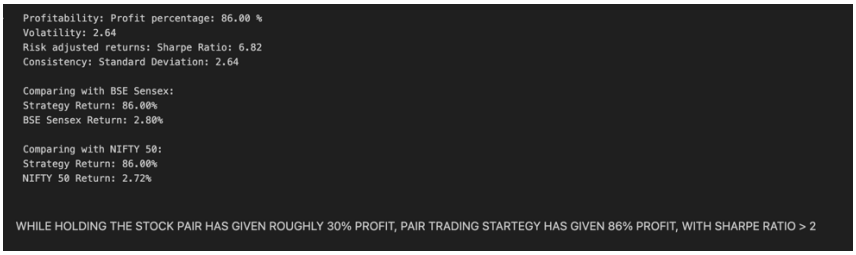
```
Profitability: Profit percentage: 181.66 %
Volatility: 5.72
Risk adjusted returns: Sharpe Ratio: 2.04
Consistency: Standard Deviation: 5.72

Comparing with BSE Sensex:
Strategy Return: 181.66%
BSE Sensex Return: 46.16%

Comparing with NIFTY 50:
Strategy Return: 181.66%
NIFTY 50 Return: 48.62%


WHILE HOLDING THE STOCK PAIR HAS GIVEN ROUGHLY 75% PROFIT, PAIR TRADING STARTEGY HAS GIVEN 181.66% PROFIT, WITH SHARPE RATIO > 2, AND RETURNS ARE MUCH HIGHER THAN BSE, NIFTY 50 INDEXES
```

```
Profitability: Profit percentage: 277.83 %
Volatility: 5.55
Risk adjusted returns: Sharpe Ratio: 1.70
Consistency: Standard Deviation: 5.55

Comparing with BSE Sensex:
Strategy Return: 277.83%
BSE Sensex Return: 79.93%

Comparing with NIFTY 50:
Strategy Return: 277.83%
NIFTY 50 Return: 73.39%


WHILE HOLDING THE STOCK PAIR HAS GIVEN ROUGHLY 50% LOSS, PAIR TRADING STARTEGY HAS GIVEN 277.83% PROFIT WITH SHAPRE RATIO >> 1, AND RETURNS ARE MUCH HIGHER THAN NBSE, NIFTY 50 INDEXES
```

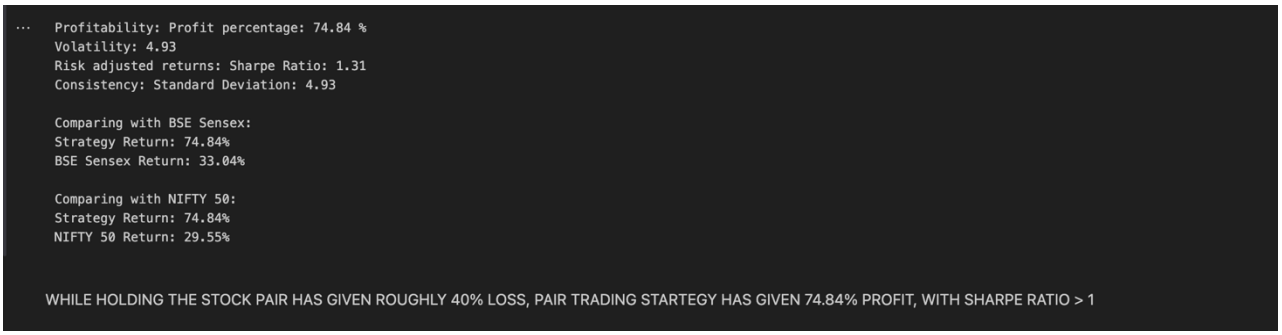
Stress Testing

- **Market Conditions**: The strategy was tested during both bullish (post-COVID recovery, 2022-23) and bearish (COVID pandemic, 2019-20) market conditions.
- **Outcomes**: Remarkably, the strategy remained profitable during these adversities, demonstrating its robustness.

Bullish Markets:



Bearish Markets:



Trading Frequencies

- **Frequency Testing**: Various trading frequencies were tested, including daily, weekly, and monthly trades.
- **Findings**: Each frequency yielded profitability, though returns varied, highlighting the flexibility of the strategy.

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4. Risk Analysis: “riskProfiling.ipynb”

Risk Profiles

- **Flexibility**: Three distinct risk profiles (low, medium, and high risk) were devised to offer users flexibility according to their risk tolerance.
- **Profile Characteristics**:
  - **Low Risk**: Conservative parameters with lower potential returns.
  - **Medium Risk**: Balanced parameters with moderate potential returns.
  - **High Risk**: Aggressive parameters with higher potential returns.

```
risk_profiles = {
    'high_risk': {'frequency': '1d', 'window1': 6, 'window2': 180, 'zscore_threshold': 0.6},
    'mid_risk': {'frequency': '5d', 'window1': 8, 'window2': 190, 'zscore_threshold': 0.8},
    'low_risk': {'frequency': '5d', 'window1': 10, 'window2': 200, 'zscore_threshold': 1.0}
}
```

Profile Parameters

- **Parameters**: These profiles were formulated based on diverse parameters, including moving average windows, trading frequencies, and z-score thresholds.
- **Customization**: Users can select a profile that aligns with their risk appetite and investment goals.

Profitability Analysis

- **Back-testing**: Back-testing across these profiles showed significant variability in profitability.
- **Results**:
  - **High Risk Profile**: Yielded the highest profit.
  - **Low Risk Profile**: Resulted in the lowest profit.
- **Conclusion**: This analysis allows users to choose a risk profile that suits their investment strategy.