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Bull, Bear & Bot

Use of Chat GPT to write HF alpha prediction signals

Presented by

Gitika Daswani
Naman Rathi
Harsh Mehta

Objective

Utilizing Generative AI, specifically GPT-4, to Craft a Pairs Trading Strategy

- Highlighting the role of GPT-4 in developing trading strategies with minimal human input, setting the stage for innovation in financial markets
- Choice of Statistical Arbitrage strategy: Pairs Trading
- AI's Potential in Strategy Development with minimal human interference
- In the subsequent slides, presenting key iterations and GPT-4's contributions in refining the Pairs Trading strategy

Statistical Arbitrage: Pairs Trading

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What is Statistical Arbitrage: Pairs Trading?

- Statistical Arbitrage (Stat Arb) are trading strategies that typically take advantage of either mean reversion in share prices or opportunities created by market microstructure anomalies
- Pairs trading is a market-neutral strategy that involves trading two highly correlated stocks. When their price relationship deviates, the strategy buys the underperformer and sells the outperformer, betting on price convergence based on mean reversion. This approach hedges market trends, aiming for profit regardless of market direction. However, if price divergence stems from structural changes rather than temporary factors, there's a significant risk of loss

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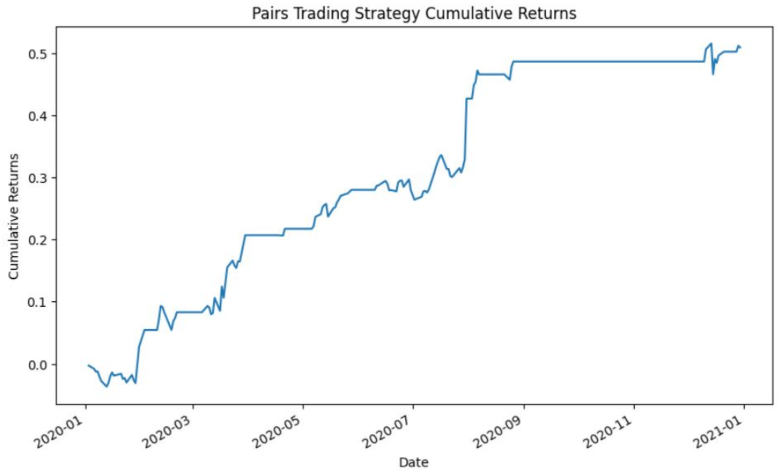
How is Statistical Arbitrage implemented?

- Stock Universe and Identification of Cointegrated Pairs of Stocks
- Calculate Spread and Hedge Ratio
- Generate Trading Signals based on deviation from spread

Iteration 1:

Prompt: Can you provide me with a Statistical Arbitrage: Pairs trading strategy in Python along with backtesting. In addition, calculate and plot the Returns, and calculate the Sharpe ratio

```
Cointegration test p-value: 0.587716325059954
```




```
Sharpe Ratio: -0.7290859963373784
```

Objective:

- To understand what kind of strategy GPT comes up with when given minimal user input

Remarks:

- The results shown are purely based on the code generated by GPT (no modifications were made)
- Upon inspection of the code, we noticed the following discrepancies:
  - AI considered only two stocks to implement the strategy
  - Did not validate the cointegration of the pair chosen
  - The time period considered was very small (1 year)

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Iteration 2:

Prompt:

1. For Identifying the pairs, can you take a diverse pool of tech stocks from the S&P 500 and then choose the most suitable pair based on cointegration
2. Use historical data for 5 years
3. Consider risk-free rate as 3.75%

```
---------------------------------------------------------------------------
IndexError                                Traceback (most recent call last)
Cell In[3], line 42
     40 pairs = find_most_cointegrated_pairs(data)
     41 pairs = sorted(pairs, key=lambda x: x[2])
---> 42 most_cointegrated_pair = pairs[0][0:2]
     43 print(f"Most cointegrated pair: {most_cointegrated_pair}")
     45 # Select the pair and calculate the spread

IndexError: list index out of range
```

Note: Since it was part of the same conversation with GPT, we didn't need to specify any other details for it to generate a code. It simply extended the previous code to incorporate these values

Objective:

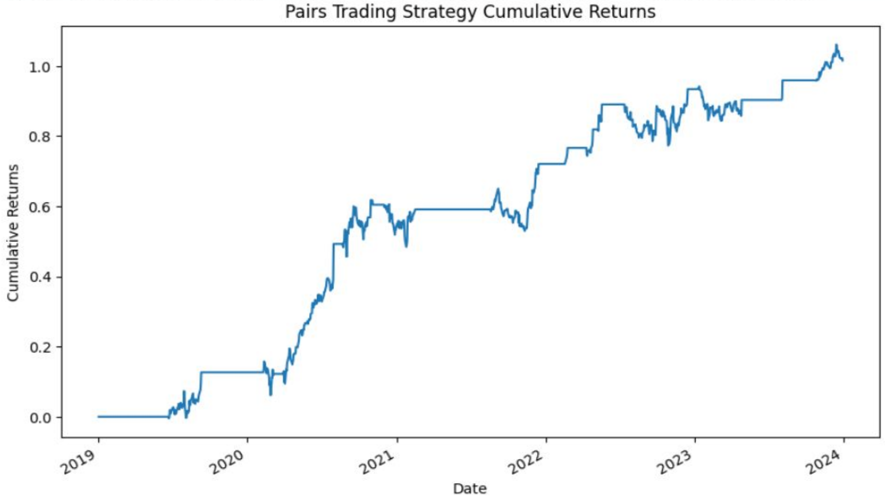
- To refine the strategy and nudging GPT in the right direction by making suggestions

Remarks:

- Based on the prompt, GPT generated code snippets to calculate the pairs dynamically based on data from the past 5 years
- The error generated implies no co-integrated pairs were found and the code is not equipped to handle this situation

Iteration 3:

```
Most cointegrated pair: ('MSFT', 'AAPL') with p-value: 0.3570670951819156
```




```
Sharpe Ratio: 0.06666114995238671
```

Objective:

- Resolve the error from the previous iteration and evaluate the strategy

Remarks:

- Selecting pairs with a p-value < 0.05 means choosing stock pairs with a statistically significant co-integration relationship
- This threshold suggests high confidence in the pair's long-term price stability relative to each other, forming the basis for profitable pairs trading strategies
- GPT relaxed the p-value constraint (<0.05) and picked pairs with a high p-value (0.35)
- This defeats the purpose of selecting stocks based on co-integration and hence not suitable for pairs trading

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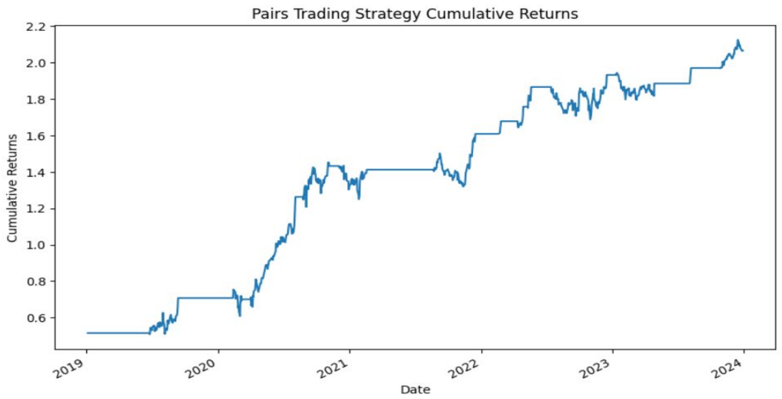
Iteration 4:

Prompt: The code that you have provided picks Apple and Microsoft as the pair but their value is around 0.35, which violates our condition that p<0.05; So include this condition in the code and give a message whenever there is no pair whose p value is less than 0.05.
Now, take a bigger universe of stocks, preferably from the same industry and do the computations

```
[('AMD', 'MSFT', 0.020972196799209277), ('CRM', 'META', 0.007633649917288749), ('IBM', 'INTC', 0.014012261685886344), ('IBM',
'MSFT', 0.028381347174872715), ('IBM', 'NVDA', 0.008147740215036604), ('IBM', 'ORCL', 0.014064635266382105)]
Most cointegrated pair: ('CRM', 'META', 0.007633649917288749)
0.5155394900691972
```




```
Sharpe Ratio: 1.4112776332831491
```

Objective:

- Re-work the pairs selection logic and include a wider universe of stocks for increasing chances of finding a co-integrated pair with p-value<0.05

Remarks:

AMD, MSFT	0.02097	IBM, INTC	0.01401
CRM, META	**0.00763**	IBM, NVDA	0.00814
IBM, MSFT	0.02838	IBM, ORCL	0.01406

- Of the given pairs which match the criterion, it finally selected the rights pairs!

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Iteration 5:

Prompt: Start with 10,000,000, buy and sell according to your signals, and calculate the daily and the final P&L.

Let's illustrate with simplified pseudocode and explanations for each step:

1. **Initial Setup**:
   - Initial capital: $10,000,000.
   - Signals: Generated as previously described, with `1` for long the spread, `-1` for short the spread, and `0` for no action.
2. **Daily Operations**:
   - For each day, check the signal.
   - If the signal is `1` (long the spread), allocate the entire capital to buying Asset 1 and selling Asset 2 according to the hedge ratio.
   - If the signal is `-1` (short the spread), allocate the entire capital to selling Asset 1 and buying Asset 2 according to the hedge ratio.
   - Calculate the change in value of the positions from the previous day to the current day to determine the daily P&L.
   - Adjust the capital based on the daily P&L.
3. **Calculate Daily and Final P&L**:
   - Daily P&L is calculated as the change in value of the portfolio (positions in Asset 1 and Asset 2) from one day to the next.
   - The final P&L is the total change in capital from the initial amount after the last trading day.

Source : GPT output

Objective:

- Now that GPT was identifying the correct pair of stocks to implement the strategy with, we wanted to focus on strategy itself and check it's effectiveness

Remarks:

- The code generated using this process did not consider exit positions for the corresponding entry positions
- GPT needed to be prompted further to take exit positions into account

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Iteration 5 (Continued):

In this version:

- **Entering** positions occurs when the signal changes from `0` to `1` or `-1`, indicating a new trade. The entire capital or a predefined portion can be allocated based on the strategy's needs.
- **Exiting** positions happens when the signal changes to `0` from either `1` or `-1`, indicating closing the trade. The P&L is calculated based on the position's value change since entry.
- **Continuing** in a position means carrying over an open trade. The P&L is calculated daily based on the ongoing position's value change.

This approach more explicitly models the actions a trader would take based on the generated signals, including the mechanics of entering and exiting trades, thus providing a more realistic representation of trading P&L.

Source : GPT output

```
[*********************100%%**********************]  10 of 10 completed
Most cointegrated pair: CRM and META with p-value: 0.007633649917288783
Final P&L: 49556365.04368122
```

Remarks:

- Initially, the code did not give exit signals, after prompting it include exit signals, we got the final output
- We understand that the P&L is not reasonable (given a capital of 10 million, getting a profit 50 million), but this is what GPT is generating at the moment

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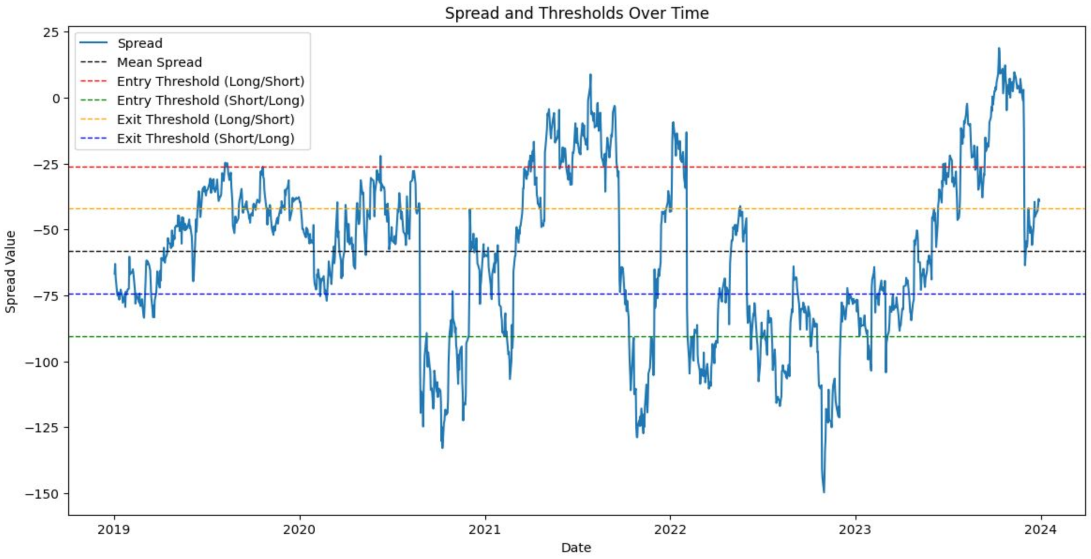
Pairs Spread



Remarks:

- The spread in a pairs trading strategy refers to the difference in price between two cointegrated securities, adjusted by a hedge ratio

- The hedge ratio is determined using a linear regression, to balance the sizes of the two positions

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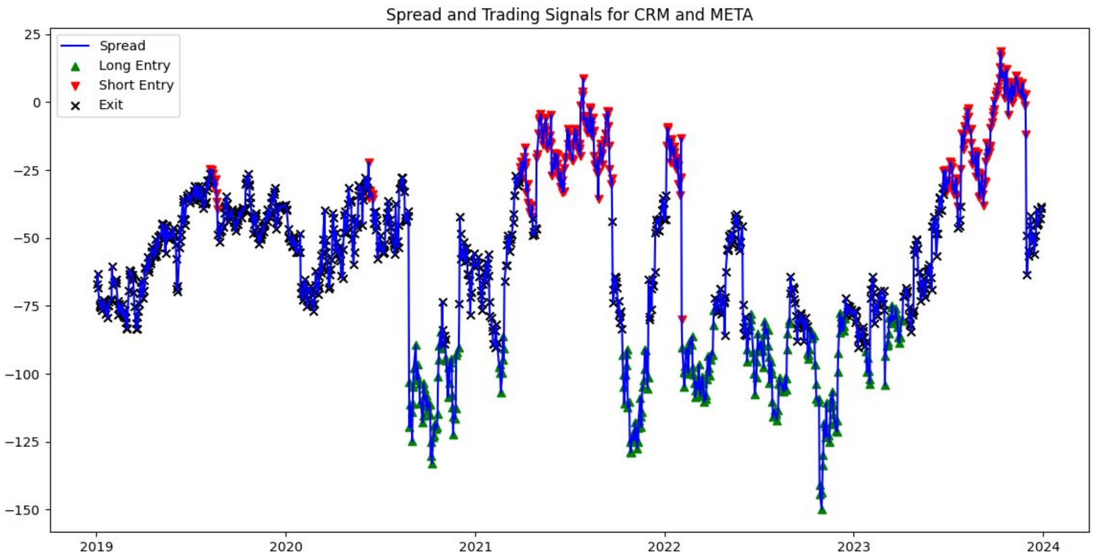
Signal



Remarks:

- Entry signals represent situations where the spread deviates significantly from the mean, as per a predefined threshold (1.0), mimicking the Z-score entry logic

- Exit signals represent situations where the spread returns to a threshold closer to the historical mean (0.5), analogous to the Z-score moving towards zero

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Challenges with Generative AI

- In the first iteration, when the code generated by GPT was giving an error and we asked the GPT to fix it. For fixing the error, it relaxed the condition of $p<0.05$, and returned a cointegrated pair, which defeats the purpose of cointegrated pairs. So, we had to give the prompt in detail to make the correction
- Upon rectifying an initial error and then requesting further code corrections, the AI resolved a second mistake but inadvertently reintroduced the original error. This recurrent issue, observed multiple times, indicates a challenge where the AI, while amending a new error, fails to maintain the continuity of previous corrections, leading to a loop of alternating errors in the code output

Conclusion

- **Human Oversight is Crucial:** The project reveals that generative AI, despite its capabilities, still requires significant human intervention to accurately implement trading strategies, underscoring the importance of human expertise in overseeing and guiding AI applications
- **Limitations in Autonomy:** Although generative AI shows promise in aiding the development of trading algorithms, it lacks the autonomy to execute these strategies flawlessly without human input, particularly in correcting and refining the generated code
- **Error Resolution and Code Optimization:** The AI's tendency to replace previously correct segments while fixing errors indicates a gap in its ability to self-optimize and learn from past corrections, highlighting the necessity for continuous human monitoring and adjustments
- **Collaborative Approach:** The project illustrates a collaborative framework where the integration of AI capabilities with human knowledge can lead to more effective trading strategies, suggesting that the future of AI in finance is not in replacing human roles but in augmenting them

Thank you!

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