DTL
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ALPHA GENERATION

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Contents

1 Primitive Variables

- N: Number of stocks in the universe.
- t: Current day (represented by d_i in the code).
- T: Lookback window, defined as: $T = \min(t + 1, 4)$
- $r_{i,t}$: Return of stock i on day t.
- $v_{i,t}$: Volume of stock i on day t.
- $c_{i,t}$: Closing price of stock i on day t.
- $h_{i,t}$: Highest price of stock i on day t.
- $l_{i,t}$: Lowest price of stock i on day t.
- $s_{i,t}$: Shares outstanding for stock i on day t.

2 Given Technique (Reversal)

The alpha for stock i on day t can be expressed as:

$$\alpha_{i,t} = 0.4 \cdot \text{signal}_{i,t} + 0.6 \cdot \alpha_{i,t-1}$$

Where the **signal** calculation is defined as:

$$\text{signal}_{i,t} = -\sum_{d=0}^{T-1} \frac{r_{i,t-d}}{T}$$

3 Modified Technique

The alpha for stock i on day t can be expressed as:

$$\alpha_{i,t} = 0.4 \cdot \left(\frac{\text{signal}_{i,t}^{\text{neutral}}}{1 + \left|\text{signal}_{i,t}^{\text{neutral}} - \alpha_{i,t-1}\right|^{0.4}} \right) + 0.6 \cdot \alpha_{i,t-1}$$

Where the $\textbf{signal}^{\textbf{neutral}}$ calculation is defined as:

$$\text{signal}_{i,t}^{\text{neutral}} = \text{signal}_{i,t} - \text{mean}(\text{signal}_{i,t} \mid \text{industry}_k)$$

and the **signal** calculation is:

$$\text{signal}_{i,t} = -0.5 \cdot \sum_{d=0}^{T-1} \left(r_{i,t-d} \cdot p_{i,t-d} \cdot \tilde{l}_{i,t-d} \cdot \tilde{v}_{i,t-d} \right) - 0.2 \cdot \sum_{d=0}^{T-1} \left(\frac{c_{i,t-d}}{c_{i,t-d-2}} \right) + 1.1 \cdot \sum_{d=0}^{T-1} \left(\frac{h_{i,t-d} - l_{i,t-d}}{c_{i,t-d}} \cdot \frac{v_{i,t-d}}{s_{i,t-d}} \right)$$

Where:

$$p_{i,t} = \begin{cases} 1.0 & \text{if } v_{i,t} > Q_{0.4}(v_t) \\ 0.6 & \text{otherwise} \end{cases}$$

$$\tilde{l}_{i,t} = \begin{cases} 1.5 & \text{if } s_{i,t} > Q_{0.6}(s_t) \\ 0 & \text{otherwise} \end{cases}$$

$$\tilde{v}_{i,t} = \begin{cases} 0.8 & \text{if } \frac{h_{i,t-d} - l_{i,t-d}}{c_{i,t-d}} > Q_{0.9}(s_t) \\ 3 & \text{otherwise} \end{cases}$$

3.1 Normalization

$$\frac{1}{1 + \left|\text{signal}_{i,t}^{\text{neutral}} - \alpha_{i,t-1}\right|^{0.4}}$$

- It creates a smooth transition between past and current signals. This helps mitigate drastic changes in alpha due to market noise, providing a more stable trading strategy.
- The exponent 0.4 modifies the responsiveness of the normalization. A lower exponent allows for the extraction of information from larger deviations in alpha, which might not be possible with a higher exponent since the signal would approach 0.

3.2 Industry Neutral

$$\text{signal}_{i,t}^{\text{neutral}} = \text{signal}_{i,t} - \text{mean}(\text{signal}_{i,t} \mid \text{industry}_k)$$

- Stocks within the same industry often exhibit correlated movements due to shared economic factors, regulatory changes, or market sentiment. Neutralizing the signal against the industry mean reduces the impact of these systematic influences.
- This helps in isolating the stock-specific signals from broader industry trends, thereby focusing on the specific performance of individual stocks.
- A stock with a high signal value relative to its industry mean may indicate stronger underlying performance that is not merely a reflection of industry trends.
- By having a alpha which is industry neutral instead of market neutral results in reduction of industry specific risks on the alpha.

3.3 First Term (Reversal)

$$\left[\text{signal}_{i,t}\right]^{\text{I}} = -0.5 \cdot \sum_{d=0}^{T-1} \left(r_{i,t-d} \cdot p_{i,t-d} \cdot \tilde{l}_{i,t-d} \cdot \tilde{v}_{i,t-d} \right)$$

1. **Mean Reversion and Return** ($r_{i,t-d}$):
   - The reversal mechanism relies on the assumption of *mean reversion*, where prices that deviate significantly from their intrinsic value tend to revert back.
   - This technique exploits the short-term price movements driven by transient factors (e.g., market overreaction, short-term noise). By negating past returns ($r_{i,t-d}$), the alpha anticipates a reversal, betting that stocks which have fallen will rise, and vice versa.
   - Terms other than return serve as penalty functions, ensuring that the reversal is actually taking place.
2. **Volume Penalty** ($p_{i,t-d}$):
   - Stocks with low trading volume are penalized using a factor of 0.6 for those in the lower 40th percentile of volume.
   - High-Volume Stocks: Focusing on highly traded stocks ensures more reliable market reactions to reversals, enhancing trading efficiency.

- Low-Volume Stocks: Limited trading activity makes it harder to generate reliable price patterns due to fewer buyers and sellers.
- Low-volume stocks are more prone to *illiquidity* and *higher transaction costs*, making them less reliable for quick reversals. By reducing the signal for these stocks, the alpha avoids positions that could suffer from higher slippage and execution risk.
- This ensures the strategy focuses on liquid stocks, which can react to reversals more efficiently.

3. **Shares Outstanding Penalty** ($l_{i,t-d}$):

   - Stocks with fewer shares held (below the 60th percentile) are penalized with a factor of 0, while those with more shares (above the 60th percentile) are boosted by 1.5.
   - Stocks with a large number of shares outstanding tend to have higher liquidity. Since these stocks are widely traded, large amounts of buying or selling may not have a significant impact on price. As a result, when a price movement occurs, it may be more likely to reverse due to market participants exploiting short-term mispricing and the ability to quickly fill orders without greatly moving the price.
   - Stocks with fewer shares outstanding typically have lower liquidity, meaning they can be more volatile and less responsive to short-term price corrections. In such stocks, sharp price movements may not reverse as easily because lower liquidity can cause larger price swings when buyers or sellers try to enter or exit positions, which can sustain trends rather than trigger reversals.
   - High-liquidity stocks (with a large number of shares outstanding) tend to experience mean reversion, while low-liquidity stocks (with fewer shares) may exhibit more momentum-driven trends.

4. **Volatility Penalty** ($\tilde{v}_{i,t-d}$):

   - Stocks in the higher 90th percentile of volatility($\frac{h_{i,t-d}-l_{i,t-d}}{c_{i,t-d}}$) receive a penalty of 0.8, while the rest are boosted by 3.
   - This discourages exposure to *high-volatility stocks*, which may experience sharp price movements due to market uncertainty, making them less predictable and more risky for mean reversion strategies.
   - Lower-volatility stocks tend to behave more predictably, improving the chances of accurately timing a reversal.
   - Mean Reversion itself is a risky strategy, so to reduce some risk I have tried penalising highly volatile stocks even though they have more trading opportunity.

3.4 Second Term (Downward Trend)

$$\left[\text{signal}_{i,t}\right]^{\text{II}} = -0.2 \cdot \sum_{d=0}^{T-1} \left(\frac{c_{i,t-d}}{c_{i,t-d-2}} \right)$$

- By comparing the closing price of a stock at different intervals, this signal aims to identify overbought or oversold conditions
- A higher cumulative ratio may indicate a longer period of upward price movement, increasing the likelihood of a reversal.
- Another way to incorporate reversal feature of the stocks.
- Lower weight of 0.2 is because this reversal feature is less prominent as compared to previous.

3.5 Third Term (Upward Trend)

$$\left[\text{signal}_{i,t}\right]^{\text{III}} = 1.1 \cdot \sum_{d=0}^{T-1} \left(\frac{h_{i,t-d} - l_{i,t-d}}{c_{i,t-d}} \cdot \frac{v_{i,t-d}}{s_{i,t-d}} \right)$$

- Stocks with large price swings and volatility presents more trading opportunity. So I've considered them here.
- Multiplication by volume ensures that along with large price swing there is large volume which means that the price movement is supported by many participants increasing reliability as a signal.
- High volume trading relative to shares-out for that stocks shows there is a strong market interest and prices are likely to move up.

4 Possible Improvements

4.1 Adding Momentum Term

Instead of using separate bias terms for upward and downward trends, we can introduce a momentum term. This momentum term, when combined with mean reversion strategies, could enhance the alpha.

4.2 Technical Indicators

Drawing inspiration from established technical indicators, we can further refine the terms in our model. This adaptation could lead to improved alpha performance by integrating insights from traditional trading methodologies.

4.3 Machine Learning

Incorporating machine learning components could yield a more robust alpha. For instance, applying simple linear regression to predict the next day's price based on the past T days' data could enhance accuracy. For larger models, utilizing Long Short-Term Memory (LSTM) networks and Transformers, pretrained on historical market data and fine-tuned on recent T days, may significantly improve trading performance without much training.

4.4 Latency

Currently, the alpha model takes approximately 152 seconds to run during in-sample testing, which is substantial compared to a simpler mean reversion technique that only takes around 15 seconds. Additionally, integrating machine learning methods may further increase latency and computational requirements. Therefore, we can optimize on this aspect if latency is crucial for trading.