Rulebook for Mean-Reverting Momentum Strategy

Objective

The objective of the **Mean-Reverting Momentum Strategy** is to exploit market inefficiencies by combining a momentum-based approach with mean-reversion principles. This strategy is particularly effective in markets with high volatility, such as small-cap equities or cryptocurrencies.

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Concepts and Theoretical Basis

1. **Momentum Effect:** The momentum effect identifies assets that exhibit strong performance over a recent period. Mathematically, momentum can be defined as:

$$\text{Momentum}(t) = \frac{P_t - P_{t-n}}{P_{t-n}} \times 100$$

where:

- P_t: Current price.
- P_{t-n}: Price n-days ago.
- n: Lookback period (e.g., 90 days for 3 months).

2. **Mean Reversion:** Assets tend to revert to their historical average price after deviating significantly. The mean price is often represented using a simple moving average (SMA):

$$\text{SMA}(t) = \frac{1}{N} \sum_{i=0}^{N-1} P_{t-i}$$

where N is the moving average period (e.g., 200 days).

To identify overbought or oversold conditions, we use Bollinger Bands:

$$\text{Upper Band} = \text{SMA}(t) + k \cdot \sigma$$

$$\text{Lower Band} = \text{SMA}(t) - k \cdot \sigma$$

where σ is the standard deviation of the prices over the period, and k is a multiplier (commonly 2).

Combining these, the strategy takes advantage of assets that exhibit positive momentum but are not excessively overbought or oversold.

3. Methods to Calculate the Threshold

Volatility-Adjusted Threshold with ATR

This method dynamically adjusts the momentum threshold using the Average True Range (ATR), ensuring that the strategy remains robust across varying market conditions.

1. Calculate the Average True Range (ATR)

The ATR measures the average volatility of the asset over a given period. It is calculated as:

$$\text{True Range}_t = \max(\text{High}_t - \text{Low}_t, |\text{High}_t - \text{Close}_{t-1}|, |\text{Low}_t - \text{Close}_{t-1}|)$$

The ATR is then computed as the average of the True Range over the lookback period n:

$$\text{ATR}(t) = \frac{1}{n} \sum_{i=1}^{n} \text{True Range}_i$$

where:

- n: Lookback period (e.g., 14 days or 30 days).
- True Range_i: True range of the asset on day i.

2. Define the Volatility-Adjusted Threshold

The thresholds for positive and negative momentum are scaled by the ATR:

- **Positive Threshold**:

$$\text{Threshold}_{\text{Momentum, pos}} = c \cdot \text{ATR}(t)$$

- **Negative Threshold**:

$$\text{Threshold}_{\text{Momentum, neg}} = -c \cdot \text{ATR}(t)$$

where:

- c: Scaling factor, typically $c = 2$ or $c = 3$.
- $\text{ATR}(t)$: Current ATR value at time t.

3. Combination with Historical Thresholds

The ATR adjustment can be combined with a static threshold (e.g., based on percentiles or standard deviation) to account for both historical and current conditions:

$$\text{Adjusted Threshold}_{\text{Momentum, pos}} = \text{Base Threshold}_{\text{Momentum, pos}} \cdot c \cdot \frac{\text{ATR}(t)}{\text{ATR}_{\text{long-term}}}$$

where $\text{ATR}_{\text{long-term}}$ is the historical average ATR for the asset.

4. Advantages of ATR-Based Adjustment

- **Robustness**: Adapts to market volatility in real-time.
- **Reduces Overreaction**: Prevents false signals in highly volatile markets.
- **Scalability**: Can be fine-tuned by modifying the scaling factor c.

Incorporating Multiperiodicity

1. Define Momentum for Multiple Periods

For each time horizon $(T_1, T_2, \ldots, T_n)$, momentum is calculated as:

$$\text{Momentum}_T(t) = \frac{P_t - P_{t-T}}{P_{t-T}} \times 100$$

where:

- T: Time period (e.g., $T_1 = 1H, T_2 = 4H, T_3 = 1D$),
- P_t: Current price,
- P_{t-T}: Price T periods ago.

2. Combine Momentum Signals

Weighted Average of Momentums

$$\text{Momentum}_{\text{combined}}(t) = \sum_{i=1}^{n} w_i \cdot \text{Momentum}_{T_i}(t)$$

where:

- w_i: Weight assigned to each time period ($\sum w_i = 1$),
- $\text{Momentum}_{T_i}(t)$: Momentum for period T_i.

Threshold Filtering

A trade signal is generated if all momentums exceed their respective thresholds:

$$\text{Trade Signal} = \begin{cases} 1 & \text{if Momentum}_{T_i}(t) > \text{Threshold}_{T_i} \, \forall i \\ 0 & \text{otherwise.} \end{cases}$$

3. Dynamic Weighting

Weights (w_i) can be adjusted dynamically based on volatility:

$$w_i = \frac{\sigma_{T_i}^{-1}}{\sum_{j=1}^{n} \sigma_{T_j}^{-1}}$$

where σ_{T_i} is the historical volatility of the T_i-period.

4. Multi-Period Decision Making

Majority Voting

$$\text{Final Signal} = \begin{cases} 1 & \text{if at least } k \text{ periods signal a positive trade} \\ 0 & \text{otherwise.} \end{cases}$$

Aggregated Scoring

$$\text{Score}(t) = \alpha \cdot \text{Momentum}_{T_1}(t) + \beta \cdot \text{Momentum}_{T_2}(t) + \gamma \cdot \text{Momentum}_{T_3}(t)$$

where α, β, γ are the weights of each time horizon.

5. Multi-Period Exits

Integrate multi-period metrics for exits:

$$\text{Take Profit}_T(t) = P_{\text{entry}} \pm k \cdot \text{ATR}_T$$

where k is a multiplier, and ATR_T is the average true range for period T.

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Rules of the Strategy

Entry Rules

- **Buy Position:** Enter a long position if the following conditions are met:
  1. Momentum is positive:

     $$\text{Momentum}(t) > \text{Threshold}_{\text{Momentum}}$$

     Example threshold: 5%.
  2. The price is below the upper Bollinger Band:

     $$P_t < \text{Upper Band}$$

- **Sell Short:** Enter a short position if the following conditions are met:

1. Momentum is negative:

$$\text{Momentum}(t) < -\text{Threshold}_{\text{Momentum}}$$

   Example threshold: -5%.

2. The price is above the lower Bollinger Band:

$$P_t > \text{Lower Band}$$

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Exit Rules

- **Take Profit:** Exit the position if the price moves in your favor by a target percentage:

$$\text{Take Profit} = P_{\text{entry}} \times (1 + \text{Target}_{\text{Return}})$$

  Example: Target return of 10%.

- **Stop Loss:** Exit the position if the price moves against you beyond a predefined threshold:

$$\text{Stop Loss} = P_{\text{entry}} \times (1 - \text{Threshold}_{\text{Loss}})$$

- **Time-Based Exit:** Exit the position if it remains open beyond a predefined time limit (e.g., 30 days).

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Risk Management

1. **Position Sizing:** Use volatility-based position sizing to determine the amount of capital to allocate to a trade:

$$\text{Position Size} = \frac{\text{Risk Capital}}{\text{ATR} \cdot \text{Multiplier}}$$

   where:

- ATR: Average True Range, a measure of volatility.
- Multiplier: A constant to control risk exposure.

2. **Max Drawdown:** Limit the maximum allowable drawdown. For example:
$$\text{Max Drawdown} = \text{Equity Peak} - \text{Equity Low}$$
Set thresholds (e.g., 10%) to halt trading if exceeded.

3. **Leverage Control:** Avoid excessive leverage by capping the notional exposure:
$$\text{Leverage Ratio} = \frac{\text{Notional Exposure}}{\text{Equity}}$$
Example cap: $2:1$.

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Backtesting and Evaluation

1. **Metrics to Evaluate**: Use the following metrics to measure performance:

   - **Sharpe Ratio:**
   $$\text{Sharpe Ratio} = \frac{\text{Mean Return} - \text{Risk-Free Rate}}{\text{Standard Deviation of Returns}}$$
   - **Maximum Drawdown:**
   $$\text{Max Drawdown} = \max(\text{Equity Peak} - \text{Equity Low})$$
   - **Win/Loss Ratio:**
   $$\text{Win/Loss Ratio} = \frac{\text{Number of Winning Trades}}{\text{Number of Losing Trades}}$$

2. **Data Requirements**: Use high-quality historical data with open, high, low, and close prices for backtesting.

3. **Execution**: Backtest using libraries like `Backtrader` or `Nautilus Trader`. Include slippage and transaction cost assumptions.

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Improvements and Extensions

1. **Sector Filtering:** Limit the strategy to specific sectors (e.g., technology, energy) with high volatility.
2. **Multifactor Approach:** Combine momentum with other factors like Relative Strength Index (RSI) or Moving Average Convergence Divergence (MACD).
3. **Dynamic Momentum Thresholds:** Adjust momentum thresholds dynamically based on market conditions (e.g., volatility regime changes).

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Advantages and Disadvantages

Advantages

- Combines two powerful approaches: momentum and mean-reversion.
- Reduces overbought or oversold risk using Bollinger Bands.

Disadvantages

- Less effective in strongly trending markets.
- Requires strict risk management to handle volatile markets.