UniPD group assignment 2025

Nicole Zattarin, nicole.zattarin@xsorcapital.com

Problem description

Mean reversion is a financial theory suggesting that prices or returns of an asset tend to move back toward their historical average or mean over time. This behavior contrasts with trending assets, which exhibit prolonged movement in one direction. Mean-reverting assets often exhibit oscillatory behavior around a central value, which could represent a long-term equilibrium. The extent and speed of this reversion to the mean can be quantified and analyzed using mathematical models and statistical techniques.

In this project, you will explore the concept of mean reversion by:

- Investigating the statistical characteristics of the asset's behavior to determine whether it exhibits mean reversion. To this end the goal is to **develop a metric** that reflects the degree of mean reversion of the asset;
- Design a method that removes the trending component of an asset's time series and reveals its mean-reverting properties.

1 Mean reversion metric

The first goal of the project is to analyze a financial asset, derive its price or return data, and develop a mathematical metric that quantifies the degree of mean reversion present in the time series of the asset.

As a hint, you could explore some of the following approaches:

- Develop a definition of trend and, according to that, define the average trend length both in terms of duration and return;
- Find the long term mean of the asset and define oscillations with respect to that, just as in a stationary model;
- Compute the average duration and amplitude of an oscillation.

We suggest to take inspiration from these ideas and to develop your own and best performing approach to the problem.

2 Trending asset into mean reverting asset

Trending assets are those whose prices or returns display a sustained movement in one direction (upward or downward) over time. Trending assets are typically non-stationary, meaning their statistical properties (e.g., mean, variance) evolve over time. This poses challenges for many standard financial analyses, which assume stationarity.

In this part of the project, instead of analyzing an already mean-reverting asset, your task is to transform a trending financial asset into one that exhibits mean-reverting behavior through mathematical or statistical normalization techniques.

Some possible approaches consist of:

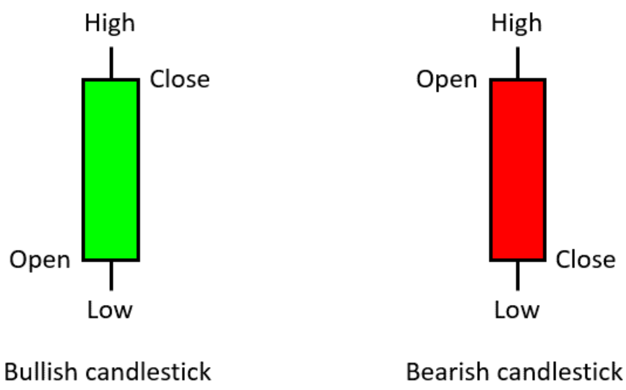
- Moving Averages: Subtracting or dividing the asset's price by a rolling mean (e.g., 50-day or 200-day moving average) to remove short-term trends.
- Linear Regression Detrending: Fitting a line to the asset's time series and removing the trend (subtracting the fitted line).

We suggest to take inspiration from these ideas and to develop your own and best performing approach to the problem.

Dataset

OHLC Data (Open, High, Low, Close) is a format in financial data analysis that captures key price points of an asset for a given timeframe (e.g., minute, hour, day). Similar to a bar chart, an OHLC candlestick chart displays the market's opening, highest, lowest, and last prices for a given timeframe. The candlestick comprises a broader section known as the "real body."

This real body signifies the price range between the opening and closing prices. If the real body is filled or colored black (or red), it signifies that the closing price was lower than the opening price. Conversely, when the real body is white (or green), it indicates that the closing price exceeded the opening price. See for instance the following figure:



In this drive you will find a selection of a few asset data in a 15 minute timeframe. Feel free to add any other resource that might be useful for the project in the drive. You can download additional daily data from Yahoo Finance with the python module yfinance.

Heiken-Ashi A useful way to visualize trends is by mean of Heiken-Ashi candlesticks. Heiken Ashi (HA) is a modified candlestick charting technique used in technical analysis to smooth out price action and highlight trends more clearly. It modifies the traditional Open, High, Low, Close (OHLC) data with a specific formula, creating a visual representation that filters out some market noise.

The Heiken Ashi (HA) values are calculated as follows:

- **HA Close:**
$$\text{HA\_Close}_t = \frac{\text{Open}_t + \text{High}_t + \text{Low}_t + \text{Close}_t}{4}$$
- **HA Open:**
$$\text{HA\_Open}_t = \frac{\text{HA\_Open}_{t-1} + \text{HA\_Close}_{t-1}}{2}$$
For the first period, the standard Open_t is used as the starting value.
- **HA High:**
$$\text{HA\_High}_t = \max(\text{High}_t, \text{HA\_Open}_t, \text{HA\_Close}_t)$$
- **HA Low:**
$$\text{HA\_Low}_t = \min(\text{Low}_t, \text{HA\_Open}_t, \text{HA\_Close}_t)$$

HA candles are useful to identify trends and reversal signals, indeed, at a high level, they can be interpreted as follow:

- Bullish Trends: Candles with large bodies and no lower wicks typically indicate strong upward trends.
- Bearish Trends: Candles with large bodies and no upper wicks typically indicate strong downward trends.
- Reversal Signals: Small bodies with both upper and lower wicks may indicate a potential reversal or consolidation.

Visualization

To visualize candlestick data you have two main options:

- Lineplot: you can directly plot the timeseries of closing prices. Although this is the most straightforward approach, it is just a simplified visualization, as it does not represent any information regarding Highs/Lows;
- Candlestick plot: it is possible to represent directly candlestick plots by means of mplfinance or Plotly. A template with mplfinance follows:

```python
def plot_OHLC(start_time, end_time, data, PNG_DIRECTORY,
   figname='trades.png'):

    if not os.path.exists(PNG_DIRECTORY):
        os.makedirs(PNG_DIRECTORY)
    else:
        for file in os.listdir(PNG_DIRECTORY):
            os.remove(os.path.join(PNG_DIRECTORY, file))
```

```
fig = mpf.figure(style='yahoo', figsize=(15, 10))
ax = fig.add_subplot(1, 1, 1)

ohlc_data = data.loc[start_time:end_time].copy()

ohlc_data = ohlc_data[['Open', 'High', 'Low', 'Close', '
    Volume']].copy()

ha_data = ohlc_data[['HA_open', 'HA_high', 'HA_low', '
    HA_close']].copy().rename(
    columns={
        'HA_open': 'Open',
        'HA_high': 'High',
        'HA_low': 'Low',
        'HA_close': 'Close'
    }
)

addplot = [
    mpf.make_addplot(ha_data, type='candle', secondary_y=
        False, ax=ax),
]

# Plot the data
mpf.plot(ohlc_data, type='ohlc', volume=False, returnfig=
    True, ylabel='', ax=ax, addplot=addplot)

fig.tight_layout()
fig.savefig(os.path.join(PNG_DIRECTORY, figname))
plt.close(fig)
```