A Market Making Game

A financial market is opening up to systematic traders for the first time. You are all about to enter the market. To be successful, you will need to buy low, sell high, and control your costs.

Market Mechanics

The asset being traded is a stock. Each period, participants must submit a pair of buy and sell *limit orders*. These represent the maximum (minimum) price you are willing to buy (sell) the stock for. Your buy price must always be less than your sell price and the difference between the two is called the spread. Once your orders are submitted:

- If the next price of the stock is less than your buy price, your position will increase by one.
- If the next price of the stock is greater than your sell price, your position will decrease by one.
- If the next price of the stock is between your buy and sell orders, your position will remain unchanged.

There are no restrictions on short selling, so your position in the stock can be negative as well as positive.

Evaluation

The main driver of profit ('PNL') is price movement in the underlying stock. You will make money if you are long (short) the stock when it goes up (down).

In addition:

- The stock pays a dividend each period. This is essentially a reward for being long the stock.
- There are financing charges (and conversely, profits) for owning positive (or negative) shares in the stock. This is essentially a reward for being short the stock.
- There is a large additional financing cost proportional to the square of the position. This is a penalty for building up a large (and therefore risky) directional position in the stock.

More precisely, the PNL from time $t-1$ to time t is defined as:

$$\underbrace{x_{t-1} \times (P_t - P_{t-1})}_{\text{inventory PNL}} + \underbrace{x_{t-1} \times D_t}_{\text{dividend PNL}} + \underbrace{-0.01 \cdot (x_{t-1} \times P_{t-1}) - 0.001 \cdot (x_{t-1} \times P_{t-1})^2}_{\text{financing PNL}}$$

where x_s denotes the position in the stock, P_s the price, and D_s the dividend, at time s.

Your objective is to trade in such a way as to make the most total PNL. To achieve this, your strategy will need to make plenty of inventory PNL whilst keeping costs under control.

A Systematic Approach

You will participate in this market by writing a Python function which takes in some recent data and returns your buy and sell prices.

To help you develop your trading strategy, we have provided a historical time series of prices, dividends, and volumes for the stock. You have reason to believe that the market will be governed by the same fundamental process going forward.

The template `solution.py` clarifies the form your solution must take and should help you get started. In particular, you are restricted to using only 7 values: the price, dividend, and volume over the last two periods, and your current position in the stock. These are provided as arguments to your function.

Once you have written a function, you can evaluate its performance using the code in `backtest.py`. To help you avoid overfitting, we have separated the data into a training and test set. You may find it helpful to build your strategy using `train.csv` and checking that there is no major drop in performance on `test.csv`.

Submission

Codebase is primarily designed as a means of submitting your final code, and is not a full IDE. You should carry out research and run backtests locally before uploading your `solution.py` file at end.

When you are happy with your solution, you should check it passes the verification checks on Codebase. In particular, your submission:

- should be written in a new-ish variant of Python 3
- should run in a manageable amount of time
- may only use the modules `numpy`, `scipy` and `pandas`

We will then run your strategy on fresh out-of-sample data. Whoever makes the most PNL will be declared the winner. Good luck!