In The Name of God

Final Project:
Optimization of Portfolio

Group Members:

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Symbols:

We have chosen the following stocks for our test:

```
Symbols:        ADA-USD    BTC-USD    ETH-USD    XRP-USD
```

Part 1 (1 year period over 2022/11/01 to 2023/11/01):

1.1. Random Weights:

- First, we try random weights for each of the stocks; the results are as follows:

```
Initial Buy & Hold status over 2022-11-01 to 2023-11-01:
-----------------------------------------------------------------
Weights:    0.37    0.22    0.30    0.11
-----------------------------------------------------------------
Net Profit: 127.11
            12.71 %
-----------------------------------------------------------------
Sharpe Ratio:   0.3202
-----------------------------------------------------------------
Sortino Ratio:  0.4534
-----------------------------------------------------------------
```

1.2. Optimized weights:

- In the next step, we find the sets of weights that optimizes each one of our three metrics; the optimized weights are:

```
Optimized Weights for Net Profit:
[-1.85286524e-08  1.00000002e+00 -2.53137955e-09  2.88778779e-09]
Optimized Weights for Sharpe Ratio:
[-9.71445158e-17  1.00000000e+00 -6.10622664e-16 -3.33066907e-16]
Optimized Weights for Sortino Ratio:
[-6.93889390e-16  1.00000000e+00 -2.03135278e-15  5.55111512e-17]
```

- The test results for the optimized weights also look as follows:

```
Net_Profit-optimized Buy & Hold status over
2022-11-01 to 2023-11-01:
-----------------------------------------------------------------
Weights:    -0.00   1.00    -0.00   0.00
-----------------------------------------------------------------
Net Profit: 692.33
            69.23 %
-----------------------------------------------------------------
Sharpe Ratio:   1.0276
-----------------------------------------------------------------
Sortino Ratio:  1.4721
-----------------------------------------------------------------
```

```
Sharpe_Ratio-optimized Buy & Hold status over
2022-11-01 to 2023-11-01:
-----------------------------------------------------------------
Weights:    -0.00   1.00    -0.00   -0.00
-----------------------------------------------------------------
Net Profit: 692.33
            69.23 %
-----------------------------------------------------------------
Sharpe Ratio:   1.0276
-----------------------------------------------------------------
Sortino Ratio:  1.4721
-----------------------------------------------------------------
```

```
Sortino_Ratio-optimized Buy & Hold status over
2022-11-01 to 2023-11-01:
-----------------------------------------------------------------
Weights:    -0.00   1.00    -0.00   0.00
-----------------------------------------------------------------
Net Profit: 692.33
            69.23 %
-----------------------------------------------------------------
Sharpe Ratio:   1.0276
-----------------------------------------------------------------
Sortino Ratio:  1.4721
-----------------------------------------------------------------
```

1.3. Comparison:

- Looking at the results, there are 2 important points to consider:

  - In order to achieve the best net profit, one stock gets the whole 1 weight while others receive 0.

    This happens because of the fact that the net profit of the portfolio is a linear combination of the net profits of stocks; therefore, if we allocate the whole capital to the stock with the best net profit rate, we will achieve the best possible net profit for the portfolio.

  - In the long 1-year period, the optimized weights of the three different measures seem to be very close.

    This might indicate that in the long run, the value $R_p - R_f$ has more effect, and dominates the effect of changes in standard deviation when changing the weights.

    It's also important to notice that $R_p - R_f$ is somewhat equivalent to net profit; therefore, all the three measures converge to the same point.

Part 2 (new 1 month period over 2023/11/02 to 2023/12/02):

2.1. Random Weights:

- First, we retry the random weights we used for the previous part:

```
Initial Buy & Hold status over 2023-11-02 to 2023-12-02:
-----------------------------------------------------------------
Weights:    0.37    0.22    0.30    0.11
-----------------------------------------------------------------
Net Profit: 142.08
            14.21 %
-----------------------------------------------------------------
Sharpe Ratio:   3.0374
-----------------------------------------------------------------
Sortino Ratio:  5.3166
-----------------------------------------------------------------
```

2.2. Previously optimized weights:

- Next, we retry the optimized weights from the previous part;

  In order to keep things short, let us include only one of the results here, as the generated weights for the different measures were identical. (Although in the generated output, all three sections are present.)

```
Previously Net_Profit-optimized Buy & Hold status over
2023-11-02 to 2023-12-02:
-----------------------------------------------------------------
Weights:    -0.00   1.00    -0.00   0.00
-----------------------------------------------------------------
Net Profit: 107.35
            10.73 %
-----------------------------------------------------------------
Sharpe Ratio:   2.5880
-----------------------------------------------------------------
Sortino Ratio:  3.8193
-----------------------------------------------------------------
```

2.3. New optimized weights:

- Finally, we re-optimize the weights, for each one of the measures, in order to find out the best combo for each measure in the new time period; the new optimized weights are:

```
Optimized Weights for Net Profit:
[ 1.00000000e+00 -3.46099815e-11  1.86947846e-10 -4.62427763e-10]
Optimized Weights for Sharpe Ratio:
[ 6.22481929e-01 -3.02275566e-16  3.77518071e-01 -2.08166817e-17]
Optimized Weights for Sortino Ratio:
[ 5.06171531e-01  9.15114320e-16  4.93828469e-01 -2.62956772e-15]
```

- Note that, as expected, net portfolio optimization, again, resulted in assigning the whole capital to one stock only.

- The new test results are as follows:

```
New Net_Profit-optimized Buy & Hold status over
2023-11-02 to 2023-12-02:
-----------------------------------------------------------------
Weights:    1.00    -0.00   0.00    -0.00
-----------------------------------------------------------------
Net Profit: 188.96
            18.90 %
-----------------------------------------------------------------
Sharpe Ratio:   3.1805
-----------------------------------------------------------------
Sortino Ratio:  5.2603
-----------------------------------------------------------------
```

```
New Sharpe_Ratio-optimized Buy & Hold status over
2023-11-02 to 2023-12-02:
-----------------------------------------------------------------
Weights:    0.62    -0.00   0.38    -0.00
-----------------------------------------------------------------
Net Profit: 177.69
            17.77 %
-----------------------------------------------------------------
Sharpe Ratio:   3.3878
-----------------------------------------------------------------
Sortino Ratio:  6.5276
-----------------------------------------------------------------
```

```
New Sortino_Ratio-optimized Buy & Hold status over
2023-11-02 to 2023-12-02:
------------------------------------------------------------
Weights:    0.51    0.00    0.49    -0.00
------------------------------------------------------------
Net Profit: 174.22
            17.42 %
------------------------------------------------------------
Sharpe Ratio:   3.3610
------------------------------------------------------------
Sortino Ratio:  6.6596
------------------------------------------------------------
```

2.4. Comparison & Conclusion:

- Looking at the results, there are 2 important points to consider:

    - The initial random values, managed to achieve better results than the previously optimized weights!

      This means that we cannot always be confident in optimizing and testing a portfolio. The future may not necessarily unfold as we expect.

      As we saw in this experiment, after training our weights over a 1-year time period, a random set of weights managed to outperform the trained portfolio.

    - In the shorter time period, the measures do not fully converge; meaning that in shorter periods of investment, portfolios are much more affected by the volatility of their forming stocks and their weights in the portfolio.