MS815: Programming for Financial Technology

Group Assignment

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Date: 06/01/2020

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Part A (Python programming)

Question 1

Your client wants to purchase Apple stocks in 2 months' time. They are exploring the Asian style option and would like evaluate the value of this option. While the European or American call options are exercised at some strike price chosen right now, the Asian style option gives the right to purchase at the average spot price over the next two months.

Assume the risk free interest rate r as 5%.

Solution:

Asian options, also known as average price options, are a special type of option. There are two basic forms: An average rate option, which is based on the fixed strike and average value of underlier over the life of the option; On the other hand, an average strike option, which is the strike price equal to the average value of the underlier over the life of the option. The following research is based on the second case of options which is average strike option.

Applying Monte Carlo simulation to forecast Asian option price. First, extract the stock price of Apple Inc. in the past ten years. And then using "percent change" method to estimate its historical log returns. The formula for log returns by using NumPy's log and then type 1 + the simple returns extracted from our data.

Hence, the plots below show the Apple stock price plot (Figure 1-1) and log_returns plot (Figure 1-2):

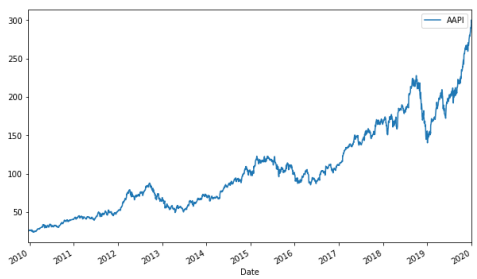


Figure 1-1

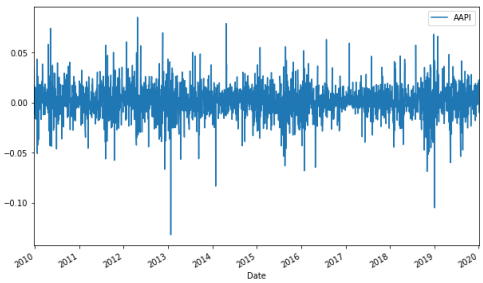


Figure 1-2

Next, compute the drift component, the formula of calculating drift is which equals the mean of log return and minus half of its variance. And for further research, transform these values into NumPy arrays.

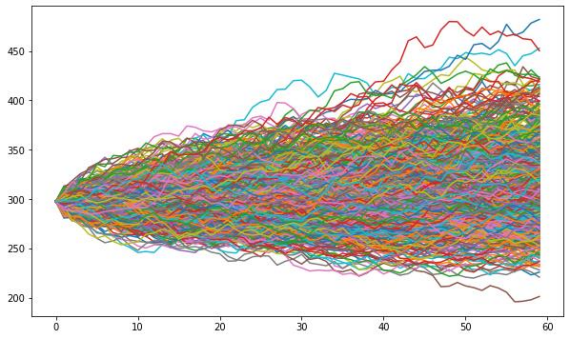
Now, attribute the value of “iterations” is 1000, which means it asks the computer to produce 1000 series of future stock price predictions. Meanwhile, set the value of “intervals” is 60, which means forecasting the stock price for the upcoming two months.

Get the future daily returns by using formula:

daily_returns = np.exp(drift.values + std.values * norm.ppf(np.random.rand(t_intervals, iterations))) , which get1000 sets of 60 random future stock prices.

Furthermore, set up a loop that begins in day 1 and ends at day 60, which will be equal to the price in day T-1 times the daily return observed in day T. Notice that the first value is the current market price.

Get the price_list plot:



Calculate the mean of 1000 sets price_list numbers and get 60 numbers as future 60 days daily_list stock price. Then compute the mean of 60 daily_list stock price as K.

A call gets money when the price of the asset at maturity, denoted by St (St = daily_list[-1]), is above the strike price K, otherwise it is worth nothing.

$$Ct = \max(0, ST - K)$$

And the option value is the present value of the expectation of its payoff at maturity T, hence:

$$Ct = PV(E[\max(0 , ST - K)])$$

$$Ct = \exp(-r*T) * E[\max(0,ST-K)], \quad \text{where } r = 5\%, T = 60/252$$

60 represent two months, 252 is the number of trading days in a year.

Above all, we get the option price Ct And under this model, people use price Ct to buy Apple call option, there will be no loss on the maturity date.

Question 2

You have another client who is a technology enthusiast and he would like to invest in tech companies. Choose 5 active tech companies and build a diversified portfolio for your client. Write a 1-page report detailing the following: a) your approach to solve the portfolio optimisation problem b) appropriate analysis of your output including charts and explanation.

Solution:

The portfolio composed of five technology stocks that were selected from S&P 500. S&P 500 is considered a good indicator, according to the certain criteria that should be met such as the market capitalization must be 5.3 million or more and the public float must consist of at least 50% of outstanding shares. It can efficiently narrow down the scope from massive technology stocks to the 69 companies with high liquidity and relatively more profitable stocks.

The next step was using P/E ratio to evaluate those companies. P/E ratio is one of the most popular evaluation ratios. It shows the price that market is willing to pay for one dollar of earnings, which can help investors to measure whether the stock is worth to buy or not. In this report, roughly using the concept of the lower P/E ratio, the more attractive the stock is. To avoid single evaluating by P/E ratio, Sharpe ratio was used to help to filter the final five securities from the relatively low P/E ratio companies. The final list of the portfolio consists of Micron Technology (MU)、Seagate Technology (STX)、Intel (INTC)、 DXC Technology (DXC) and IBM which with higher Sharpe ratio.

Mean-variance portfolio theory and Monte Carlo simulation were utilized to optimize the portfolio. Figure 1 illustrates 25,000 sets of combinations that are generated by Monte Carlo simulation. Each spot represents a portfolio of the return and standard deviation calculated by random weights. Through mean-variance portfolio theory can diversify the investment, rational investors will maximize the expected return at the given level of risk or minimize the risk at a given level of expected return. Figure 1 emphasizes three portfolios with different levels of returns and risks on the efficient frontier. The green star represents the portfolio with minimizing risk, the red star represents the portfolio with the highest Sharpe ratio, and the yellow star represents the portfolio with maximizing return.

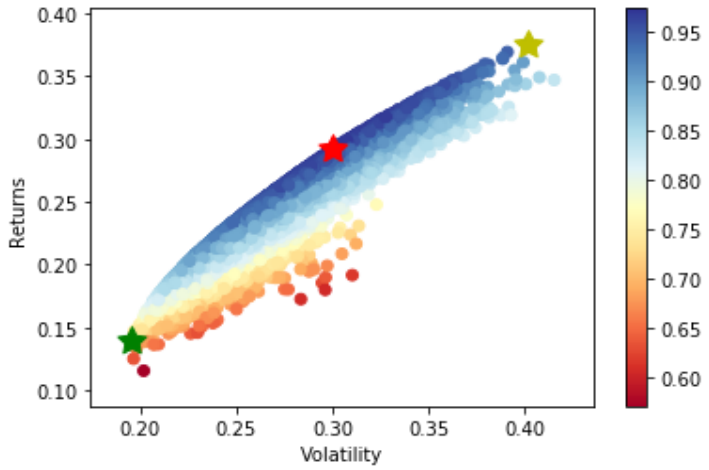


Figure 1

Max Sharpe ratio

```
ret        0.291818
stdev      0.299787
sharpe     0.973418
MU         0.110755
STX        0.011351
INTC       0.332180
DXC        0.230270
IBM        0.315445
Name: 23330, dtype: float64
```

Min risk

```
ret        0.139258
stdev      0.195028
sharpe     0.714041
MU         0.122148
STX        0.575357
INTC       0.258013
DXC        0.002799
IBM        0.041682
Name: 22826, dtype: float64
```

Max return

```
ret        0.375946
stdev      0.401948
sharpe     0.935309
MU         0.008292
STX        0.004000
INTC       0.027074
DXC        0.536403
IBM        0.424232
Name: 15856, dtype: float64
```

Figure 2

High return usually accompanied by high risk, figure 2 shows the portfolio of maximizing return has the highest expected return, however, it also has the highest risk. Sharpe ratio can help investors to find the balance between returns and risks. Through visualizing the accumulated returns, figure 3 verifies the portfolio with the highest Sharpe ratio (Portfolio_MSR) has higher returns compared to other portfolios.

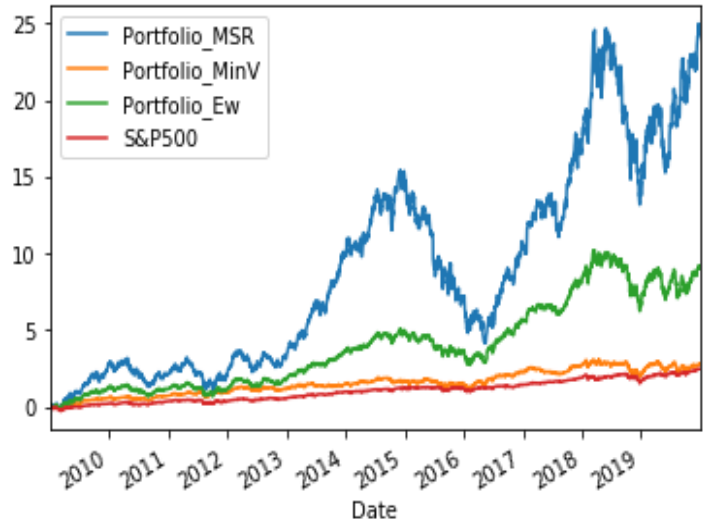


Figure 3

In conclusion, to form an effective portfolio, using Monte Carlo simulation to generate diversified sets of portfolios, then combing with the Mean-variance portfolio theory to find out the spots on the efficient frontier. Among the spots on the efficient frontier, because the higher Sharpe ratio means the higher return that investors can receive for each unit of risk they undertake, the portfolio with the highest Sharpe ratio is better for investors.