Financial Calculator

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Motivation

Usually when we use financial calculators online, we'll get different results with the same input due to algorithms the author chose, and we don't know which formula they are using. In order to make calculations more clear to ourselves, we decided to create our own financial calculator. Moreover, with our own product we could check our homework answers for courses such as stochastic calculus more confidently, and get better understanding of some financial models.

Functionality

Our program consists of six sub-functions, corresponding to stocks, options and portfolios.

Stock:

Simulate stock price by Geometric Brownian Motion with user defined starting price, risk free rate, volatility, time span and steps. Among these parameters, volatility can be either input manually, or calculated from historical data with given ticker.

Option:

Find out volatility with Black Scholes Model and Price an option using Binomial Tree model with user defined parameters such as strike and spot prices, output the result together with the stock price tree, option value tree at the same time.

Portfolio:

Allow user to build their own portfolio by inputting ticket names and corresponding weights. Then they could get the sharp ratio as well as the value change of this portfolio. Or user can use random generated weight to build their portfolio.

Usage (Input & output)

Stock

User could choose either to type in the volatility or point out a ticket name so that computer could calculate it with input file. For the second choice, there should be a csv file named with corresponding ticker in the "input" folder.

Aside from volatility, use should also determine initial price as starting point, as well as simulate time span, risk free rate and simulate steps.

Output here will be a number indicating the most likely price this stock would have after specific time period. Here are two samples:

With given volatility:

```
"E:\Stevens\2020-SPRING\FE-522\Final Project\Program\cmake-build-debug\Program.exe"
Do you want to analyze stock, option or portfolio? stock
You want to input data yourself or read from file? (A/B) A
What's the volatility: 0.2
What's the initial stock price: 30
How long you want to simulate (in year): 1
What's the risk free rate you want to use: 0.09
How many steps you want use in this simulation: 252
According to Monte Carlo simulation, the stock price is likely to be: 30.32690
```

With given ticker:

```
"E:\Stevens\2020-SPRING\FE-522\Final Project\Program\cmake-build-debug\Program.exe"
Do you want to analyze stock, option or portfolio? stock
You want to input data yourself or read from file? (A/B) B
What's the ticket symbol you want to analyze? BOA
What's the initial stock price: 30
How long you want to simulate (in year): 1
What's the risk free rate you want to use: 0.015
How many steps you want use in this simulation: 252
According to Monte Carlo simulation, the stock price is likely to be: 27.80510

Process finished with exit code 0
```

Option

Price an option:

Input requires information such as option type (call or put), spot price (of the underlying asset), strike price, interest rate, volatility (of the underlying asset) and time to maturity. And user could choose to see the binomial tree or not.

```
"E:\Stevens\2020-SPRING\FE-522\Final Project\Program\cmake-build-debug\Program.exe"
Do you want to analyze stock, option or portfolio? option
You want to price an option or calculate volatility? (A/B) A
Are you analyzing a call option or a put? put
What's the spot price: 100
What's the strike price: 95
What's the risk free rate you want to use: 0.05
What's the volatility: 0.2
What's the time to mature in year: 1
How many terms you want in this binomial tree model: 3
Do you want to see the binomial tree? yes
```

If user choose to see the process, they will get all these three trees:

```
The stock price tree is:
       HHH       100    112.24   125.978   141.398
       HHT       100    112.24   125.978    112.24
       HTH       100    112.24       100    112.24
       HTT       100    112.24       100   89.0947
       THH       100   89.0947       100    112.24
       THT       100   89.0947       100   89.0947
       TTH       100   89.0947   79.3787   89.0947
       TTT       100   89.0947   79.3787   70.7222

Value tree of American Option is:
       HHH   4.41636   1.18883         0         0
       HHT   4.41636   1.18883         0         0
       HTH   4.41636   1.18883   2.64959         0
       HTT   4.41636   1.18883   2.64959   5.90527
       THH   4.41636   8.42598   2.64959         0
       THT   4.41636   8.42598   2.64959   5.90527
       TTH   4.41636   8.42598   15.6213   5.90527
       TTT   4.41636   8.42598   15.6213   24.2778

Value tree of European Option is:
       HHH   4.10025   1.18883         0         0
       HHT   4.10025   1.18883         0         0
       HTH   4.10025   1.18883   2.64959         0
       HTT   4.10025   1.18883   2.64959   5.90527
       THH   4.10025   7.72145   2.64959         0
       THT   4.10025   7.72145   2.64959   5.90527
       TTH   4.10025   7.72145   14.0511   5.90527
       TTT   4.10025   7.72145   14.0511   24.2778

Do you want to continue or exit?
```

Four or more teams can also be fulfilled, but will take more space to display

```
The stock price tree is:
      HHHH       100   110.517    122.14   134.986   149.182
      HHHT       100   110.517    122.14   134.986    122.14
      HHTH       100   110.517    122.14   110.517    122.14
      HHTT       100   110.517    122.14   110.517       100
      HTHH       100   110.517       100   110.517    122.14
      HTHT       100   110.517       100   110.517       100
      HTTH       100   110.517       100   90.4837       100
      HTTT       100   110.517       100   90.4837   81.8731
      THHH       100   90.4837       100   110.517    122.14
      THHT       100   90.4837       100   110.517       100
      THTH       100   90.4837       100   90.4837       100
      THTT       100   90.4837       100   90.4837   81.8731
      TTHH       100   90.4837   81.8731   90.4837       100
      TTHT       100   90.4837   81.8731   90.4837   81.8731
      TTTH       100   90.4837   81.8731   74.0818   81.8731
      TTTT       100   90.4837   81.8731   74.0818    67.032
```

```
Value tree of American Option is:
      HHHH   4.06104   1.24837         0         0         0
      HHHT   4.06104   1.24837         0         0         0
      HHTH   4.06104   1.24837         0         0         0
      HHTT   4.06104   1.24837         0         0         0
      HTHH   4.06104   1.24837   2.73495         0         0
      HTHT   4.06104   1.24837   2.73495         0         0
      HTTH   4.06104   1.24837   2.73495   5.99179         0
      HTTT   4.06104   1.24837   2.73495   5.99179   13.1269
      THHH   4.06104    7.4444   2.73495         0         0
      THHT   4.06104    7.4444   2.73495         0         0
      THTH   4.06104    7.4444   2.73495   5.99179         0
      THTT   4.06104    7.4444   2.73495   5.99179   13.1269
      TTHH   4.06104    7.4444   13.1269   5.99179         0
      TTHT   4.06104    7.4444   13.1269   5.99179   13.1269
      TTTH   4.06104    7.4444   13.1269   20.9182   13.1269
      TTTT   4.06104    7.4444   13.1269   20.9182    27.968
```

```
Value tree of European Option is:
      HHHH   3.86622   1.24837         0         0         0
      HHHT   3.86622   1.24837         0         0         0
      HHTH   3.86622   1.24837         0         0         0
      HHTT   3.86622   1.24837         0         0         0
      HTHH   3.86622   1.24837   2.73495         0         0
      HTHT   3.86622   1.24837   2.73495         0         0
      HTTH   3.86622   1.24837   2.73495   5.99179         0
      HTTT   3.86622   1.24837   2.73495   5.99179   13.1269
      THHH   3.86622   7.01758   2.73495         0         0
      THHT   3.86622   7.01758   2.73495         0         0
      THTH   3.86622   7.01758   2.73495   5.99179         0
      THTT   3.86622   7.01758   2.73495   5.99179   13.1269
      TTHH   3.86622   7.01758   12.1918   5.99179         0
      TTHT   3.86622   7.01758   12.1918   5.99179   13.1269
      TTTH   3.86622   7.01758   12.1918   19.7381   13.1269
      TTTT   3.86622   7.01758   12.1918   19.7381    27.968
```

For better explanation, we also include the stock directions with all attributes. “H” stands for head while “T” stands for tail.

If user choose not to see the tree, output will be two sentences telling the expected price:

```
Do you want to continue or exit? continue
Do you want to analyze stock, option or portfolio? option
You want to price an option or calculate volatility? (A/B) A
Are you analyzing a call option or a put? put
What's the spot price: 100
What's the strike price: 95
What's the risk free rate you want to use: 0.05
What's the volatility: 0.2
What's the time to mature in year: 1
How many terms you want in this binomial tree model: 3
Do you want to see the binomial tree? no
Price of this American Option should be: 4.41636
Price of this European Option should be: 4.10025
Do you want to continue or exit? exit
Have a good day.

Process finished with exit code 1
```

Calculate volatility:

Input should be all other parameters and it price. Then user will get a sentence describing the implied volatility.

```
"E:\Stevens\2020-SPRING\FE-522\Final Project\Program\cmake-build-debug\Program.exe"
Do you want to analyze stock, option or portfolio? option
You want to price an option or calculate volatility? (A/B) B
Are you analyzing a call option or a put? call
What's the spot price: 100
What's the strike price: 105
What's the risk free rate you want to use: 0.09
What's the time to mature in days: 252
What's the option price? 2.56
The implied volatility is: 0.0553132
```

Portfolio

We apply the template, linked node and sorted list concepts(insert nodes in the order of input), so it allows user to create portfolio containing whatever number of stocks they want.

```
class Portfolio{
public:
    SortedList<Stocks> Tickets;
    SortedList<double> Shares;
    SortedList<double> Weight;
    Portfolio()= default;
```

However, this function requires pre-stored data as csv files in the “input” folder. And all stocks files used in one portfolio should have the same time-span.

Set weights

User need to input the stocks tickers they want to take and corresponding weights. Output will be s short description of assets status and portfolio profitability

```
"E:\Stevens\2020-SPRING\FE-522\Final Project\Program\cmake-build-debug\Program.exe"
Do you want to analyze stock, option or portfolio? portfolio
You want to set shares, or use random weight? (A/B) A
How many stocks you want in this portfolio? 3
What's the ticket symbol you want to analyze? AAPL
How many shares you want to buy of this stock? 100
What's the ticket symbol you want to analyze? BOA
How many shares you want to buy of this stock? 120
What's the ticket symbol you want to analyze? FB
How many shares you want to buy of this stock? 200
At the beginning, value of this portfolio is: 62037.3
At the End, value of this portfolio is: 74156.2
Asset profit and loss: 12118.9
With every 100 dollars, you earned: 19.5348

Process finished with exit code 0
```

Use random weights

User need to input the tickers as well as the total capital they want to put into the market. Output here will be a short description indicating the optimal weight .

```
"E:\Stevens\2020-SPRING\FE-522\Final Project\Program\cmake-build-debug\Program.exe"
Do you want to analyze stock, option or portfolio? portfolio
You want to set shares, or use random weight? (A/B) B
How many stocks you want in this portfolio? 3
How much starting capital do you prefer? 1000000
What's the ticket symbol you want to analyze? AAPL
What's the ticket symbol you want to analyze? BOA
What's the ticket symbol you want to analyze? FB
The optimal weight with highest sharp ratio 0.0753028 is:
0.0593448 of AAPL, 0.632437 of BOA, 0.308219 of FB,
Buy 292.094 shares of AAPL
Buy 21555.4 shares of BOA
Buy 1587.45 shares of FB
Do you want to continue or exit?
```

Together with a csv file tracking the value change of this portfolio

2019-07-01	11.8519
2019-07-02	30.1194
2019-07-03	89.6056
2019-07-05	101.527
2019-07-08	119.627
2019-07-09	179.729
2019-07-10	191.749
2019-07-11	209.787
2019-07-12	270.568
2019-07-15	282.577
2019-07-16	300.746
2019-07-17	361.28
2019-07-18	373.042
2019-07-19	391.172
2019-07-22	451.509
2019-07-23	463.343
2019-07-24	481.567
2019-07-25	542.967
2019-07-26	554.918
2019-07-29	572.937
2019-07-30	635.422
2019-07-31	647.286
2019-08-01	665.516
2019-08-02	727.539
2019-08-05	739.494
2019-08-06	757.78
2019-08-07	820.925
2019-08-08	832.992
2019-08-09	851.135
2019-08-12	913.984

Files contained in our program: