Problem 1

- Current Stock Price $165
- Strike Price $165
- Current Date 03/13/2022
- Options Expiration Date 04/15/2022
- Risk Free Rate of 4.25%
- Continuously Compounding Coupon of 0.53%

Implement the closed form Greeks for GBSM. Implement a finite difference derivative calculation.
Compare the values between the two methods for both a call and a put.

Implement the binomial tree valuation for American options with and without discrete dividends. Assume the stock above:

- Pays dividend on 4/11/2022 of $0.88

Calculate the value of the call and the put. Calculate the Greeks of each.

What is the sensitivity of the put and call to a change in the dividend amount?

Analysis

The follow is the Greeks calculated by closed form and finite difference for GBSM.

	Closed form Greeks for GBSM		Finite Difference Greeks	
	Call	Put	Call	Put
Delta	0.5340	-0.4655	0.5340	-0.4655
Gamma	0.0400	0.0400	0.0400	0.0400
Vega	19.7101	19.7101	19.7102	19.7102
Theta	-24.8985	-18.7870	-24.8988	-18.7873
Rho	7.5836	-7.2770	-0.3826	-0.3326
Carry Rho	7.9662	-6.9444	7.9662	-6.9444

As can be seen from the table above, using different method of closed form and finite difference to calculate the Greeks, values of Delta, Gamma, Vega, Theta, and Carry Rho are almost the same, while there are big differences between values of Rho.

Then I implemented the binomial tree model to calculate the values of options with or without dividends.

	Without discrete dividends		With discrete dividends	
	Call	Put	Call	Put
Option value	4.23	3.71	4.12	4.11

Using binomial tree model to calculate the Greeks:

	Greeks of Binomial Tree Greeks	
	Call	Put
Delta	0.5386	-0.4931
Gamma	-1.7763	7.1054
Vega	19.5150	19.8241
Theta	-24.7956	-18.5331
Rho	-0.3301	-0.3331
Carry Rho	7.1600	-6.8867

Sensitivity of put and call to a change in the dividend amount:
Call: -0.094, Put: 0.513

Problem 2

Using the options portfolios from Problem3 last week (named problem2.csv in this week's repo) and assuming:

- American Options
- Current Date 03/03/2023
- Current AAPL price is 165
- Risk Free Rate of 4.25%
- Dividend Payment of $1.00 on 3/15/2023

Using DailyPrices.csv. Fit a Normal distribution to AAPL returns – assume 0 mean return. Simulate AAPL returns 10 days ahead and apply those returns to the current AAPL price (above). Calculate Mean, VaR and ES.

Calculate VaR and ES using Delta-Normal.

Present all VaR and ES values a $ loss, not percentages.

Compare these results to last week's results.

Analysis

I simulated AAPL returns 10 days ahead and applied those returns to the current AAPL

price. The portfolios' value of mean, VaR, ES are as follows.

Portfolio	Mean	VaR	ES
Call	1.706962	5.483445	6.050029
CallSpread	0.185515	3.439044	3.912883
CoveredCall	-0.984139	12.044354	16.329624
ProtectedPut	1.824740	7.006539	7.643182
Put	1.246235	4.396165	4.597241
PutSpread	0.355063	2.684004	2.825462
Stock	0.708515	15.600699	20.133811
Straddle	2.953197	0.005066	0.005541
SynLong	0.460727	16.408753	21.260096

Using Delta-Normal hedge:

Portfolio	Mean	VaR	ES
Call	1.310913	-0.020801	-0.011600
CallSpread	-0.017134	1.329257	2.231382
CoveredCall	-1.395555	5.314494	7.197291
ProtectedPut	1.316436	0.018738	0.023852
Put	1.570095	-0.023316	-0.012566
PutSpread	0.527424	-0.019742	0.002864
Stock	0.000000	-0.000000	-0.000000
Straddle	2.881008	-0.044963	-0.024547
SynLong	-0.259182	0.907556	1.030796

Results from last week assignment:

Portfolio	Mean	VaR	ES
Call	1.014871	6.064081	6.383327
CallSpread	-0.010401	3.913309	4.200177
CoveredCall	-0.562214	12.372318	16.038336
ProtectedPut	1.132652	8.118721	8.721664
Put	0.677828	4.423475	4.624093
PutSpread	0.240285	2.672989	2.828842
Stock	0.541706	16.198269	19.975608
Straddle	1.692699	1.379503	1.387616
SynLong	0.337043	16.442157	20.241654

It can be seen from the above three tables, results from last week assignment have highest risk and using Delta-Normal hedge, portfolios have low risk.

Problem 3

Use the Fama French 3 factor return time series (F-F_Research_Data_Factors_daily.CSV) as well as the Carhart Momentum time series (F-F_Momentum_Factor_daily.CSV) to fit a 4 factor model to the following stocks.

AAPL	FB	UNH	MA
MSFT	NVDA	HD	PFE
AMZN	BRK-B	PG	XOM
TSLA	JPM	V	DIS
GOOGL	JNJ	BAC	CSCO

Fama stores values as percentages, you will need to divide by 100 (or multiply the stock returns by 100) to get like units.

Based on the past 10 years of factor returns, find the expected annual return of each stock.
Construct an annual covariance matrix for the 10 stocks.

Assume the risk-free rate is 0.0425. Find the super-efficient portfolio

Analysis

Based on the past 10 years of factor returns, the annual returns of each stock are as follow.

Stock	Annual Return	Stock	Annual Return
AAPL	0.157144	PG	0.08154
META	0.017941	XOM	0.521821
UNH	0.2538	TSLA	-0.033253
MA	0.222901	JPM	0.098273
MSFT	0.155944	V	0.241054
NVDA	0.279721	DIS	-0.155372
HD	0.120591	GOOGL	-0.017075
PFE	0.076962	JNJ	0.124206
AMZN	-0.042945	BAC	-0.112301
BRK-B	0.129923	CSCO	0.147807

Sharpe Ratio of super-efficient portfolio is 1.47 and the weights of super-efficient portfolio are as follow.

Stock	Weight	Stock	Weight
AAPL	0.00	PG	0.00
META	0.00	XOM	57.44
UNH	22.57	TSLA	0.00
MA	0.00	JPM	0.00
MSFT	0.00	V	12.93
NVDA	0.00	DIS	0.00
HD	0.00	GOOGL	0.00
PFE	0.00	JNJ	7.05
AMZN	0.00	BAC	0.00
BRK-B	0.00	CSCO	0.00