Project ----- Week07
Tina Zhao

Problem 1

Updated the Options class to have methods for calculating Greeks using two methods. Instantiate the following option:

- Current Stock Price $165
- Strike Price $165
- Current Date 03/13/2022
- Options Expiration Date 04/15/2022
- Risk Free Rate of 0.25%
- Continuously Compounding Coupon of 0.53%
- Implied volatility 20%

Get the Greeks:

	Call(GBSM)	Call(FD_central)	Call(FD_forward)	Call(FD_backward)	Put(GBSM)	Put(FD_central)	Put(FD_forward)	Put(FD_backward)
delta	0.510071	0.510072	0.510072	0.510073	-0.489450	-0.489452	-0.489450	-0.489453
gamma	0.040173	0.040173	0.040173	0.040173	0.040173	0.040173	0.040173	0.040173
theta	21.628607	21.628606	21.628607	21.628605	22.090281	22.090282	22.090282	22.090282
vega	19.776582	19.776583	19.776583	19.776583	19.776582	19.776583	19.776584	19.776581
rho	7.253304	7.253305	7.253304	7.253306	-7.661132	-7.661133	-7.661131	-7.661134
carryrho	7.609135	7.609134	7.609133	7.609135	-7.301527	-7.301527	-7.301526	-7.301529

The results align with expectations. The value of delta, rho, and carry rho will be positive for call options and negative for put options. The value of gamma, theta and vega should be positive for both. The differences between different approaches in the finite definite approximation also tell us about the shape of the option value's curves. For example, the plot of a call option's value against the underlying asset price is convex, so a forward difference will overestimate the value while a backward difference will underestimate it.

Added American option binomial tree valuation module

Assume the underlying stock Pays dividend on 4/11/2022 of $0.88.

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Value of American call without dividend payment:  3.9683834268184377
Value of American call with dividend payment:  3.8219358100467176
Value of American put without dividend payment:  4.007520415586838
Value of American put with dividend payment:  4.45348200349653
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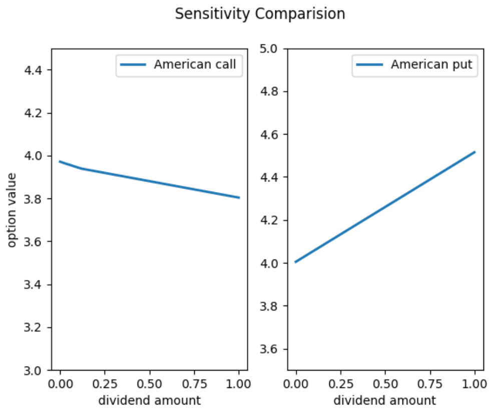
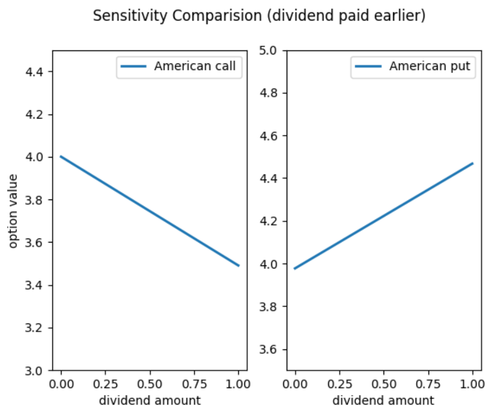
A dividend payment before the expiration of an option contract will decrease the value of a call and increase the value of a put.

Calculate the Greeks for the American options.

	American Call(no dividend)	American Call(with dividend)	American Put(no dividend)	American Put(with dividend)
delta	0.510235	0.518702	-0.489372	-0.489013
gamma	-1.554312	-0.222045	1.998401	-2.442491
theta	-21.825374	-21.767844	-22.256169	-22.272059
vega	19.927488	19.852676	19.926682	19.962072
rho	6.406625	6.062072	-7.661912	-7.612112
carryrho	6.700426	6.107738	-7.299588	-6.879419

Set different dividend amounts and see how the value of options change.





The put option is more sensitive to dividend amount change comparing to call option. Notice that the payment date is closer to the expiration date. If we move the payment date forward, the sensitivity of the call option for dividend amount changed will increase.

Problem 2

Results from Last week (European option)

	Mean	VaR	ES
Call	0.836915	-3.859903	-4.150611
CallSpread	0.144304	-3.158845	-3.437744
CoveredCall	-1.093139	-9.029976	-12.161225
ProtectedPut	0.885553	-3.718670	-3.967498
Put	1.141777	-3.638979	-3.915020
PutSpread	0.422362	-2.280678	-2.469182
Stock	-0.256224	-12.889879	-16.311836
Straddle	1.978691	0.009913	0.002230
SynLong	-0.304862	-13.031112	-16.494948

Results from this week (American option)

	Mean	VaR	ES
Call	0.093070	-8.055305	-10.125321
CallSpread	-0.315476	-4.978049	-6.162531
CoveredCall	-0.242686	-7.552295	-9.409231
ProtectedPut	0.541222	-7.246904	-9.225402
Put	0.690838	-7.195558	-9.199021
PutSpread	0.642285	-3.859419	-5.003033
Stock	-0.149616	-14.402218	-18.022954
Straddle	0.783908	-5.475329	-7.065428
SynLong	-0.597768	-15.362742	-19.113642

Portfolios constructed with American options (with dividend payment) can be riskier than those with European options.

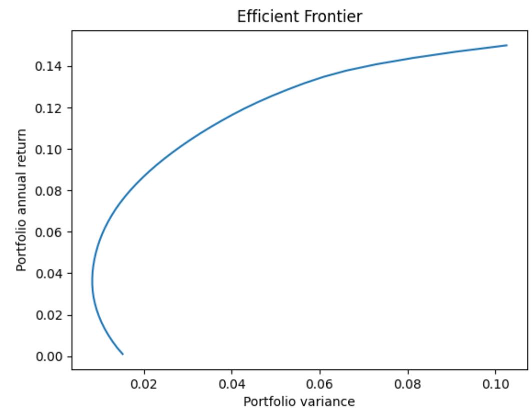
Problem 3

Fit the returns in to Fama-French three-factor-model and the Carhart Momentum model respectively. Estimate annual return of stocks based on parameters from the models.

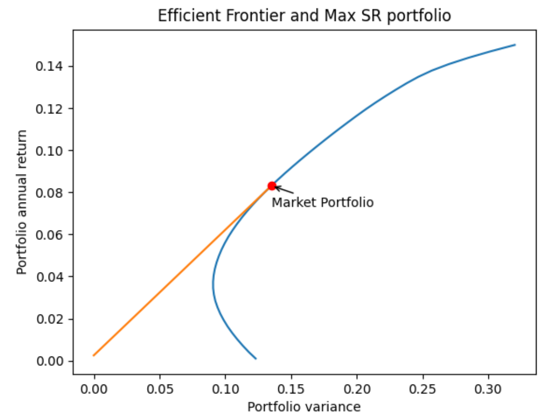
	estimated annual return by FF3 model (%)	estimated annual return by FF-M model (%)
AAPL	6.127418	7.021200
FB	10.020913	9.039345
UNH	4.504481	3.957734
MA	13.383286	10.406414
MSFT	5.999827	7.025647
NVDA	14.501962	18.252571
HD	5.135118	6.718574
PFE	-8.951634	-6.794314
AMZN	5.834868	4.459358
BRK-B	6.942455	6.329842
PG	3.431705	2.921530
XOM	12.763285	12.479405
TSLA	12.342020	16.704499
JPM	9.517161	9.375788
V	11.238276	9.955383
DIS	7.515613	5.861864
GOOGL	6.409085	6.423902
JNJ	1.805466	0.534692
BAC	12.242512	11.652437
CSCO	5.728352	5.101363

If the four factor model result in a larger estimated return, it largely suggests that the corresponding stock has a positive exposure on the momentum factor and vice versa.

Construct an annual covariance matrix and solve for minimum variance portfolio.
Set different returns and we can get an efficiency frontier.



Assume the risk-free rate is 0.0025. Find the super-efficient portfolio.



With the weights of each stock at:

	Stock	weights(%)
0	AAPL	3.3567
1	FB	5.9815
2	UNH	0.0000
3	MA	-0.0000
4	MSFT	6.3334
5	NVDA	3.2210
6	HD	14.6053
7	PFE	4.5333
8	AMZN	0.0000
9	BRK-B	27.1741
10	PG	0.9876
11	XOM	17.2842
12	TSLA	2.3850
13	JPM	3.3065
14	V	0.0000
15	DIS	0.0000
16	GOOGL	0.0000
17	JNJ	0.0000
18	BAC	10.0875
19	CSCO	0.7441