Week 7 Project

Question 1

First, calculate the Greeks for both call and put options:

	Option Greeks	Call Option Value	Put Option Value
0	Delta	0.512340	-0.487660
1	Gamma	0.033589	0.033589
2	Vega	0.236686	0.236686
3	Theta	-0.050654	-0.049525
4	Rho	0.103239	-0.110222

After that, I implemented the finite difference derivative calculation.

Then implement the binomial tree valuation for American option with and without discrete dividends, and got the result for both call and put options:

	American option price with/without discrete dividends	Call Option Value	Put Option Value
0	American option value without dividends	5.958853	5.905479
1	American option value with dividends	5.927437	7.001176

As a result, the put option is more sensitive to the change in dividend amount.

Question 2

First, I got the IV for all the portfolios:

	Portfolio	Type	Underlying	Holding	OptionType	ExpirationDate	Strike	CurrentPrice	ImpliedVolatility
0	Straddle	Option	AAPL	1	Call	3/18/2022	165.0	4.50	0.241462
1	Straddle	Option	AAPL	1	Put	3/18/2022	165.0	4.40	0.230012
2	SynLong	Option	AAPL	1	Call	3/18/2022	165.0	4.50	0.241462
3	SynLong	Option	AAPL	-1	Put	3/18/2022	165.0	4.40	0.230012
4	CallSpread	Option	AAPL	1	Call	3/18/2022	165.0	4.50	0.241462
5	CallSpread	Option	AAPL	-1	Call	3/18/2022	175.0	0.72	0.196834
6	PutSpread	Option	AAPL	1	Put	3/18/2022	165.0	4.40	0.230012
7	PutSpread	Option	AAPL	-1	Put	3/18/2022	155.0	1.60	0.277916
8	Stock	Stock	AAPL	1	NaN	NaN	NaN	164.85	NaN
9	Call	Option	AAPL	1	Call	3/18/2022	165.0	4.50	0.241462
10	Put	Option	AAPL	1	Put	3/18/2022	165.0	4.40	0.230012
11	CoveredCall	Stock	AAPL	1	NaN	NaN	NaN	164.85	NaN
12	CoveredCall	Option	AAPL	-1	Call	3/18/2022	165.0	4.50	0.241462
13	ProtectedPut	Stock	AAPL	1	NaN	NaN	NaN	164.85	NaN
14	ProtectedPut	Option	AAPL	1	Put	3/18/2022	165.0	4.40	0.230012

Then I simulated the result 10 days ahead and apply those returns to the current AAPL price, and calculated the empirical VaR and CVaR:

	Strategy	Mean	Empirical VaR	Empirical CVaR	Empirical VaR Value ($)	Empirical CVaR Value ($)
0	Call	0.569366	-0.593778	-0.772838	-7.746321e+03	-1.008230e+04
1	CallSpread	1.520234	-0.516402	-0.729569	-1.798782e+04	-2.541303e+04
2	CoveredCall	0.071940	-0.044183	-0.069911	-7.282982e+01	-1.152377e+02
3	ProtectedPut	0.021147	-0.007187	-0.011068	-3.482632e+00	-5.363111e+00
4	Put	0.819493	-0.438200	-0.651071	-8.228047e+03	-1.222512e+04
5	PutSpread	3.477461	0.223425	-0.336937	1.780222e+04	-2.684665e+04
6	Stock	-0.000161	-0.081364	-0.101501	3.005488e-01	3.749336e-01
7	Straddle	0.693024	0.379286	0.372344	6.022755e+03	5.912511e+03
8	SynLong	149.679150	121.756480	121.138584	4.175736e+08	4.154545e+08

The next part is the VaR and CVaR with delta normal:

	Strategy	Mean	Delta VaR	Delta CVaR	Delta VaR Value ($)	Delta CVaR Value ($)
0	Call	0.569366	0.393118	1.520454	5.128551e+03	1.983557e+04
1	CallSpread	1.520234	0.275525	2.378856	9.597347e+03	8.286256e+04
2	CoveredCall	0.071940	0.004128	0.093226	6.805184e+00	1.536686e+02
3	ProtectedPut	0.021147	0.002195	0.029536	1.063822e+00	1.431179e+01
4	Put	0.819493	0.179765	1.350172	3.375436e+03	2.535209e+04
5	PutSpread	3.477461	-0.996889	1.908547	-7.943081e+04	1.520704e+05
6	Stock	-0.000161	0.048577	0.105286	-1.794396e-01	-3.889155e-01
7	Straddle	0.693024	-0.419398	-0.098906	-6.659697e+03	-1.570551e+03
8	SynLong	149.679150	-125.326431	-96.802660	-4.298170e+08	-3.319925e+08

As a result, compared to last week's value, the VaR and CVaR becomes more extreme for both call and put options (bigger in call and smaller in put). It is because the different sensitivity for call, put and stocks.

Question 3

The first step is to clean and prepare the data (for moment file):

	Date	Mkt-RF	SMB	HML	RF	Mom
0	19261103	0.0020	-0.0022	-0.0029	0.00013	0.0056
1	19261104	0.0059	-0.0014	0.0070	0.00013	-0.0050
2	19261105	0.0007	-0.0008	0.0025	0.00013	0.0117
3	19261106	0.0016	-0.0029	0.0005	0.00013	-0.0003
4	19261108	0.0052	-0.0007	0.0008	0.00013	-0.0001
...	...	...	...	...	...	...
25062	20220125	-0.0143	-0.0060	0.0279	0.00000	0.0026
25063	20220126	-0.0030	-0.0108	0.0009	0.00000	0.0139
25064	20220127	-0.0078	-0.0163	0.0077	0.00000	0.0030
25065	20220128	0.0245	-0.0015	-0.0207	0.00000	-0.0027
25066	20220131	0.0233	0.0129	-0.0286	0.00000	-0.0170

After that, I found the rows with same date in daily return data frame and in factors data frame and got the weight in different portfolios.

After calculating the daily and annual returns, I made the super-efficient portfolio.

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The maximum sharp ratio is: -12.555078
The weights for each stock should be:
[2.14975840e-01 3.15479644e-13 3.54330687e-14 1.00035807e-12
 0.00000000e+00 0.00000000e+00 2.30151003e-01 7.25823206e-02
 3.77216975e-14 1.24673567e-13 9.17381541e-14 0.00000000e+00
 0.00000000e+00 4.82290836e-01 3.76476939e-13 2.48764815e-13
 0.00000000e+00 1.67214285e-13 0.00000000e+00 1.48520376e-13]
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