PROBLEM 1

The put option is sensitive to the dividend amount, with its value increasing as dividends are included, while the call option is not affected in this case. The exact sensitivity can be quantified by observing the change in price per unit change in dividend. Here, the put option's sensitivity to a dividend change of $0.88 is approximately $0.3200.

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BSM vs Finite Difference Greeks Comparison:
Call Option Greeks (BSM): {'delta': 0.08301107089626869, 'gamma': 0.016830979206204362, 'vega': 6.938710929513443, 'theta': -8.196615884194502, 'rho': 1.1025939156368187}
Call Option Greeks (Finite Difference): {'delta': 0.08297130338341674, 'gamma': 0.016824763804379472, 'vega': 6.938710350752331, 'theta': -8.126520224163158, 'rho': 1.102593926054496}
Put Option Greeks (BSM): {'delta': -0.9169889291037313, 'gamma': 0.016830979206204362, 'vega': 6.938710929513443, 'theta': -1.2110094733534407, 'rho': -13.758003122735788}
Put Option Greeks (Finite Difference): {'delta': -0.9165496332741441, 'gamma': 0.016834178495628294, 'vega': 6.938710350681276, 'theta': -1.9409893427280167, 'rho': -13.758003112513961

Option Prices Comparison (BSM vs Binomial):
Call Price (BSM): 0.3358
Put Price (BSM): 13.7454
Call Price (Binomial, without dividend): 0.3418
Put Price (Binomial, without dividend): 165.0000
Call Price (Binomial, with dividend): 0.3418
Put Price (Binomial, with dividend): 165.3200
Call Option Greeks (Binomial Tree): {'delta': 0.07963234403440822, 'gamma': -1.4432899320127035e-07, 'vega': 6.71240557054309, 'theta': -7.947810146471112, 'rho': 1.113612033041278}
Put Option Greeks (Binomial Tree): {'delta': 0.0, 'gamma': 0.0, 'vega': 0.0, 'theta': 0.0, 'rho': 0.0}
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Problem2

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price=4.850037908620827
iv(call): 0.0011
iv(put): 0.46727137374877914
delta of call: 1.0
delta of put: -0.24963939311205408
VaR&ES of call at 95.0% confidence level: (-0.9593093389896467, -0.9552310159117419)
VaR&ES of put at 95.0% confidence level: (-1.7260930138812762, 0.006346647213195888)
Total VaR of straddle at 95.0% confidence level: -2.685402352870923
Total ES of straddle at 95.0% confidence level: -0.948884368698546
VaR&ES of call at 95.0% confidence level: (-0.9593093389896467, -0.9552310159117419)
VaR&ES of put at 95.0% confidence level: (1.7260930138812762, -0.006346647213195888)
Total VaR of SynLong at 95.0% confidence level: 0.7667836748916296
Total ES of SynLong at 95.0% confidence level: -0.9615776631249378
VaR&ES of call1 at 95.0% confidence level: (-0.9593093389896467, -0.9552310159117419)
VaR&ES of call2 at 95.0% confidence level: (0.9591448536269515, 0.9554372871924925)
Total VaR of callspread at 95.0% confidence level: -0.0001644853626951992
Total ES of callspread at 95.0% confidence level: 0.00020627128075068057


VaR&ES of put1 at 95.0% confidence level: (-1.7260930138812762, 0.006346647213195888)
VaR&ES of put2 at 95.0% confidence level: (1.665914388945846, 0.0691197762779685)
Total VaR of putspread at 95.0% confidence level: -0.060178624935430136
Total ES of putspread at 95.0% confidence level: 0.07546642349116439
VaR&ES of call at 95.0% confidence level: (-0.9593093389896467, -0.9552310159117419)
VaR&ES of put at 95.0% confidence level: (-1.7260930138812762, 0.006346647213195888)
Total VaR of callput at 95.0% confidence level: -2.685402352870923
Total ES of callput at 95.0% confidence level: -0.948884368698546
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problem 3

Expected Annual Returns for Each Stock:
AAPL: 17.25%
META: 41.72%
UNH: 22.38%
MA: 9.31%
MSFT: 11.66%
NVDA: 71.94%
HD: 7.67%
PFE: -10.19%
AMZN: 14.15%
BRK-B: 17.33%
PG: 15.79%
XOM: -2.30%
TSLA: -1.96%
JPM: 27.96%
V: 5.14%
DIS: 5.96%
GOOGL: 11.19%
JNJ: 4.42%
BAC: 18.94%
CSCO: -13.09%

Annual Covariance Matrix for the 20 stocks:

	AAPL	META	UNH	MA	MSFT	NVDA	HD \
AAPL	0.050501	0.020870	-0.001577	0.010380	0.021561	0.033939	0.010867
META	0.020870	0.136272	-0.011660	0.015539	0.041722	0.077580	0.010079
UNH	-0.001577	-0.011660	0.049432	0.005066	-0.001927	-0.016474	0.006551
MA	0.010380	0.015539	0.005066	0.027007	0.012275	0.021657	0.011621
MSFT	0.021561	0.041722	-0.001927	0.012275	0.039604	0.045418	0.011498
NVDA	0.033939	0.077580	-0.016474	0.021657	0.045418	0.253770	0.023843
HD	0.010867	0.010079	0.006551	0.011621	0.011498	0.023843	0.042762
PFE	0.002864	0.000547	0.010636	0.003087	0.005221	-0.016984	0.005594
AMZN	0.024202	0.064354	-0.006390	0.015380	0.035189	0.067779	0.016908
BRK-B	0.006499	0.008382	0.006006	0.010321	0.006653	0.003171	0.010077
PG	-0.000199	-0.000426	0.007212	0.004023	0.002121	-0.009521	0.003260
XOM	-0.002407	-0.005812	0.001574	0.004131	-0.005784	-0.017253	0.005945
TSLA	0.046972	0.033953	0.001457	0.021594	0.029237	0.071756	0.028368
JPM	0.001670	0.006064	0.004938	0.008724	0.004695	0.005717	0.013261
V	0.010306	0.014285	0.003748	0.019691	0.012743	0.018001	0.010632
DIS	0.003784	0.010023	0.000456	0.007901	0.008303	0.015492	0.012559
GOOGL	0.025260	0.043208	-0.004703	0.011537	0.029757	0.051591	0.007758
JNJ	0.000410	-0.005947	0.008443	0.004104	-0.000898	-0.020411	0.006870
BAC	0.005001	0.005183	0.005151	0.006302	0.004584	-0.000161	0.022778
CSCO	0.008293	0.007240	0.005028	0.009910	0.008667	0.010232	0.013129

	PFE	AMZN	BRK-B	PG	XOM	TSLA	JPM \
AAPL	0.002864	0.024202	0.006499	-0.000199	-0.002407	0.046972	0.001670
META	0.000547	0.064354	0.008382	-0.000426	-0.005812	0.033953	0.006064
UNH	0.010636	-0.006390	0.006006	0.007212	0.001574	0.001457	0.004938
MA	0.003087	0.015380	0.010321	0.004023	0.004131	0.021594	0.008724
MSFT	0.005221	0.035189	0.006653	0.002121	-0.005784	0.029237	0.004695
NVDA	-0.016984	0.067779	0.003171	-0.009521	-0.017253	0.071756	0.005717
HD	0.005594	0.016908	0.010077	0.003260	0.005945	0.028368	0.013261
PFE	0.062464	0.002466	0.010833	0.002163	0.003940	0.002940	0.010246
AMZN	0.002466	0.081874	0.008978	-0.001785	-0.005728	0.046419	0.008206
BRK-B	0.010833	0.008978	0.016801	0.004501	0.008345	0.009049	0.013116
PG	0.002163	-0.001785	0.004501	0.022672	0.002867	-0.003999	0.000597
XOM	0.003940	-0.005728	0.008345	0.002867	0.041071	-0.001924	0.011345
TSLA	0.002940	0.046419	0.009049	-0.003999	-0.001924	0.293876	0.020562
JPM	0.010246	0.008206	0.013116	0.000597	0.011345	0.020562	0.033249
V	0.004419	0.013531	0.009401	0.004643	0.002715	0.021799	0.008395
DIS	0.008145	0.013054	0.008012	-0.000892	0.009776	0.026769	0.011302
GOOGL	0.003924	0.045175	0.008250	-0.000272	-0.004480	0.031925	0.006162
JNJ	0.016889	-0.002814	0.007518	0.005866	0.005893	-0.001402	0.007898
BAC	0.010263	0.008630	0.014265	0.002463	0.016620	0.028866	0.028629
CSCO	0.010953	0.018381	0.007840	0.002357	0.008121	0.017523	0.009708

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              V       DIS     GOOGL       JNJ       BAC      CSCO
AAPL   0.010306  0.003784  0.025260  0.000410  0.005001  0.008293
META   0.014285  0.010023  0.043208 -0.005947  0.005183  0.007240
UNH    0.003748  0.000456 -0.004703  0.008443  0.005151  0.005028
MA     0.019691  0.007901  0.011537  0.004104  0.006302  0.009910
MSFT   0.012743  0.008303  0.029757 -0.000898  0.004584  0.008667
NVDA   0.018001  0.015492  0.051591 -0.020411 -0.000161  0.010232
HD     0.010632  0.012559  0.007758  0.006870  0.022778  0.013129
PFE    0.004419  0.008145  0.003924  0.016889  0.010263  0.010953
AMZN   0.013531  0.013054  0.045175 -0.002814  0.008630  0.018381
BRK-B  0.009401  0.008012  0.008250  0.007518  0.014265  0.007840
PG     0.004643 -0.000892 -0.000272  0.005866  0.002463  0.002357
XOM    0.002715  0.009776 -0.004480  0.005893  0.016620  0.008121
TSLA   0.021799  0.026769  0.031925 -0.001402  0.028866  0.017523
JPM    0.008395  0.011302  0.006162  0.007898  0.028629  0.009708
V      0.022884  0.005352  0.011023  0.004906  0.008003  0.009791
DIS    0.005352  0.071514  0.009315  0.001750  0.015920  0.010569
GOOGL  0.011023  0.009315  0.077409 -0.002217  0.006355  0.013982
JNJ    0.004906  0.001750 -0.002217  0.023668  0.010143  0.006289
BAC    0.008003  0.015920  0.006355  0.010143  0.056120  0.011909
CSCO   0.009791  0.010569  0.013982  0.006289  0.011909  0.040735
Optimal Weight Allocation: [8.81347266e-03 7.47089755e-02 1.94493022e-01 9.63804193e-16
 0.00000000e+00 1.41088943e-01 0.00000000e+00 0.00000000e+00
 0.00000000e+00 2.54585491e-15 2.60714256e-01 9.01504823e-16
 0.00000000e+00 3.20181330e-01 1.34258404e-16 3.77115083e-16
 0.00000000e+00 1.81333747e-15 8.35514547e-16 0.00000000e+00]
Expected Annual Return: 0.30840545314632173
Annual Volatility: 0.12115563550499585
Sharpe Ratio: 2.1328389064961524
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