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Question 1

$S(0)$ = Initial stock price = 100

K = Strike price = 95

T = Time to maturity = 1 year

r = Risk free rate = 4%

σ = Volatility of the stock = 25%

At each time step prices of the stock can go up by a factor of u or go down by a factor of d .

Formula used for u and d –

$$u = e^{\sigma\sqrt{\Delta t}}$$

$$d = e^{-\sigma\sqrt{\Delta t}}$$

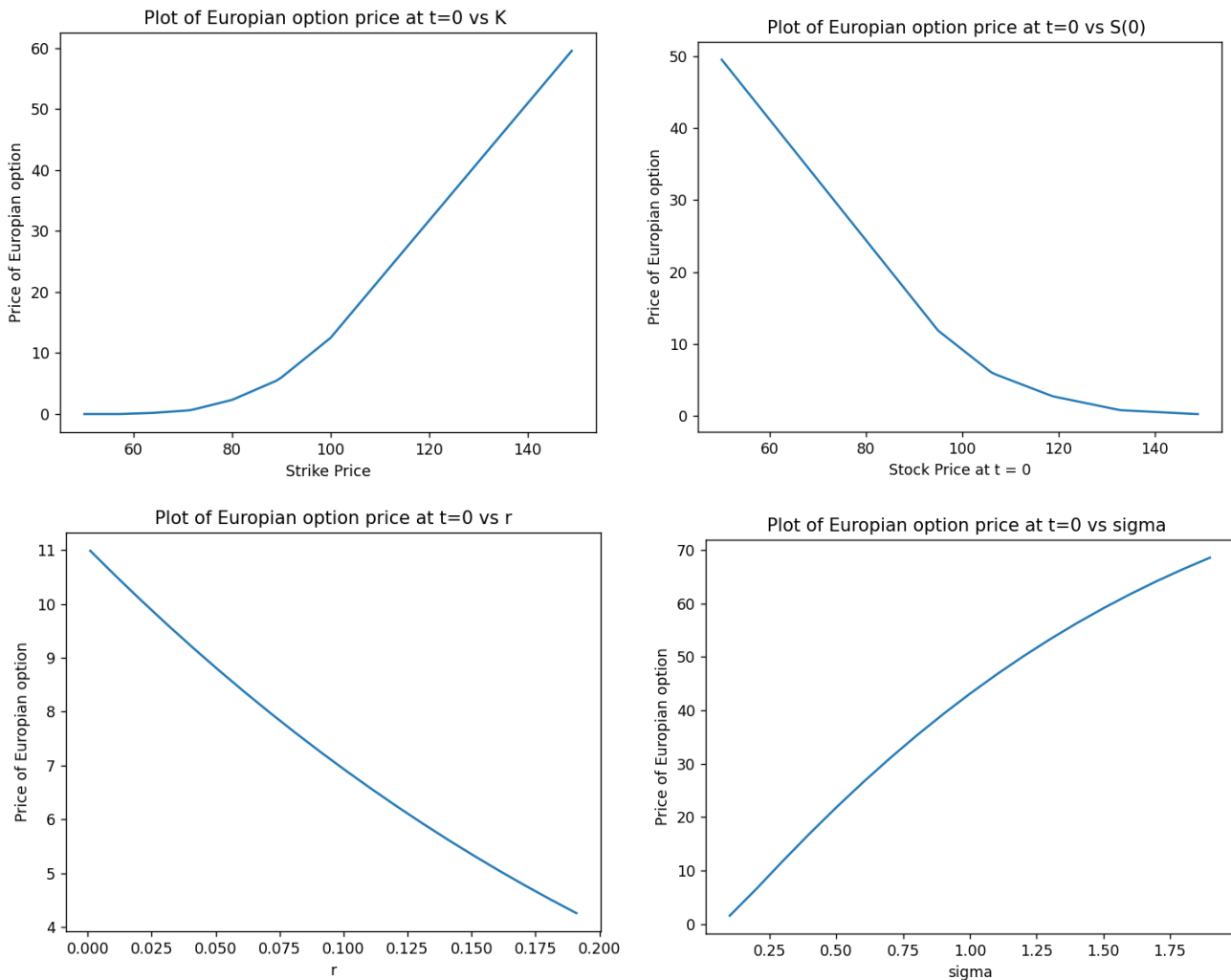
a) Various price of the options by varying M is shown below -

	M	Price
0	1.0	7.918359
1	2.0	8.341639
2	3.0	8.779927
3	4.0	9.078197
4	5.0	9.234335
5	6.0	9.426849
6	7.0	9.509024
7	8.0	9.645581
8	9.0	9.697383
9	10.0	9.800739

b) Values of the option at intermediate time points for $M = 5$ is tabulated as follows -

9.23433513870916	15.269121076784483 3.5338732765782277	22.334412983990624 8.665738345340532 6.569485703954287 0.6488606336643565	28.3971940080213 16.81398833795282 12.085766200299329 5.4894577738531005 12.085766200299336 1.3292102176407603 1.3292102176407603 0.0	34.11349376012058 23.30831390401782 19.04628266396353 14.917234628274842 19.046282663963517 5.533549568064787 5.533549568064787 5.533549568064787 19.04628266396353 5.533549568064787 2.7229264822290484 0.0 2.7229264822290484 0.0 0.0 0.0	37.8229 31.0593 23.4955 23.4955 23.4955 15.0371 15.0371 15.0371 23.4955 15.0371 5.578 5.578 5.578 5.578 5.578 23.4955 15.0371 5.578 5.578 5.578 0 0 0 5.578 0 0 0 0 0 0
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c)



Obeservations

- Price of options increases with increase in strike price. Graph is nearly a straight line at larger strike price.
- Price of options decreases with increase in strike price. Graph is nearly a straight line for less stock price.
- Price of options decreases with increase in risk free rate.
- Price of options increases with increase in volatility.

Question 2

a)

Mean return vector -

```
Stock 1    0.118316
Stock 2    0.214662
Stock 3    0.263047
```

Covariance Matrix -

	Market	Stock 1	Stock 2	Stock 3
Market	0.104841	0.027927	0.140206	0.152531
Stock 1	0.027927	0.139356	0.017555	0.065887
Stock 2	0.140206	0.017555	0.310790	0.270370
Stock 3	0.152531	0.065887	0.270370	0.479589

Mean return and Variance for market index -

```
Mean return for market index - 0.1539970739470484
Variance for market index - 0.10484083838670624
```

b)

Taking Risk free rate = 0.04, beta, alpha, systematic risk and unsystematic risk of the stocks are computed as follows.

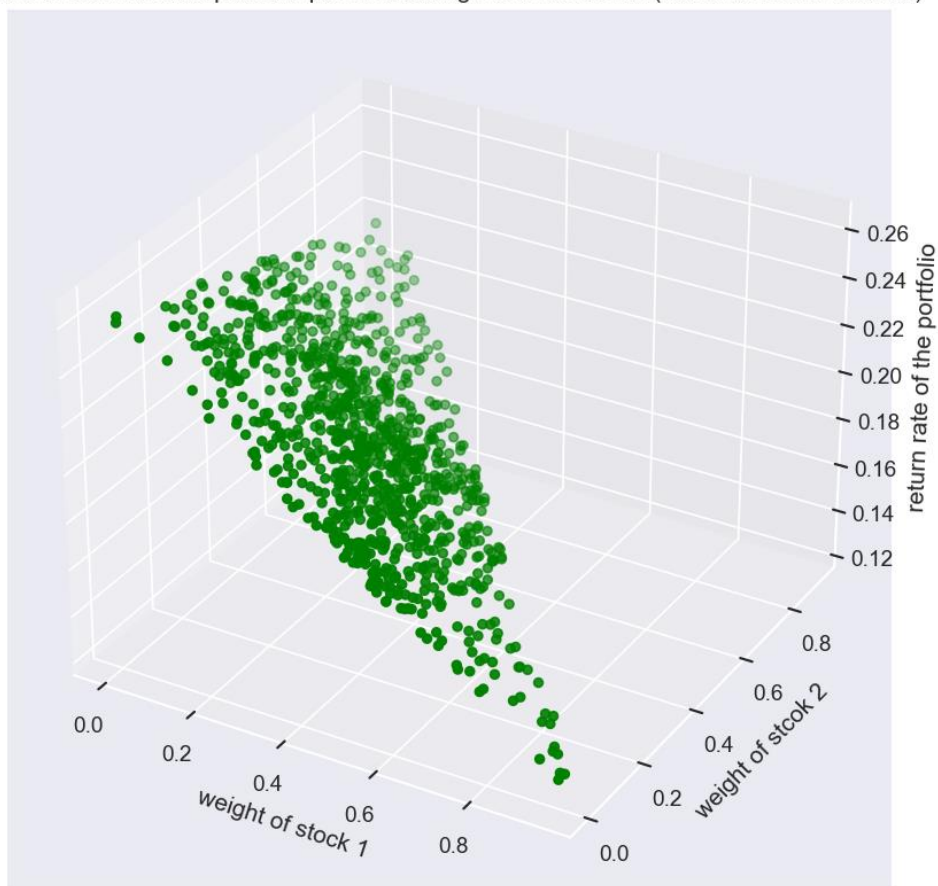
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Beta for Stock 1 is 0.027927410454671092
Alpha for Stock 1 is 0.07513272159002451
Systematic_risk for Stock 1 is 0.027927410454671092
Unsystematic_risk for Stock 1 is 0.34537737205026053

Beta for Stock 2 is 0.14020570219995263
Alpha for Stock 2 is 0.15867922708732185
Systematic_risk for Stock 2 is 0.14020570219995263
Unsystematic_risk for Stock 2 is 0.4172801098890535

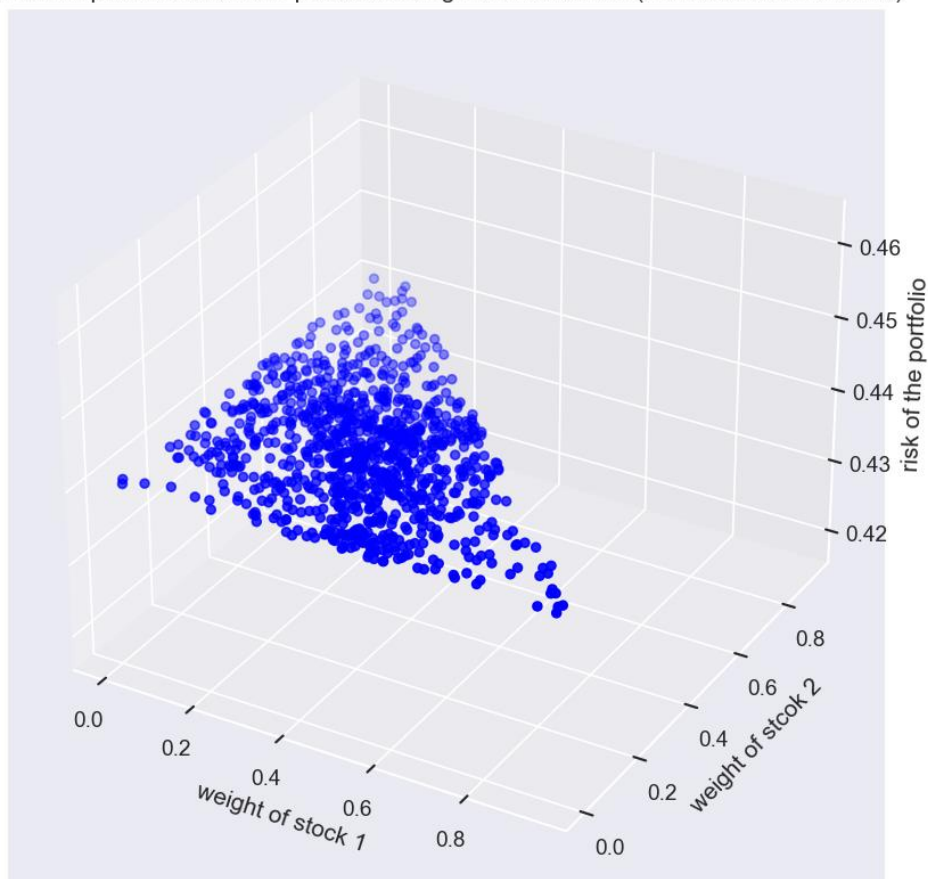
Beta for Stock 3 is 0.15253091851962458
Alpha for Stock 3 is 0.20565860762800312
Systematic_risk for Stock 3 is 0.15253091851962458
Unsystematic_risk for Stock 3 is 0.5399930503780874
```

c)

return of all attainable possible portfolios using the three stocks (with short sales allowed)



risk of all possible attainable portfolios using the three stocks (with short sales allowed)



d)

Various quantities for minimum variance portfolio are computed as follows -

```
Weights in minimum variance portfolio :  
[[ 0.72718927  0.3694258 -0.09661506]]  
  
risk in minimum variance portfolio :  
[[0.31852524]]  
  
return in minimum variance portfolio :  
0.13992589718286255  
  
market risk :  
[[0.32379135]]  
  
market return :  
[0.15399707]
```