MA 374 – Financial Engineering Lab

Lab – 4

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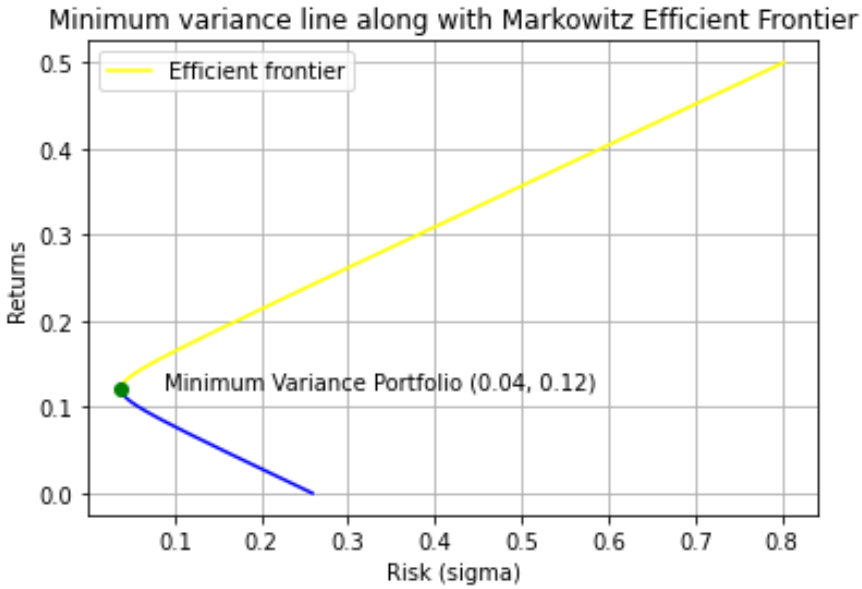
1 QUESTION - 1:

a) The Markowitz efficient frontier is as follows:



The minimum variance line is constructed using the following steps:

i) Obtain the required weights ***w*** using the following relation –

$$w = \frac{\begin{vmatrix} 1 & uC^{-1}M^T \\ \mu_v & MC^{-1}M^T \end{vmatrix} uC^{-1} + \begin{vmatrix} uC^{-1}u^T & 1 \\ MC^{-1}u^T & \mu_v \end{vmatrix} MC^{-1}}{\begin{vmatrix} uC^{-1}u^T & uC^{-1}M^T \\ MC^{-1}u^T & MC^{-1}M^T \end{vmatrix}}$$

where, μ_v = return,

u = [1, 1, 1, …, 1] (with same dimension as that of number of assets)

ii) Obtain the risk using following relation –

$$\sigma_v^2 = wCw^T$$

and then take square root to obtain the risk in terms of std. deviation.

Now, the minimum variance portfolio has weights:

$$w = \frac{uC^{-1}}{uC^{-1}u^T}$$

Using this, we find the corresponding point on the minimum variance curve.
Now, the efficient frontier is the one with higher expected return and lower standard deviation (lower risk). So, the points with higher return than the minimum variance portfolio point shows the efficient frontier on the curve ***(denoted by yellow)***.

b) The weights, return and risk of the portfolios for 10 different values on the efficient frontier:

SI No.	Weights	Return	Risk
1.	[1.83550649, -0.1653936, -0.67011288]	0.02405612017613421	0.04995499549954996
2.	[1.11983859, 0.11903851, -0.2388771]	0.0034570647912315977	0.09995999599959997
3.	[0.40417069, 0.40347062, 0.19235869]	0.005229455948986914	0.14996499649964998
4.	[-0.3114972, 0.68790274, 0.62359447]	0.029373293649400157	0.19996999699969997
5.	[-1.0271651, 0.97233485, 1.05483025]	0.0758885778924713	0.24997499749975
6.	[-1.742833, 1.25676696, 1.48606604]	0.14477530867820082	0.29997999799979996
7.	[-2.4585009, 1.54119907, 1.91730182]	0.23603348600658744	0.34998499849985
8.	[-3.17416879, 1.82563119, 2.34853761]	0.34966310987763205	0.3999899989999
9.	[-3.88983669, 2.1100633, 2.77977339]	0.4856641802913356	0.44999499949995003
10.	[-4.60550459, 2.39449541, 3.21100917]	0.6440366972476959	0.5

c) For 15 % risk,

Minimum return = 0.052455245524552455
Weights of the portfolio = [1.79972309, -0.151172, -0.64855109]

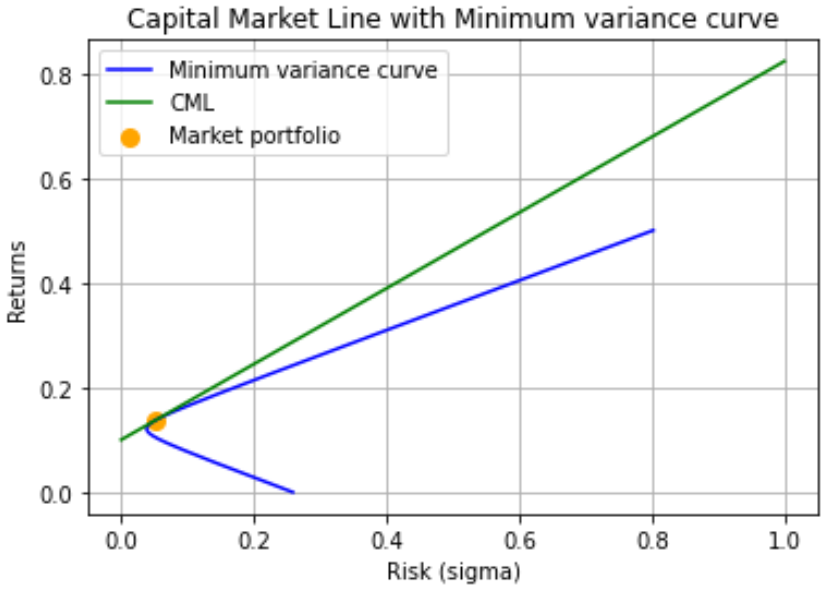
Maximum return = 0.1895689568956896
Weights of the portfolio = [-0.16263828, 0.62874086, 0.53389743]

d) For a 18 % return, the minimum risk portfolio is:

Minimum risk for 18% return = 13.056827100982519 %
Weights of the portfolio = [-0.02568807, 0.57431193, 0.45137615]

e) The market portfolio is:

Market Portfolio Weights = [0.59375, 0.328125, 0.078125]
Return = 0.13671875
Risk = 5.081128919221593 %



The equation of the CML is: $\mu = 0.72\,\sigma + 0.1$

The equation is obtained using the following formula:

$$\mu = \frac{\mu_M - \mu_{rf}}{\sigma_M}\,\sigma + \mu_{rf}$$

where,

μ_M = return corresponding to market portfolio

μ_{rf} = risk free return

σ_M = risk corresponding to market portfolio

f) The required portfolio with risk at 10 % is:

Risk-free weights = -0.9680665771282883

Risky Weights = [1.16853953, 0.64577185, 0.1537552]

Returns = 0.17226494462892933

The required portfolio with risk at 25 % is:

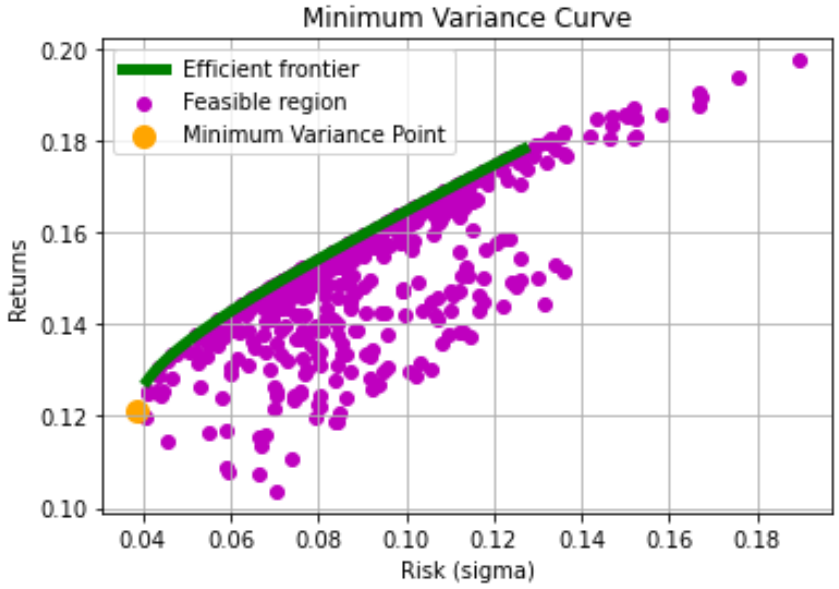
Risk-free weights = -3.9201664428207224

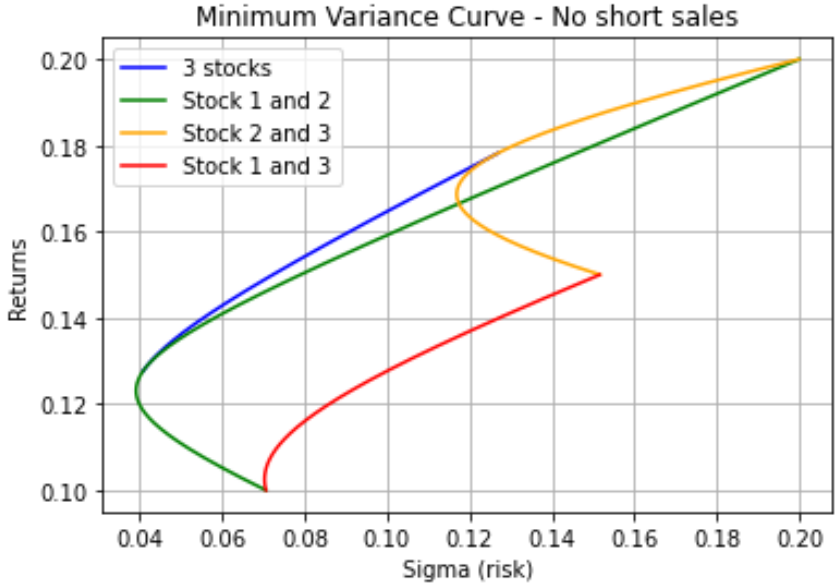
Risky Weights = [2.92134883, 1.61442961, 0.384388]

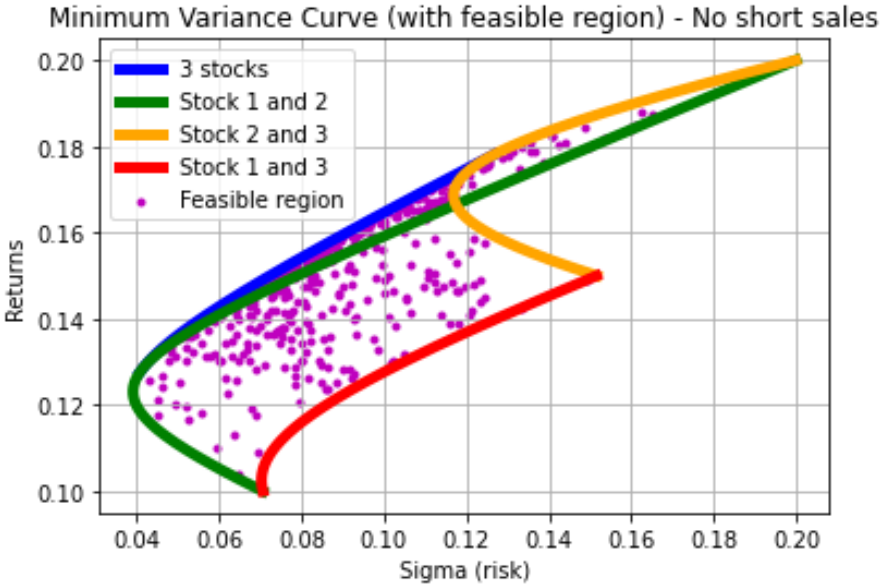
Returns = 0.2806623615723234

2 QUESTION - 2:

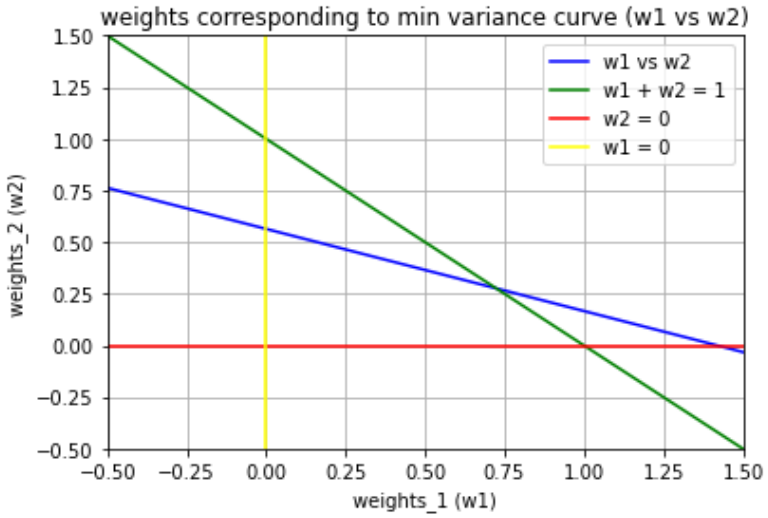
The various plots (assuming short sales are not allowed, i.e., weights are non-negative) are:



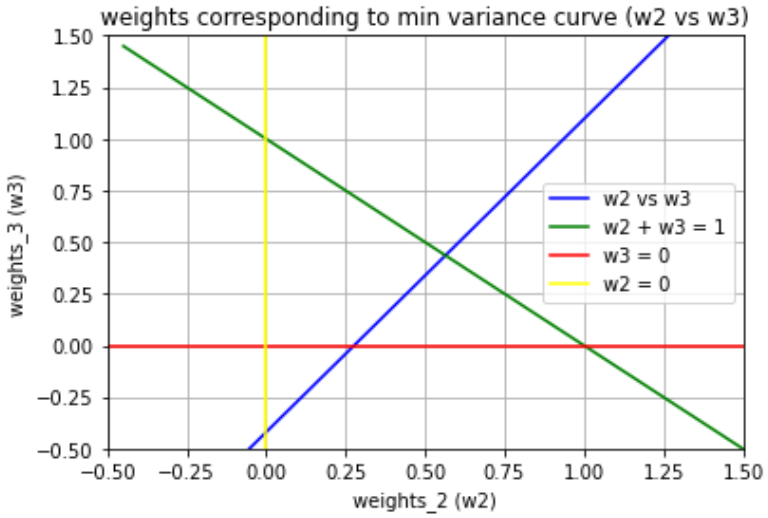




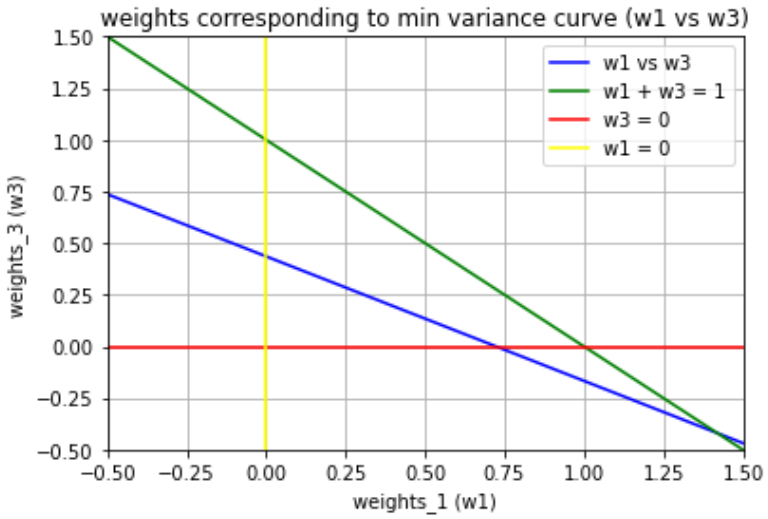
The plot for the weights corresponding to the minimum variance curve are:



Equation of w1 vs w2: $w2 = -0.40\ w1 + 0.56$



Equation of w2 vs w3: $w3 = 1.52\ w2 - 0.42$



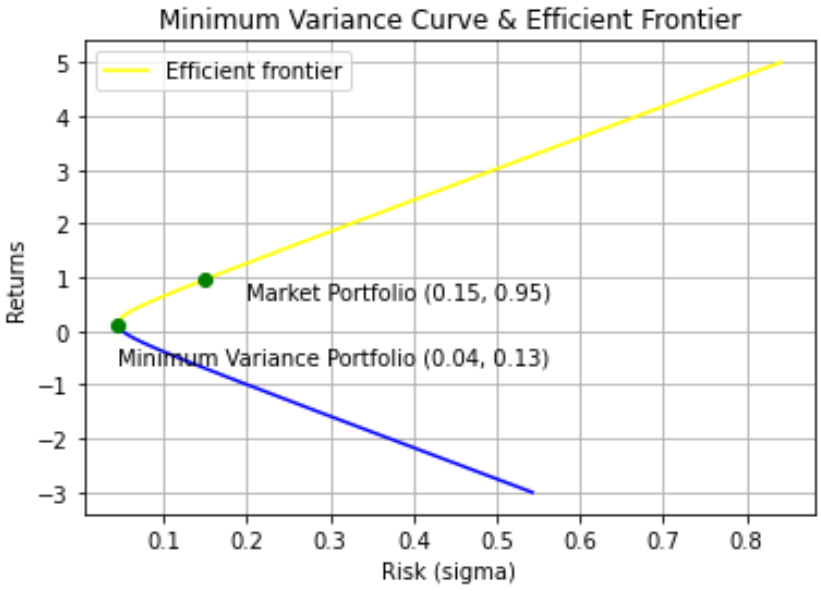
Equation of w1 vs w3: $w3 = -0.60\ w1 + 0.44$

3 QUESTION – 3 :

The data for the stocks had been collected for the time period between 01/01/2015 to 01/12/2019 on monthly basis (total 60 data points).

The companies considered are **Apple, Amazon, Facebook, Google, IBM, Intel, Microsoft, Netflix, Nike**, and **Tesla**. The monthly return was obtained as the difference in stock prices between beginning of 2 consecutive months. Then annual return was calculated suitably.

a) The Markowitz efficient frontier is:



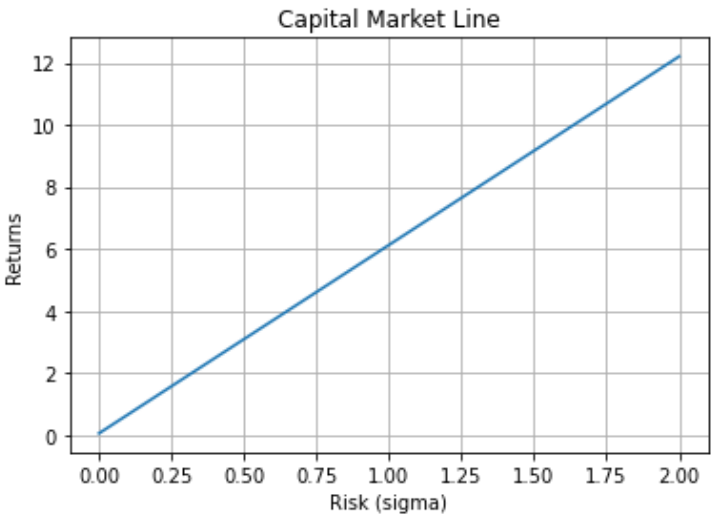
b) The market portfolio is:

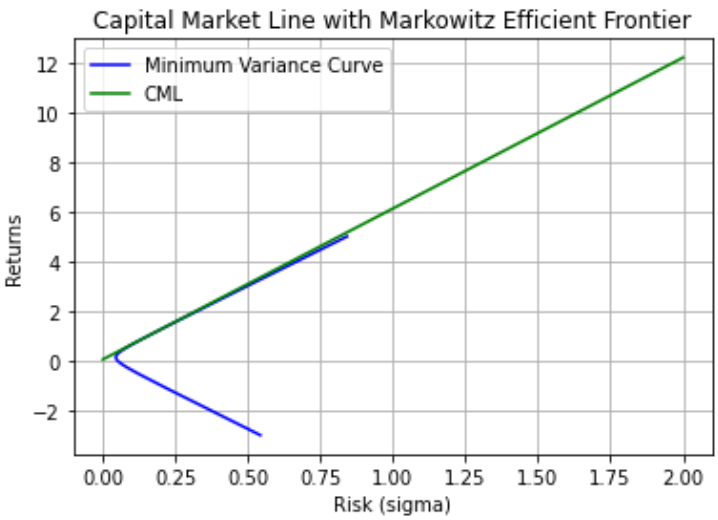
Market Portfolio Weights = [0.22761242, 1.13992789, -0.21802614 , - 0.27195818, -1.86085521, -0.2067485, 1.09153062, 0.28576137, 0.7953939, 0.01736182]

Return = 0.9494417828642239

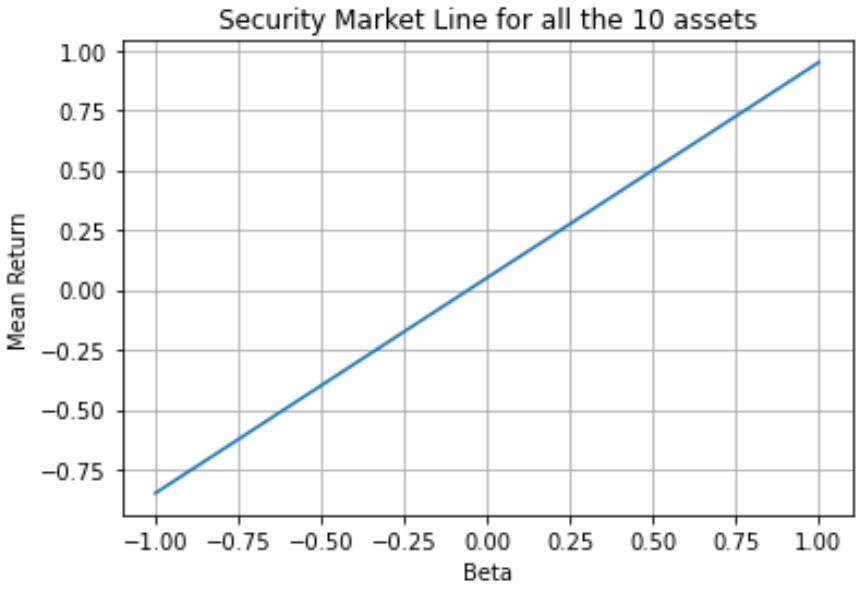
Risk = 14.801199750536021 %

c) The equation of Capital Market Line is: $y = 6.08\,x + 0.05$





d) The equation of Security Market Line is: mu = 0.90 beta + 0.05



The Security market line is obtained using the following formula:

$$\mu = (\mu_M - \mu_{rf})\beta + \mu_{rf}$$

where,

μ_M = return corresponding to market portfolio

μ_{rf} = risk free return