FINANCIAL ENGINEERING PROJECT
PORTFOLIO OPTIMIZATION

SUBMITTED TO:- VIVEK VIJAY

SUBMITTED BY:- JAYESH BUDHWANI
M21CS007

Assets Used:

1. VLNS - Valens Growork Coorporation.
2. PFMT - Performant Financial coorporation
3. AXP - American Express company
4. DIS - Walt Disney Company
5. IBM - International Business Machines
6. INTC - Intel Coorporation
7. JPM - JP Morgan chase and co.
8. MSFT - Microsoft coorporation
9. WMT - Wallmart Inc.
10. AAPL - Apple Inc.

Closing prices of October 2021 to December 2021 were used

Returns:

Returns calculated are simple return calculated on the closing price using the formula:
$R(0,T) = V(T) - V(0) / V(0)$

Expected returns, Variance (risk), and Covariance:

Expected returns, Variance, and Covariance are calculated using the functions provided by Numpy library of python which are np.mean(), np.var(), and np.cov() respectively.

Inverse of covariance matrix is calculated using the function np.linalg.inv()

Weights of optimised portfolio with a given Return(μ):

Can be calculated using:

$a1 = OC^{-1}O^T$

$b1 = OC^{-1}M^T$

$a2 = MC^{-1}O^T$

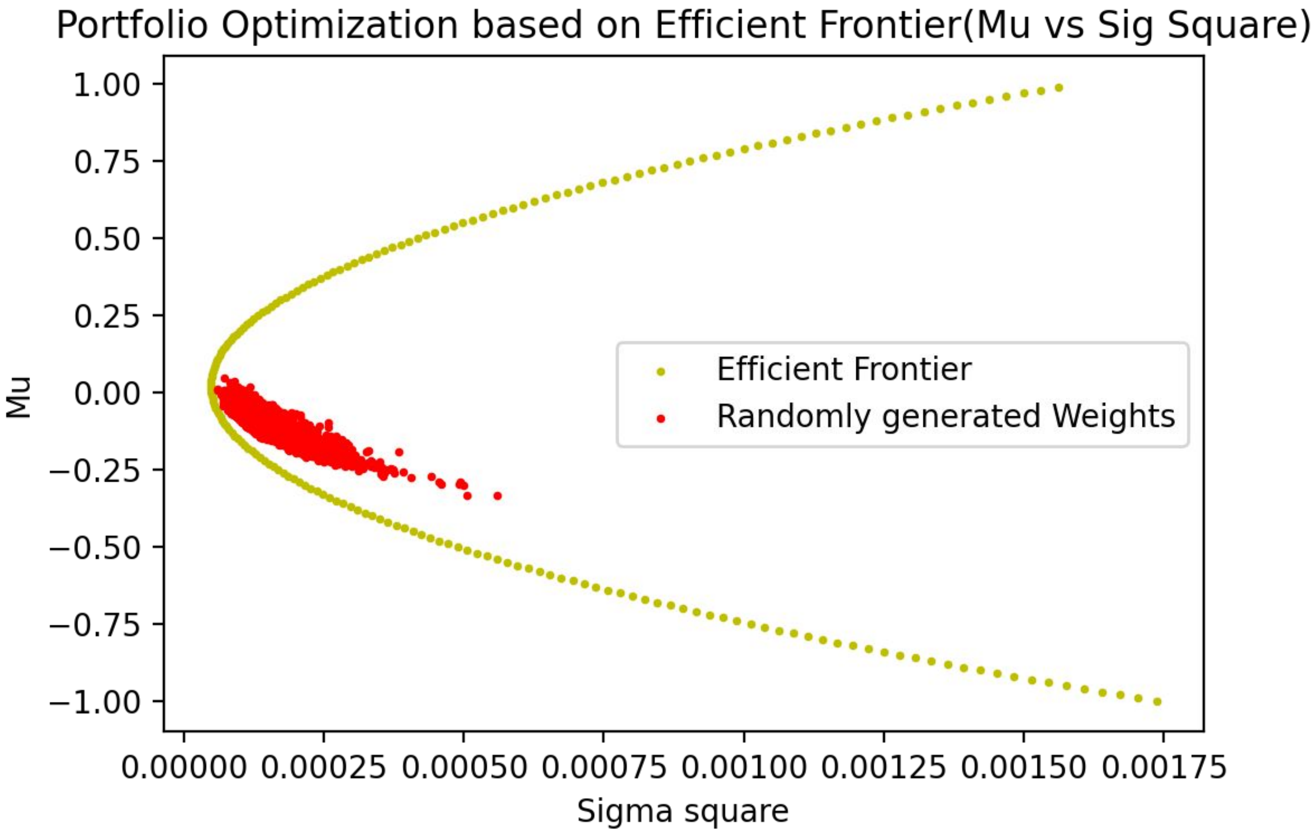
$b2 = MC^{-1}M^T$

$W = ((\mu * b1 - b2)C^{-1}O^T + (a2 - \mu * a1)C^{-1}M^T)/(a1 * b2 - a2 * b1)$

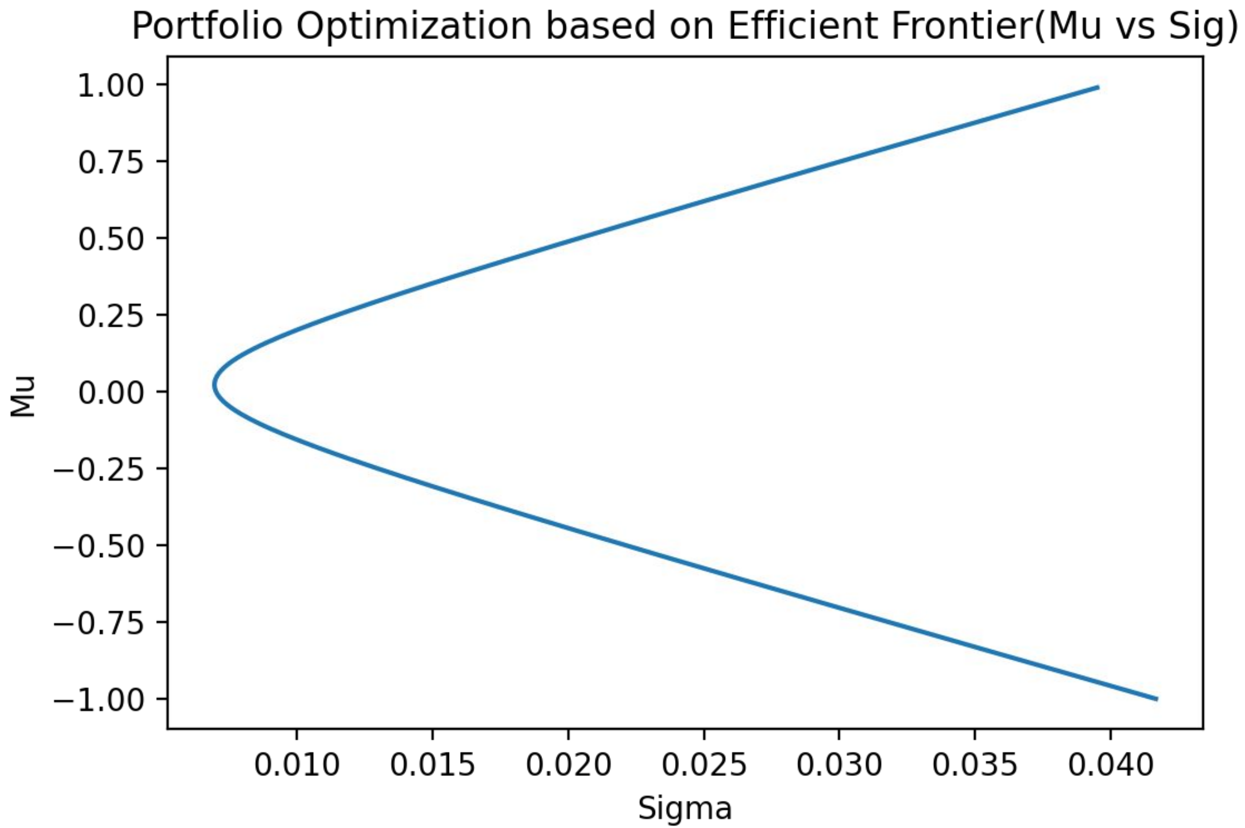
Then using this W we can calculate the value of sigma as $\sigma^2 = WCW^T$

Then based on different values of μ we can calculate different values of σ^2 and can plot the efficient frontier.

Efficient frontier:



Efficient frontier (Markowitz bullet):



CAP-M(Capital Asset pricing model):

Let the risk free rate of interest be μ_{rf} and the risky assets as before are used then.
$W^* = ((M1 - \mu_{rf} * O)C^{-1})/((M1 - \mu_{rf} * O)C^{-1}O^T)$

Based on above W^* we can calculate $\mu_{der} = M1*W^{*T}$ and $\sigma^2_{der} = W^*CW^{*T}$

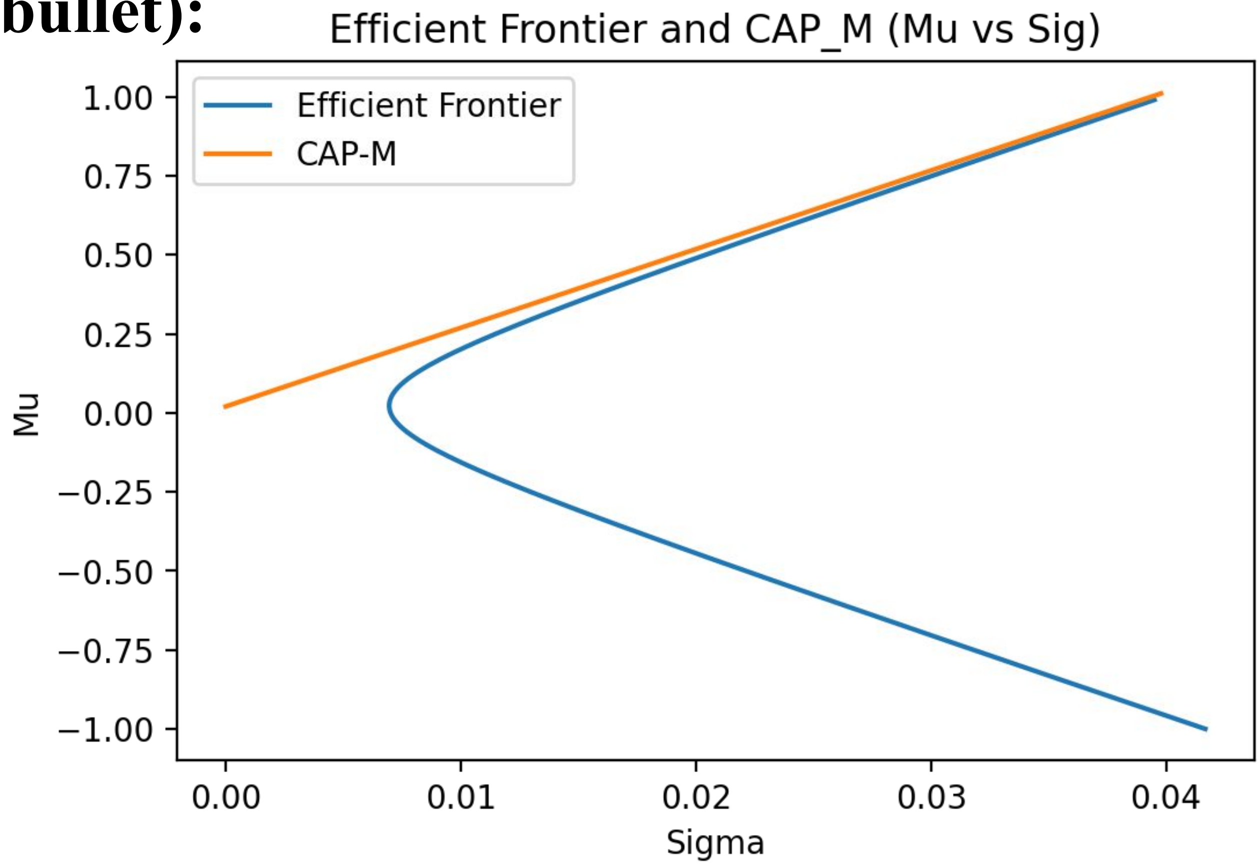
And then we can calculate (given μ) the value of $W_{risky} = (\mu-\mu_{rf})/(\mu_{der}-\mu_{rf})$

And then we can calculate $W_i = W^*/W_{risky}$

And then we can calculate the value of $W_{rf} = 1-W_{risky}$

In This way we can calculate the optimised portfolio with risk $\sigma^2 = \sigma^2_{der} * W^2_{risky}$

CAP-M and Efficient Frontier (Cap-M is tangent to Markowitz bullet):



Optimised Portfolio: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For the portfolio:
The Expected return is considered as 0.4
For Risky Asset 1 Weight associated is: -0.1068148638314677
For Risky Asset 2 Weight associated is: 0.22938740951905642
For Risky Asset 3 Weight associated is: 0.6172134172220904
For Risky Asset 4 Weight associated is: -0.27027683473423486
For Risky Asset 5 Weight associated is: -0.1523093806237759
For Risky Asset 6 Weight associated is: -0.12659301670350245
For Risky Asset 7 Weight associated is: -0.09755122387642891
For Risky Asset 8 Weight associated is: -0.6829260203154535
For Risky Asset 9 Weight associated is: 0.32539900329174826
For Risky Asset 10 Weight associated is: 0.29385424291020307
For Risk free Asset Weight associated is: 0.970617267141765
For Risk free the expected return is: 0.02
For the portfolio the risk associated is 0.00044872489711662356
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SML(Security Market Line) uses single assets:

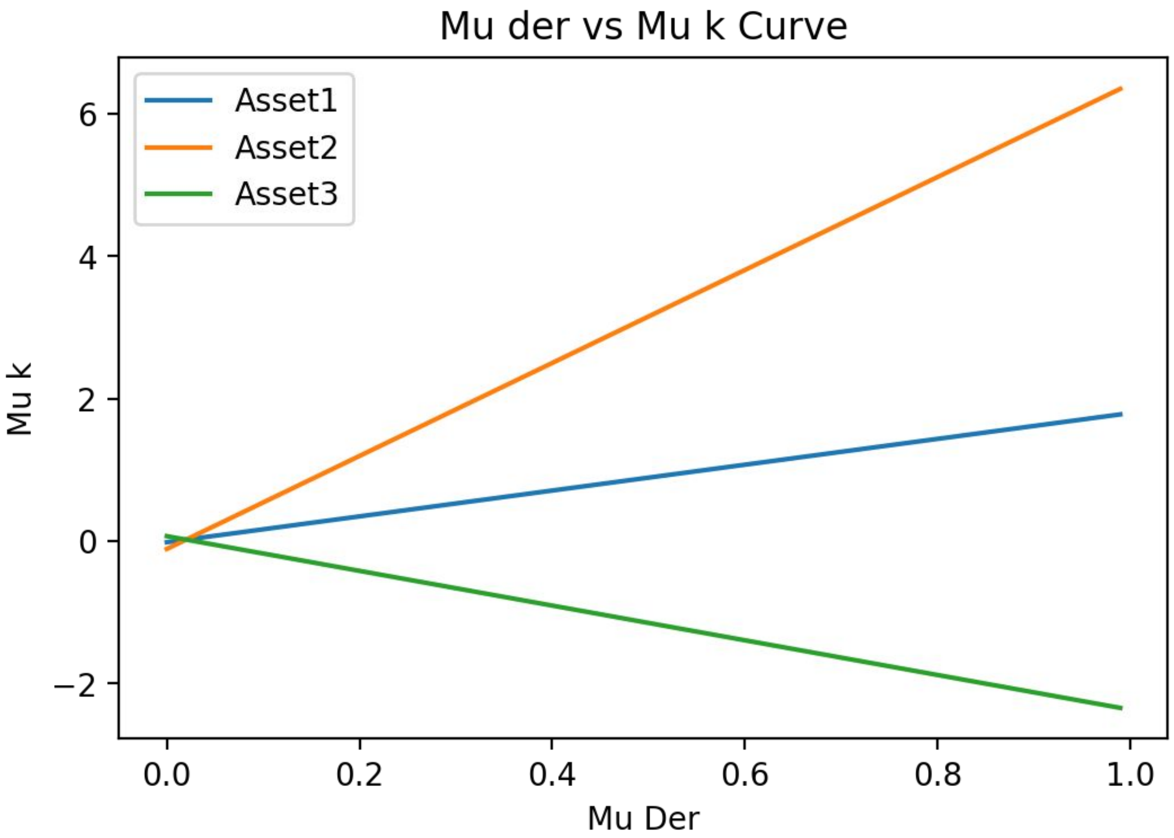
SML's can be plotted between μ_K and μ_{M1} as :

$\mu_k = \mu_{rf} + \beta*(\mu_{M1}-\mu_{rf})$

Where β is Product of $W^{*T}*COV(R_i,R_k)$ Called as $COV(R_{M1},R_K)$

And $W^* = ((M1 - \mu_{rf} * O)C^{-1})/((M1 - \mu_{rf} * O)C^{-1}O^T)$

SML’s Between three different Assets:



Thank you