Financial Engineering
Group Project

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1. Pick a minimum of 10 risky assets from the market. Use their 3-month closing price and obtain simple returns.

We have picked 10 risky assets from the market with their 3-months closing price data for months of October 2022, November 2022, and December 2022, whose respective expected return and variance based on their daily returns are as follows: (here, 1e-n = 10^{-n})

STOCK	EXPECTED RETURN	RISK/VARIANCE
Meta	-0.00227973	0.0023607
Amazon	-0.00518933	0.0009504
Google	-0.00179887	0.00070118
JPM	0.00353158	0.00032122
Tesla	-0.01091843	0.00185451

Baba	0.00146328	0.0017944
SWN	-0.00182296	0.00133783
ZM	-0.00141254	0.00127867
PYPL	-0.00326131	0.00089337
NFLX	0.00338609	0.00141676

This Group Project is implemented using the dataset of daily returns of the stocks' closing price in Python.

Mean Vector / Expected Return Vector (M):

	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
M	-2.2e-3	-5.1e-3	-1.7e-3	3.5e-3	-1.1e-3	1.5e-3	-1.8e-3	-1.4e-3	-3.2e-3	3.4e-3

From the above M matrix, we can find maximum possible expected return (μ_{max}): 3.5e-3

Covariance Matrix (C):

	META	AMZN	GOOGL	JPM	TSLA	BABA	SWN	ZM	PYPL	NFLX
META	0.002361	0.000737	0.000734	0.000188	0.000436	0.000601	0.000403	0.000639	0.000597	0.000689
AMZN	0.000737	0.00095	0.000588	0.000269	0.000659	0.000452	0.000545	0.000791	0.000645	0.000632
GOOGL	0.000734	0.000588	0.000701	0.000191	0.000446	0.000258	0.000459	0.000594	0.000461	0.000452
JPM	0.000188	0.000269	0.000191	0.000321	0.00031	0.000251	0.000217	0.00029	0.00022	0.000263
TSLA	0.000436	0.000659	0.000446	0.00031	0.001855	0.000493	0.00045	0.000788	0.000599	0.000918
BABA	0.000601	0.000452	0.000258	0.000251	0.000493	0.001794	0.00011	0.000636	0.000363	0.00047
SWN	0.000403	0.000545	0.000459	0.000217	0.00045	0.00011	0.001338	0.000563	0.000469	0.000265

ZM	0.000639	0.000791	0.000594	0.00029	0.000788	0.000636	0.000563	0.001279	0.00079	0.000642
PYPL	0.000597	0.000645	0.000461	0.00022	0.000599	0.000363	0.000469	0.00079	0.000893	0.000542
NFLX	0.000689	0.000632	0.000452	0.000263	0.000918	0.00047	0.000265	0.000642	0.000542	0.001417

Now for Problem-1 of Markowitz Portfolio Optimization, we need to find out the weight matrix W such that the risk or the variance is minimum, that is:

Minimize, $\sigma^2 = W \cdot C \cdot W^T$ such that $O \cdot W^T = 1$

$$W_{min} = \frac{O \cdot C^{-1}}{O \cdot C^{-1} \cdot O^T}$$

W_{min}	-4.9e-2	-3.41	9.4e-2	2.01	-1.10	4.2e-2	1.2e-1	5.6e-1	-3.4e-1	1.006

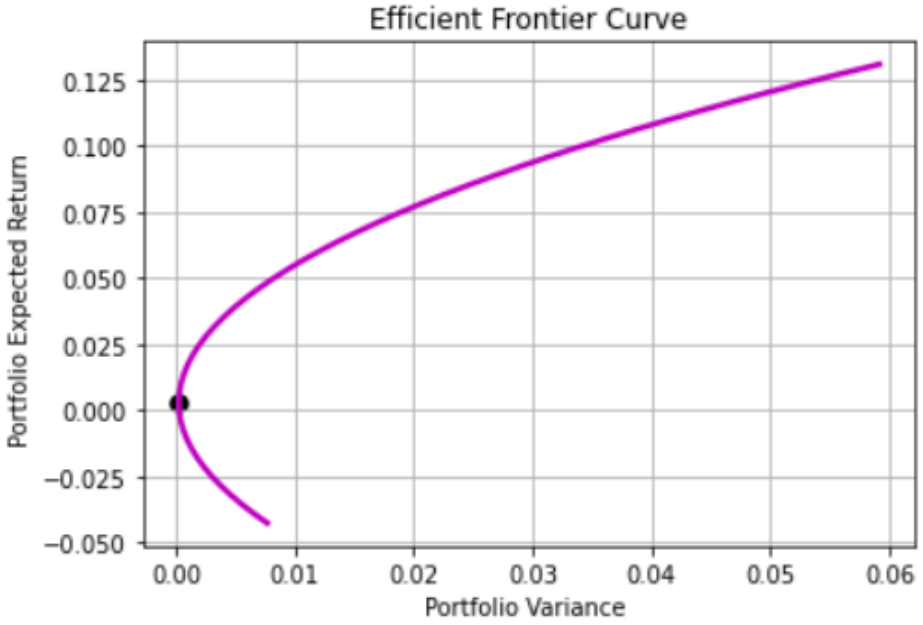
1. Use the mean-variance theory and build the Markowitz efficient frontier.

For Problem 1, we need to find minimum risk and the corresponding value of weight matrices for a given value of expected return which lies between the minimum and maximum expected returns.

Minimize, $\sigma^2 = W \cdot C \cdot W^T$ such that $O \cdot W^T = 1$ and $M \cdot W^T = \mu$

$$W_{min} = \frac{(B2 - B1 \cdot \boldsymbol{\mu}) \cdot O \cdot C^{-1} + (\boldsymbol{\mu} \cdot A1 - A2) \cdot M \cdot C^{-1}}{A1 \cdot B2 - A2 \cdot B1}$$

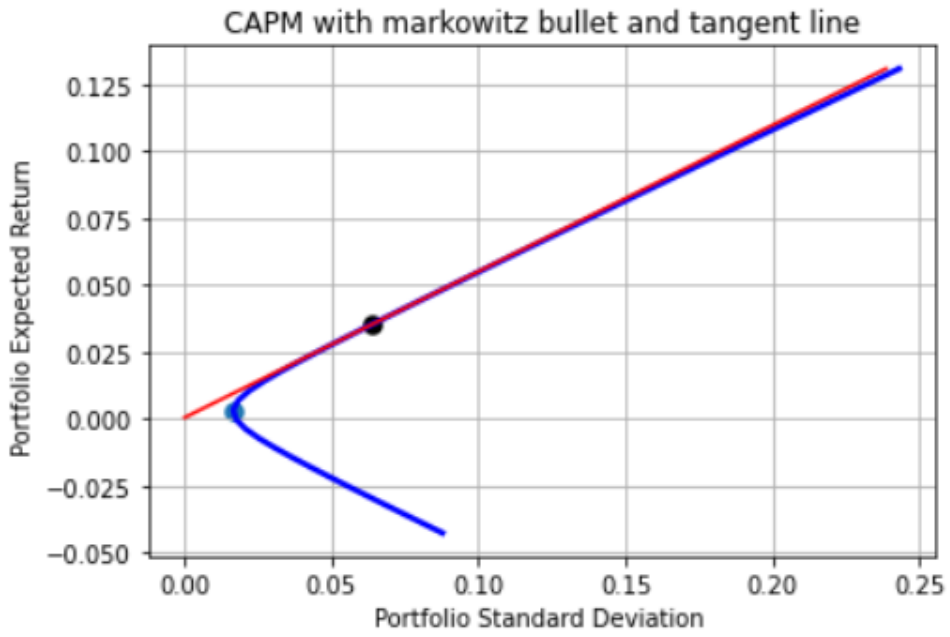
,where, $A1 = O \cdot C^{-1} \cdot O^T$, $A2 = M \cdot C^{-1} \cdot O^T$, $B1 = O \cdot C^{-1} \cdot M^T$, and $B2 = M \cdot C^{-1} \cdot M^T$.



2. **Use a risk-free asset along with the risky assets to obtain CAP"M". Draw the straight line and show that it is tangent to the efficient frontier. Obtain the market portfolio.**

Taking risk free expected return,

mu_rf = 0.00050



3. **Use any three assets out of the 10 risky assets to get three different Security Market Lines.**

Taking risk free expected return in this case,

mu_rf = 0.000138

And three risky assets are chosen as NFLX, PYPL and BABA, whose expected returns are given as,

Mkt_Ret_1 = 0.00338609, Mkt_Ret_2 = -0.00326131, Mkt_Ret_3 = 0.00146328

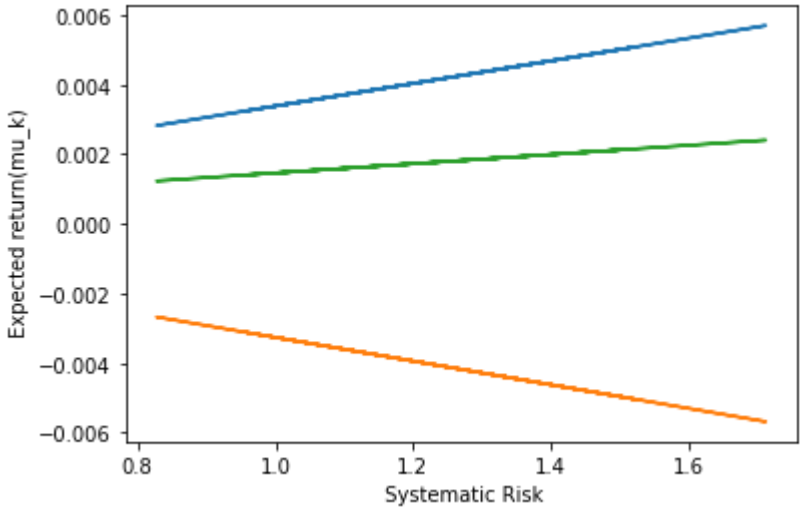
The equation of the Security Market Line (SML) is given as:

$$\mu_k = \mu_{rf} + (\mu_M - \mu_{rf})\cdot\beta_k, \text{ where } \beta_k = \frac{cov(R_M, R_k)}{\sigma_M^2}$$

Beta_ks for all the risky assets are given as:

AMZN	1.518946
BABA	0.958400
GOOGL	1.352352
JPM	0.827127
META	1.519148
NFLX	1.388469
PYPL	1.329434
SWN	1.406500
TSLA	1.566521
ZM	1.712078

Substituting these beta_ks, expected returns of 3 risky assets and risk-free return in the above equation one by one, we get three security market lines between beta _ks and mu_k, which is shown below:



The files attached in the zip file:

1. Financial.pdf - Report of the Project.
2. Python code for Markowitz Efficient Frontier, Capital Asset Pricing Model with Market Line and Security Market Lines.