Financial Engineering Assignment Report

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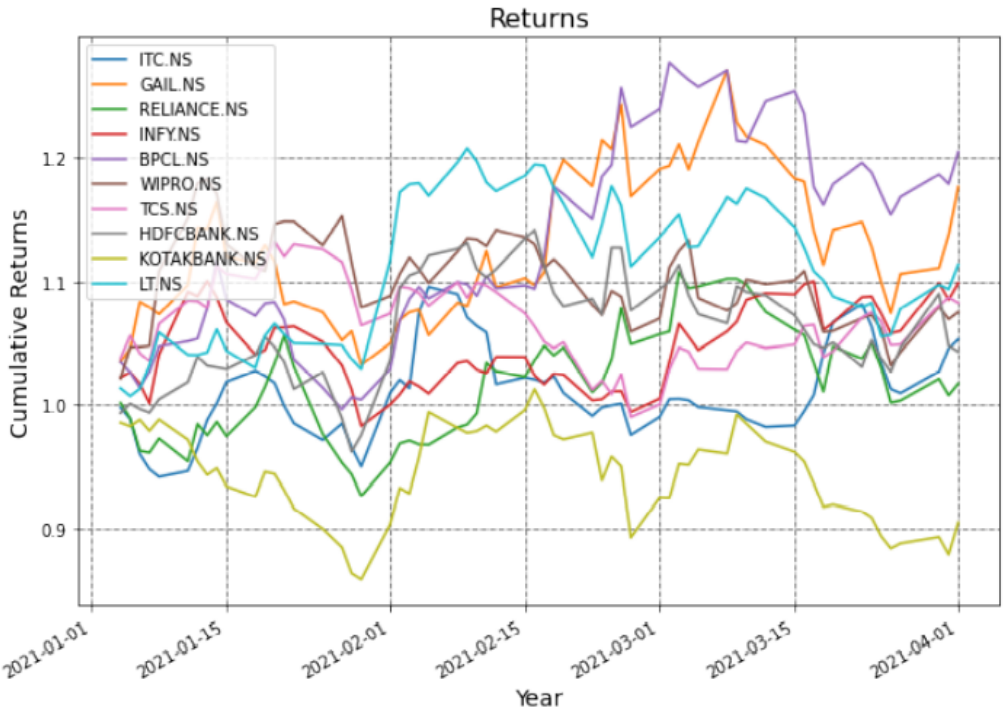
Ques1 : Pick any 10 risky assets from the market. Use their 3 months closing price to obtain simple returns.

Procedure : Let us take 10 risky assets from the market.and the companies name are as follows:

" ITC, GAIL, RELIANCE, INFY, BPCL, WIPRO, TCS, HDFC BANK, KOTAK BANK, LT "

Now we are dividing these 10 assets into 2 sets of 5 assets in which the first five are tickers1 and rest five are tickers2. We are comparing these assets from january 1,2021 to march 31,2021. Then we plot a time-cumulative return curve for each set and find which company gives us more return. We got that in the first set of assets BPCL gives us maximum return at the end of march and in the second set of assets LT gives us maximum return at the end of march. Then we plot a time-cumulative return curve for all 10 assets and we get that BPCL gives us maximum return at the end of march.

Output :



Ques2 : Use the mean-variance theory and build the Markowitz efficient frontier.

Procedure : Modern Portfolio Theory (MPT) is an investment theory developed by Harry Markowitz and published under the title " Portfolio Selection " in the Journal of Finance in 1952. If you are familiar with finance, you might know what the acronym "TANSTAAFL" stands for. It is a famous acronym for " There Ain't No Such Thing As A Free Lunch ". This concept is also closely related to ' risk-return trade-off '.

Higher risk is associated with greater probability of higher return and lower risk with a greater probability of smaller return. MPT assumes that investors are risk-averse, meaning that given two portfolios that offer the same expected return, investors will prefer the less risky one. Thus, an investor will take on increased risk only if compensated by higher expected returns.

Another factor that comes into play in MPT is " diversification ". MPT says that it is not enough to look at the expected risk and return of one particular stock. By investing in more than one stock, an investor can reap the benefits of diversification – chief among them, a reduction in the riskiness of the portfolio.

What we need to understand is “risk of a portfolio is not equal to average/weighted-average of individual stocks in the portfolio.” In terms of return, yes it is the average/weighted average of individual stock's returns, but that's not the case for risk. The risk is about how volatile the asset is, if you have more than one stock in your portfolio, then you have to take count of how these stocks' movements correlate with each other. The beauty of diversification is that you can even get lower risk than a stock with the lowest risk in your portfolio, by optimising the allocation.

From the plot of 10 randomly chosen asset portfolios, we can see it forms a shape of an arch line on the top of clustered blue dots. This line is called the efficient frontier. It is efficient because points along the line will give us the lowest risk for a given target return. All the other dots right to the line will give you higher risk with the same returns. If the expected returns are the same, why would we take an extra risk when there's an option with lower risk?

Now, we will try to explain how we are getting this Markowitz efficient frontier.

We are taking the above 10 assets to build its Markowitz efficient frontier. First we will put a stock table of returns of january 1,4,5,6 and january 7 for all the risky assets then we convert this table into a logarithmic returns table to simplify our calculation.

Now, we are going to use 6000 random portfolios to get a frontier. Then we formulate weights(W*_i), expected return, expected volatility and sharpe ratio in our code. After that we print our maximum sharpe ratio and its allocation in an array which is :

Max Sharpe = 2.1829045591482688
location in array = 5829

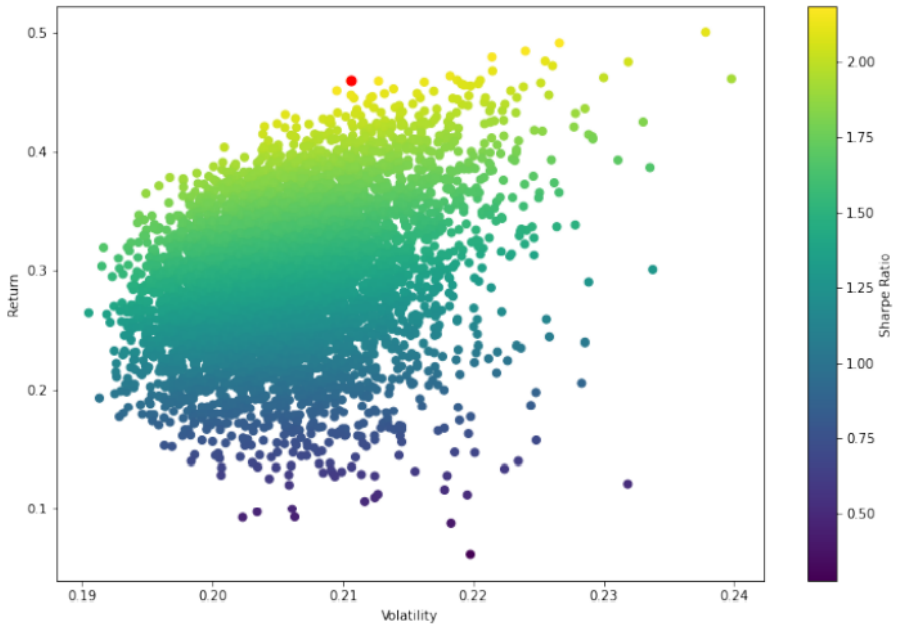
Then we print all weights of every asset in that corresponding portfolio which gives us a max sharpe ratio and that is :

[0.16018557 0.16545621 0.01349526 0.12533042 0.20906412 0.01196343 0.0928393 0.10107981 0.00231196 0.11827392]

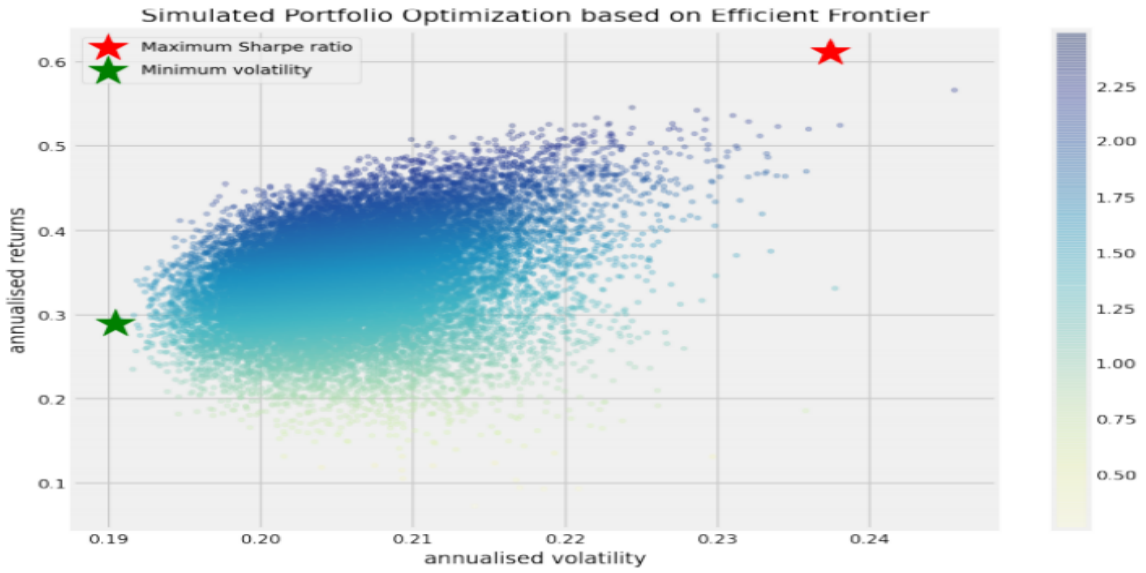
And we print the allocation of every asset in this portfolio and those allocations are:

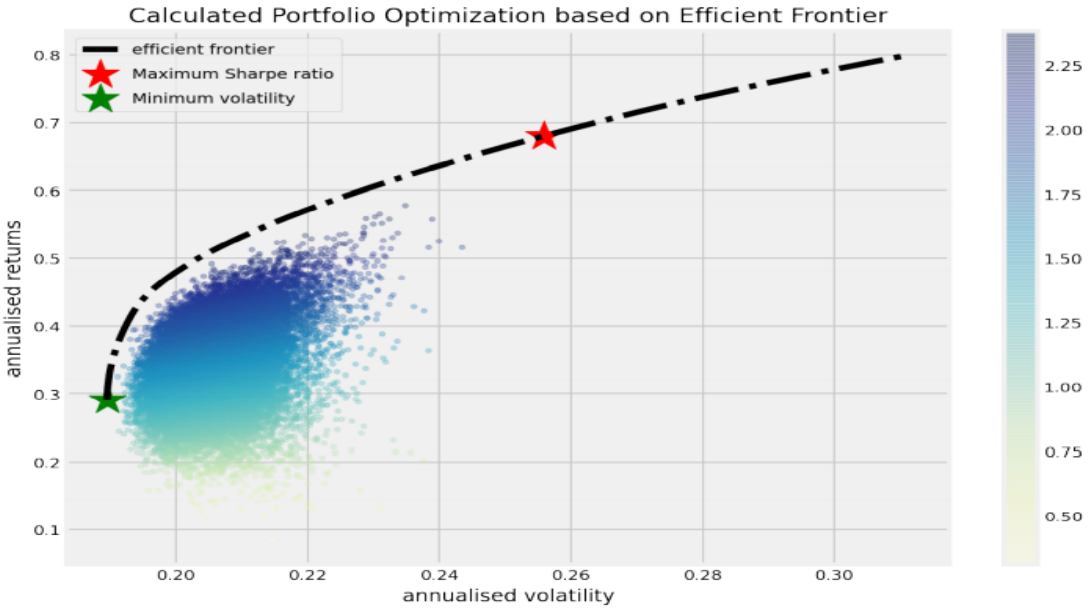
The allocation for: ITC is : 0.16018557420080826
The allocation for: GAIL is : 0.16545621356234136
The allocation for: RELIANCE is : 0.01349525532525986
The allocation for: INFY is : 0.12533041875814782
The allocation for: BPCL is : 0.20906411879687964
The allocation for: WIPRO is : 0.01196342922286724
The allocation for: TCS is : 0.09283929590658799
The allocation for: HDFCBANK is : 0.10107981312449213
The allocation for: KOTAK BANK is : 0.002311956828650832
The allocation for: LT.NS is : 0.11827392427396483

Finally we plot a volatility - return curve and we plot a red dot in the place of max volatility and max return.



then we plot a frontier which is passing through the red dot and this is called the Markowitz efficient frontier.





Ques3 : Use a risk-free asset along with the 10 risky assets to obtain CAP"M". Draw the straight line and show that it is tangent to the efficient frontier. Obtain the market portfolio.

Procedure : The Capital Asset Pricing Model (CAPM) describes the relationship between systematic risk and expected return for assets, particularly stocks. CAPM is widely used throughout finance for pricing risky securities and generating expected returns for assets given the risk of those assets and cost of capital.

The risk-free rate in the CAPM formula accounts for the time value of money. The other components of the CAPM formula account for the investor taking on additional risk.

The beta of a potential investment is a measure of how much risk the investment will add to a portfolio that looks like the market. If a stock is riskier than the market, it will have a beta greater than one. If a stock has a beta of less than one, the formula assumes it will reduce the risk of a portfolio. A stock's beta is then multiplied by the market risk premium, which is the return expected from the market above the risk-free rate. The risk-free rate is then added to the product of the stock's beta and the market risk premium. The result should give an investor the required return or discount rate they can use to find the value of an asset. The goal of the CAPM formula is to evaluate whether a stock is fairly valued when its risk and the time value of money are compared to its expected return.

Using the CAPM to build a portfolio is supposed to help an investor manage their risk. If an investor were able to use the CAPM to perfectly optimize a portfolio's return relative to risk, it would exist on a curve called the efficient frontier. The graph shows how greater expected returns (y-axis) require greater expected risk (x-axis). Modern Portfolio Theory suggests that starting with the risk-free rate, the expected return of a portfolio increases as the risk increases. Any portfolio that fits on the Capital Market Line (CML) is better than any possible portfolio to the right of that line, but at some point, a theoretical portfolio can be constructed on the CML with the best return for the amount of risk being taken.

Now, we will try to explain how we are proceeding with above 10 risky assets and 1 risk free asset and get CAPM.

Firstly we apply the above method to get markowitz efficient frontier and for this we get ,

Max Sharpe = 2.5718716857320993
location in array = 3788

And after this we print all weights of every asset in that corresponding portfolio which gives us a max sharpe ratio and that is :

[0.12530348 0.16239756 0.00593159 0.1072165 0.14898168 0.00405427 0.00566325 0.02825753 0.01251961 0.1913007 0.20837384]

And we print the allocation of every asset in this portfolio and those allocations are:

The allocation for: ITC is : 0.12530347887086948
The allocation for: GAIL is : 0.16239755747954962
The allocation for: RELIANCE is : 0.0059315892039434595
The allocation for: INFY is : 0.10721649690309175
The allocation for: BPCL is : 0.14898167714016328
The allocation for: WIPRO is : 0.004054269345481703
The allocation for: TCS is : 0.0056632489073559856
The allocation for: HDFCBANK is : 0.028257531213158056
The allocation for: KOTAK BANK is : 0.01251960906160665
The allocation for: LT is : 0.19130070001718671

And based on these we get our tangent line to the efficient frontier and these are the final Weights of Portfolio:

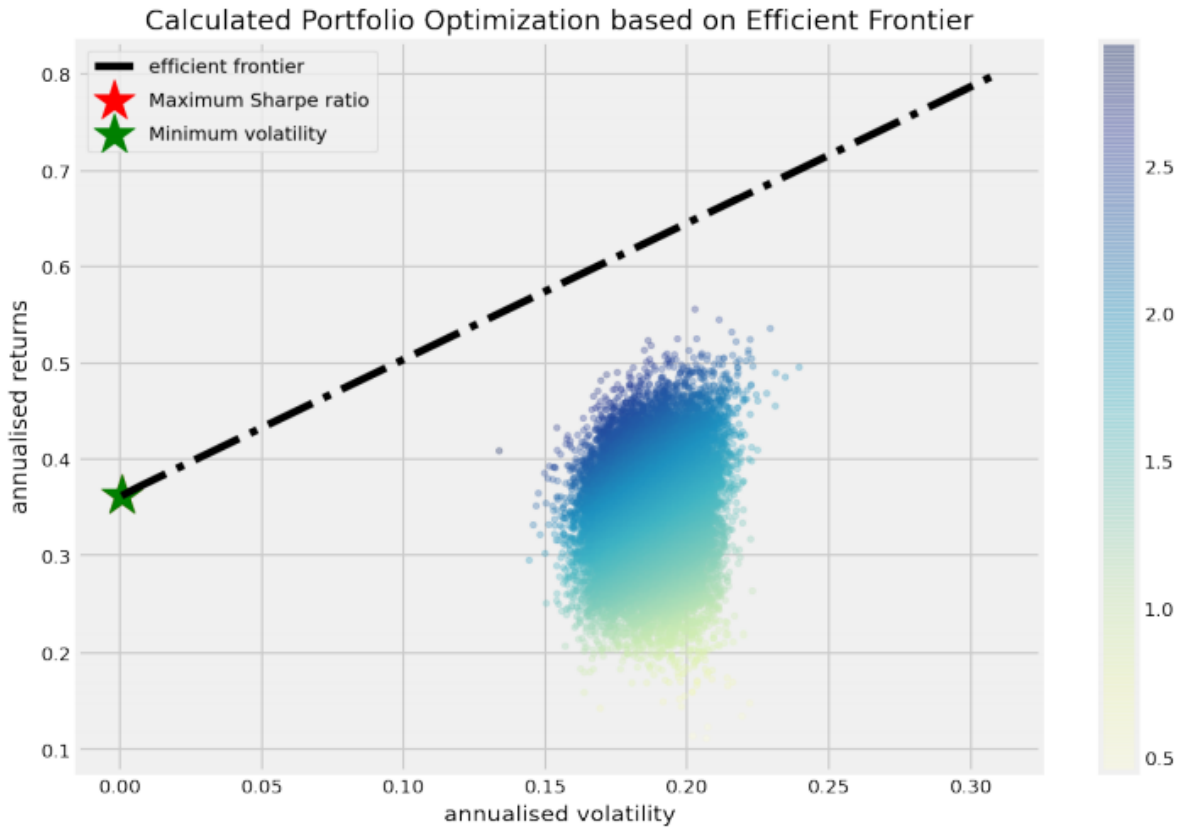
ITC	9.09%
GAIL	9.09%
RELIANCE	9.09%
INFY	9.09%
BPCL	9.09%
WIPRO	9.09%
TCS	9.09%
HDFC BANK	9.09%
KOTAK BANK	9.09%
LT	9.09%
Risk free	9.09%

And we get our final

Average Return : 0.301
Average Standard Deviation : 0.182
Sharpe Ratio : 1.378

And we get our best portfolio at
(606.5056807383834, [0.00010112492544409907, 2.3502899429924264e-12, 2.2313386469138176e-06, 4.0054732161749244e-06, 2.2318388158435086e-11, 0.0, 0.0, 0.0, 4.766230789861632e-06, 3.013975053333845e-13, 0.9999023957857084])
With weights

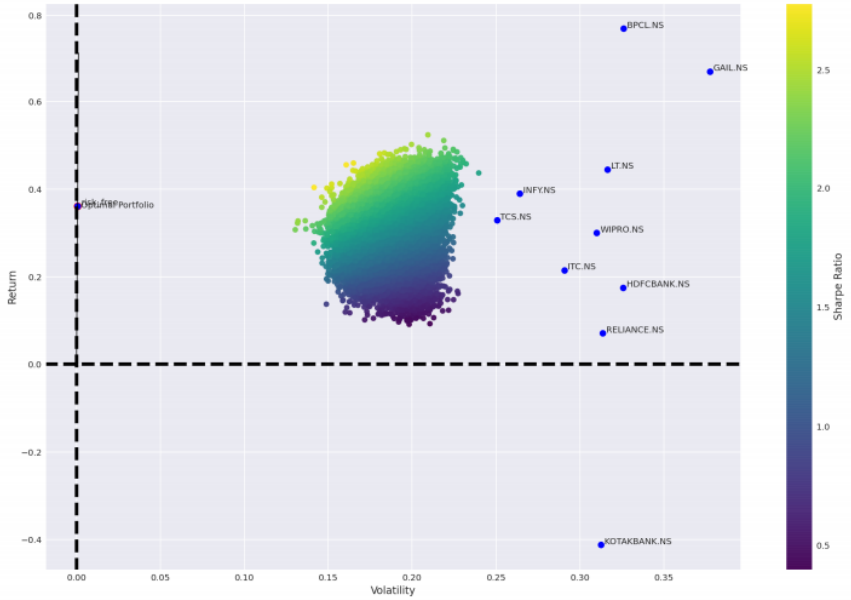
ITC	0.01%
GAIL	0.00%
RELIANCE	0.00%
INFY	0.00%
BPCL	0.00%
WIPRO	0.00%
TCS	0.00%
HDFC BANK	0.00%
KOTAK BANK	0.00%
LT	0.00%
Risk free	99.99%



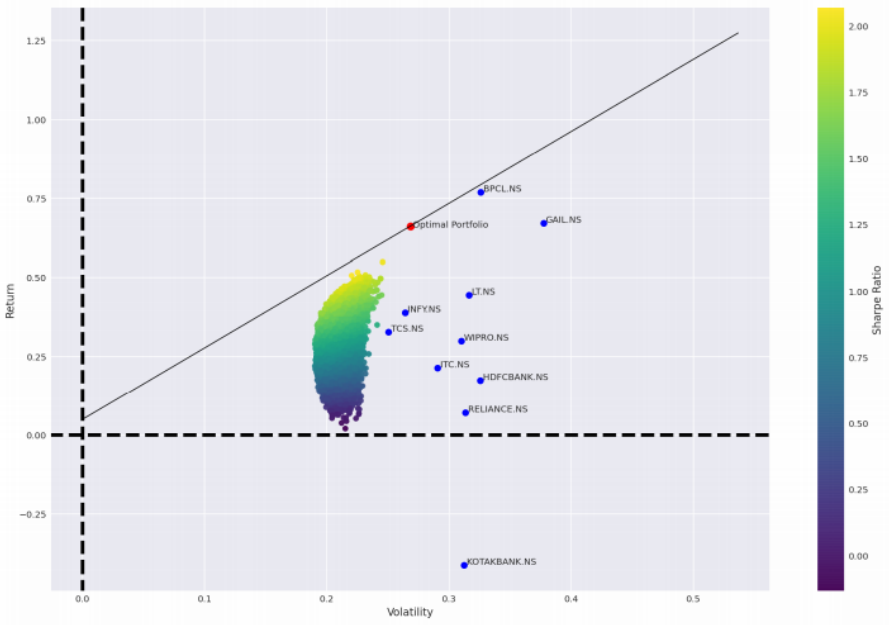
Output :

When we add risk free assets then we get a straight line along the x-axis and for risky assets we get the tangent line on the efficient frontier.

For Risk free assets



For Risky assets



Ques4: Use any three assets out of the 10 risky assets to get three different SMLs.

Procedure : The security market line (SML) is a line drawn on a chart that serves as a graphical representation of the capital asset pricing model (CAPM)—which shows different levels of systematic, or market risk, of various marketable securities, plotted against the expected return of the entire market at any given time.

Also known as the "characteristic line," the SML is a visualization of the CAPM, where the x-axis of the chart represents risk (in terms of beta), and the y-axis of the chart represents expected return. The market risk premium of a given security is determined by where it is plotted on the chart relative to the SML.

For this we are taking 3 assets namely, ITC, Reliance, HDFC BANK from all 10 assets and then plot a curve between asset return and asset beta and we get three different security market lines for these three assets.

Output :