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Maximizing the Returns While Minimizing the Risk using Sharpe's Ratio

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ABSTRACT
Intake manifolds have to be designed to improve engine performance by avoiding the phenomena like inter-cylinder robbery of charge, inertia of the flow in the individual branch pipes, resonance of the air masses in the pipes and the Helmholtz effect. The objective of work is to predict and analyze the flow through intake manifold of four cylinder spark ignition engine. One of the important factors is runner. The steady state analysis has been carried out for three for All runners open, The predicted results of total pressure loss and total outlet mass flow were discussed. Inlet pipe and plenum connection creates a back step geometry which causes more total pressure loss due to flow recirculation in conventional model. Tapering the geometry is causing more inlet mass flow due to reduction in total pressure loss in the plenum chamber.

Keywords: Fluent, Intake, Manifold, Runners

I. INTRODUCTION

Investment in stocks is done with the objective of maximizing the returns. But the stock price movements are affected by many factors which cannot be predicted in advance. The upward and downward movement of the stock values leads to a variation which is termed as risk. It is a traditional practice to use the fundamental factors and technical factors to select the stocks for investment. But none of these factors have 100% efficiency in predicting the stock price movements. If an investor wishes to earn higher returns, it is inevitable that he should be ready to face higher risk. One way of handling this tradeoff is to have a portfolio of stocks which leads to diversification of risk. But the process of constructing a portfolio is complicated due to the availability of many alternative investment opportunities. This process can be made scientific by using mathematical models which consider all possible alternatives and identify the best alternative. With this focus the following literature is explored.

The conceptual framework for selecting an optimal portfolio was provided by Markowitz (1952). This development has led to the scientific approach in portfolio construction, a process which was done without any scientific considerations previously.

Sharpe(1963) proved that the portfolio is affected by the movement in the stock market and introduced Single Index Model for portfolio construction.

Sharpe et al in 1964 developed CAPM. This Capital Asset Pricing model established the relationship between the return and risk and it gives a framework to identify whether the assets are under priced or overpriced.

In 1966 Sharpe developed Sharpe index which measures excess portfolio return over the risk-free rate relative to its standard deviation and this ratio helped in choosing securities in a relative manner.

Treynor in 1965 suggested the reward to volatility ratio arguing that standard deviation measures the systematic and unsystematic risk whereas the unsystematic risk gets cancelled under diversification.

Jensen in 1968 has developed a model for evaluation of performance of a portfolio. This measure is based on differential returns and is known as Jensen's ratio. It measures the difference between the actual return of a portfolio and expected return of a portfolio in view of the risk of the portfolio.

There is a large body of literature trying to test and explore the various implications of CAPM using historical rates of return and market returns using cross sectional and time series regression analysis by Fama and Macbeth, 1973 and Rosenberg, 1998.

Sharpe 1996 explains the theory of portfolio selection, the theory of pricing of capital assets under conditions of risk, and the general behavior of stock market prices.

Modigliani and Modigliani (1997) gave a measure which describes that a portfolio is adjusted by mixing a sufficient quantum of risk –free securities so that the risk of portfolio is equal to the risk of the market index.

II. METHODS AND MATERIAL

Constructing a Portfolio:

A portfolio is simply a collection of assets, characterized by mean, variances and co variances of their returns. The mean return of ith asset is denoted as r_i. The variances and co variances of n assets are represented in the following matrix.

	r1	r2	r3	---	rn
r1	σ_1^2	σ_{12}	σ_{13}	---	σ_{1n}
r2	σ_{21}	σ_2^2	σ_{23}	---	σ_{2n}
r3	σ_{31}	σ_{32}	σ_3^2	--	σ_{3n}
-	--	--	--	--	-
rn	σ_{n1}	σ_{n2}	σ_{n3}	--	σ_n^2

Thus the covariance of an asset with itself is the variance. $\sigma_{nn} = \sigma_n^2$

A portfolio of two assets is characterized by the value invested in each asset. Let V_1 and V_2 be the amount invested in assets 1 and 2 respectively. Then the total value of the portfolio is $V = V_1 + V_2$. Then the weights on asset 1 is $w_1 = V_1/V$ and $w_2 = V_2/V$ and $w_1 + w_2 = 1$ .The portfolio return is a weighted average of the individual returns computed as

$$\bar{r}_p = w_1\bar{r}_1 + w_2\bar{r}_2 .$$

The variance of the portfolio return with two assets is

$$\sigma_p^2 = Var(\bar{r}_p) = w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2\sigma_{12}$$

Variance of the portfolio is the sum of all entries of the following table.

	$w_1\bar{r}_1$	$w_2\bar{r}_2$
$w_1\bar{r}_1$	$w_1^2\sigma_1^2$	$w_1w_2\sigma_{12}$
$w_2\bar{r}_2$	$w_1w_2\sigma_{12}$	$w_2^2\sigma_2^2$

If n assets each with weight w_1, w_2 -------w_n are considered such that $\sum_{i=1}^{n} w_i = 1$ the expected portfolio return is derived as

$$\bar{r}_p = w_1\bar{r}_1 + w_2\bar{r}_2 + - - - + w_n\bar{r}_n = \sum_{i=1}^{n} w_i\bar{r}_i .$$

The variance of the portfolio return with two assets is

$$\sigma_p^2 = Var(\bar{r}_p) = \sum_{i=1}^{n}\sum_{j=1}^{n} w_iw_j\sigma_{ij} \quad where\ \sigma_{ii} = \sigma_i^2$$

The volatility of the portfolio return is $\sigma_p = \sqrt{Var(\bar{r}_p)} = \sqrt{\sigma_p^2}$

In an equally weighted portfolio of n assets, the variance term is $(1/n)^2\sigma_{ii}$ and the covariance term is $(1/n)^2\sigma_{ij}$. Adding all the terms

$$\sigma_p^2 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{ij} = \sum_{i=1}^{n}\left(\frac{1}{n}\right)^2 \sigma_{ii} + \sum_{i=1}^{n}\sum_{j\neq i=1}^{n}(1/n)^2\sigma_{ij}$$

$$= \left(\frac{1}{n}\right)\left(\frac{1}{n}\sum_{i=1}^{n}\sigma_i^2\right) + \left(\frac{n^2-n}{n^2}\right)\left(\frac{1}{n^2-n}\sum_{i=1}^{n}\sum_{j\neq i=1}^{n}\sigma_{ij}\right)$$

$$= \left(\frac{1}{n}\right) * average\ variance + \left(\frac{n^2-n}{n^2}\right) * Average\ covariance$$

As n becomes very large, the contribution of variance terms goes to zero and the contribution of covariance terms goes to the average covariance.

The securities differ in their risk and return characteristics. Holding more than one security is considered ideal by the investors for the reason that the loss in one security will be compensated by the gain in other securities in the portfolio. Even though the entire investor's domain accepts that diversification minimizes the risk, the following considerations require sound decisions.

- What number of securities should be included in the portfolio?
- What securities should be included in the portfolio? This decision is generally made based on fundamental analysis and technical analysis.
- What proportion of the money should be invested in each security?

Even after finding convincing answers to the first two questions, finding the weights for each security will remain complicated due to the availability of many alternative solutions. The intention is to identify the best among the available alternatives and to do this we need a framework which analyses all the possible alternatives. One such framework which considers all possible alternatives and picks the best among all alternatives is the Linear Programming Problem (LPP). It is a setup in which the objective function is a linear function which is to be optimized and the constraints are the linear equations or inequalities.

The main issue with the LPP is that it can entertain only one objective at a time. But the problem of portfolio construction is concerned with two objectives that the return should be maximized and the risk should be minimized. Among these two objectives the natural choice of an average investor will be to maximize the returns. An optimum solution of a LPP with this objective will be invariably associated with maximum risk which questions the credibility of this framework. But this effect is due to the fact that the variables Risk and Return move together. A possible solution may be that a risk averting investor should go with the objective of minimizing the risk. But in this case, the optimum solution will be associated with minimum returns. Hence for a risk averting investor, the problem is to search for some other form of objective function with which the LPP gives the return which is reasonably more and the risk which is comparatively less.

Optimal portfolio selection:

In this study three methods of constructing portfolios are considered. The first method has an objective of maximizing the return

LPP for maximizing the return (MaxRet Model):

$$Maximise\ \bar{r}_p = w_1\bar{r}_1 + w_2\bar{r}_2 + - - - + w_n\bar{r}_n = \sum_{i=1}^{n} w_i\bar{r}_i$$

$$subject\ to$$

$$\sum_{i=1}^{n} w_i = 1$$

$$w_i \geq 0\ for\ all\ i$$

The second method has an objective of minimizing the risk. The Linear programming problem for this approach is as follows:

LPP for minimizing the risk (MinVar Model):

$$Minimise\ \sigma_p^2 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{ij}$$
$$subject\ to$$
$$\sum_{i=1}^{n} w_i = 1$$
$$w_i \geq 0\ for\ all\ i$$

In the third method, the objective is to maximize the Sharpe's ratio. Sharpe ratio is the measure of risk-adjusted return of a financial portfolio. It is the ratio of the excess portfolio return over the risk free rate relative to its standard deviation.

The Sharpe Ratio is computed as $\frac{r_p - r_f}{\sigma_p}$. Here r_p is the return of the portfolio, r_f is the risk free return and σ_p is the standard deviation of the portfolio. This ratio measures the additional return an investor earns by taking additional risk. It allows us to add new assets which can have a positive effect without adding any undue risk. Hence the third method is framed with Sharpe's ratio in the objective function which is to be maximized.

LPP for maximizing the Sharpe's ratio (MaxSharpe Model)

$$Maximise\ SR = \frac{\overline{r_p} - r_f}{\sigma_p}$$
$$subject\ to\ \sum_{i=1}^{n} w_i = 1$$
$$w_i \geq 0\ for\ all\ i$$

III. RESULTS AND DISCUSSION

The daily closing prices of randomly selected stocks from NIFTY 50 from January 2020 to January 2022 are used to form portfolios in this study. In order to identify an appropriate strategy for the risk averting investor LPP formed with three different objectives are compared in this

LPP-1: MaxSharpe Model. The objective is to maximize the Sharpe's ratio.

LPP-2:. Minvar Model. The objective is to minimize the risk

LPP-3: Maxret Model. The objective is to maximize the returns.

Maximizing the return may not be the best objective for a risk averting investor. But the result derived from MaxRet model is used as a benchmark to analyze the results derived from the other two models. To compare the credibility of the models with these three objectives, five portfolios are formed each with five stocks which are randomly selected. The Linear programming problem formulated for each of the five portfolios is solved using Excel Solver which uses the method of simulation.

For the process of constructing a portfolio, it is a practice to filter the securities which have strong fundamentals and the securities which are technically strong. The objective of the study is to select an appropriate objective for the risk averting investor. In this process, the credibility of the objectives should be tested with all types of stocks. Hence no filters are used for selecting the securities rather the securities are selected at random.

Portfolio-1 is constructed with the stocks HCLTECH, JSWSTEEL, CIPLA, SUNPHARMA and UPL. The following graph shows the distribution of closing prices of the stocks included in Portfolio-1.

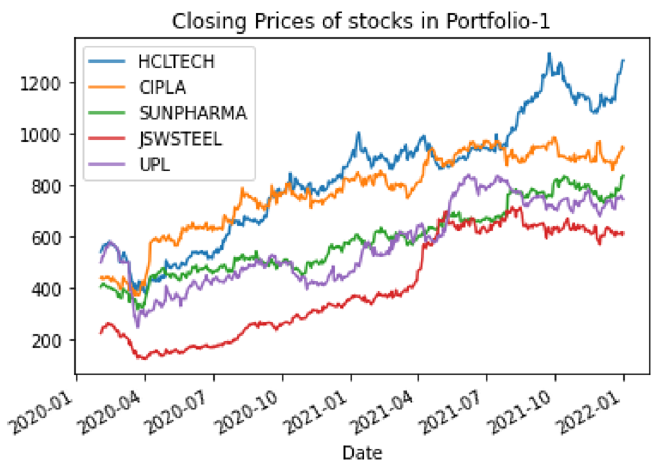


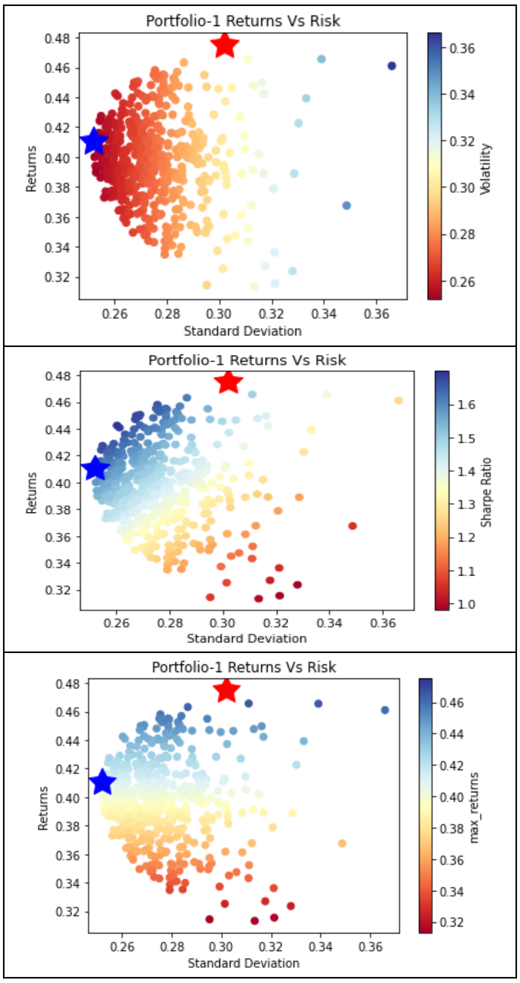
Figure-1 : Distribution of Closing Prices of Stocks-Portfolio-1

Table-1: Results for Portfolio-1 based on three models

Model	Returns	Volatility	Weights	
MaxSharpe	0.442505	0.260326	HCLTECH	0.32
			CIPLA	0.35
			SUNPHARMA	0.12
			JSWSTEEL	0.21
			UPL	0
MinVar	0.410269	0.252178	HCLTECH	0.31
			CIPLA	0.32
			SUNPHARMA	0.23
			JSWSTEEL	0.07
			UPL	0.07
MaxRet	0.475042	0.302118	HCLTECH	0.41
			CIPLA	0.14
			SUNPHARMA	0.03
			JSWSTEEL	0.42
			UPL	0.01

The returns in Minvar approach is approximately 0.41 with a risk of 0.25. Thus the risk is very much less than the benchmark 0.30 (Return of the Benchmark model MaxRet). But the risk in Sharpe's portfolio is just 0.26 but the return is 0.44. Hence the objective of the risk averting investor may be maximizing Sharpe' Ratio rather than minimizing the risk.

Figure-2 : Graphical display of the result-Portfolio-1



The following figure gives the graphicl display of the stocks INFY,CIPLA, NTPC, DIVISLAB and UPL included in Portfolio-2.

Figure-3 : Distribution of Closing Prices of Stocks-Portfolio-2

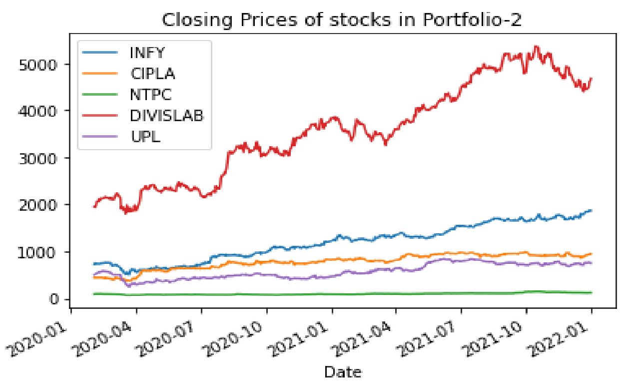
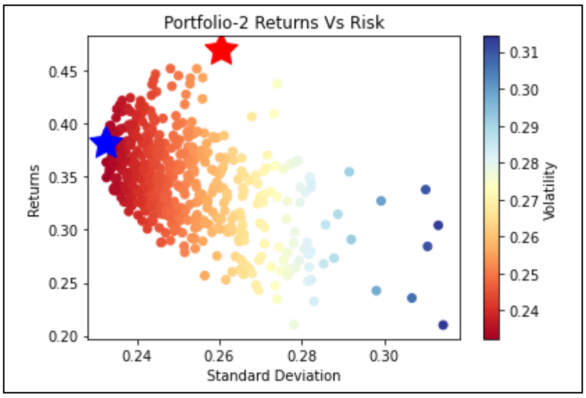


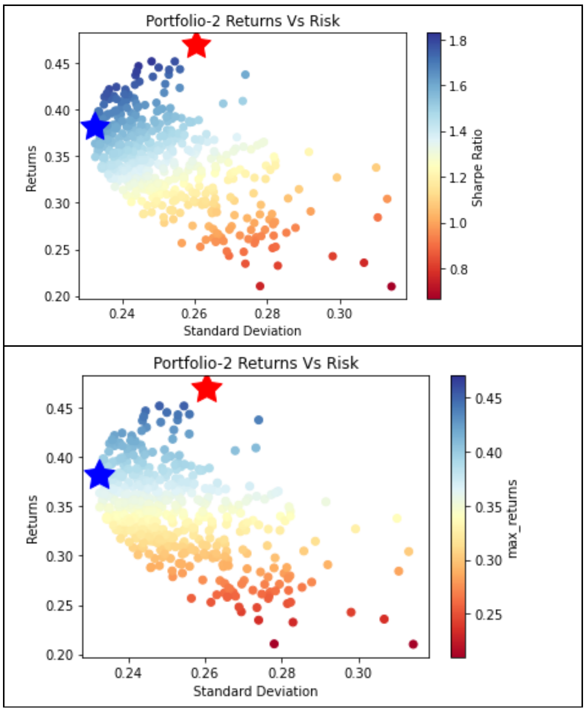
Table-2 : Results for Portfolio-2 based on three models

Model	Returns	Volatility	Weights	
MaxSharpe	0.447125	0.24455	INFY	0.38
			CIPLA	0.37
			NTPC	0.02
			DIVISLAB	0.23
			UPL	0.01
MinVar	0.382193	0.2323	INFY	0.3
			CIPLA	0.3
			NTPC	0.22
			DIVISLAB	0.16
			UPL	0.01
MaxRet	0.470029	0.260443	INFY	0.41
			CIPLA	0.01
			NTPC	0.02
			DIVISLAB	0.55
			UPL	0.01

The returns in Minvar approach is approximately 0.38 with a risk of 0.23. Thus the risk is very much less than the benchmark 0.26. But the risk in Sharpe's portfolio is just 0.24 but the return is 0.45 which is reasonably close to the benchmark 0.47. Hence the objective of the risk averting investor may be maximizing Sharpe' Ratio rather than minimizing the risk.

Figure-4 : Graphical display of the result-Portfolio-2





The following figure is the graphical display of the closing prices of the stocks POWERGRID, HCLTECH, HEROMOTOCO, BHARTIATL and UPL selected for Portfolio-3.

Figure-5 : Distribution of Closing Prices of Stocks-Portfolio-3

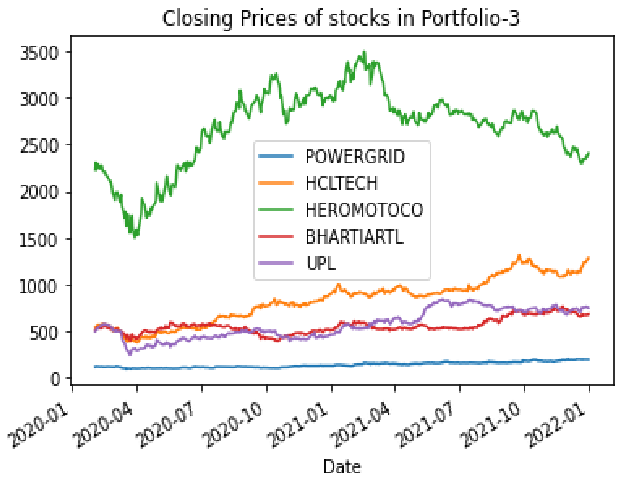
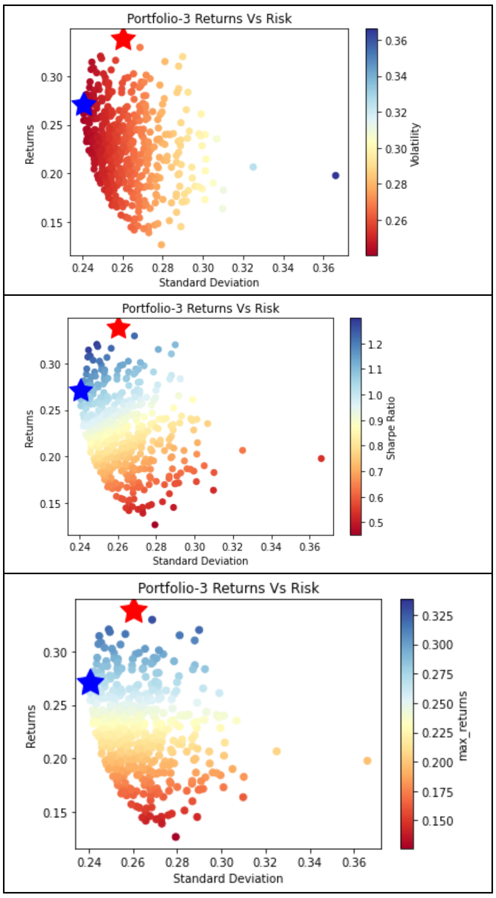


Table-3 : Results for Portfolio-3 based on three models

Model	Returns	Volatility	Weights	
MaxSharpe	0.371404	0.284672	POWERGRID	0.16
			HCLTECH	0.02
			HEROMOTOCO	0.62
			BHARTIARTL	0.01
			UPL	0.20
MinVar	0.254194	0.240649	POWERGRID	0.28
			HCLTECH	0.2
			HEROMOTOCO	0.28
			BHARTIARTL	0.18
			UPL	0.06
MaxRet	0.386184	0.310605	POWERGRID	0.0
			HCLTECH	0.04
			HEROMOTOCO	0.73
			BHARTIARTL	0.01
			UPL	0.22

The returns in Minvar approach is approximately 0.25 with a risk of 0.24. Thus the risk is very much less than the benchmark 0.31. But the risk in Sharpe's portfolio is just 0.28 but the return is 0.37 which is reasonably close to the benchmark 0.39. Hence the objective of the risk averting investor may be maximizing Sharpe' Ratio rather than minimizing the risk.

Figure-6 : Graphical display of the result-Portfolio-3



BAJAJFINANCE, KOTAKBANK, TATASTEEL, INDUSINDBANK and

HEROMOTOCO are the stocks included in portfolio-4 and the following graph shows the closing prices.

Figure-7 : Distribution of Closing Prices of Stocks-Portfolio-4

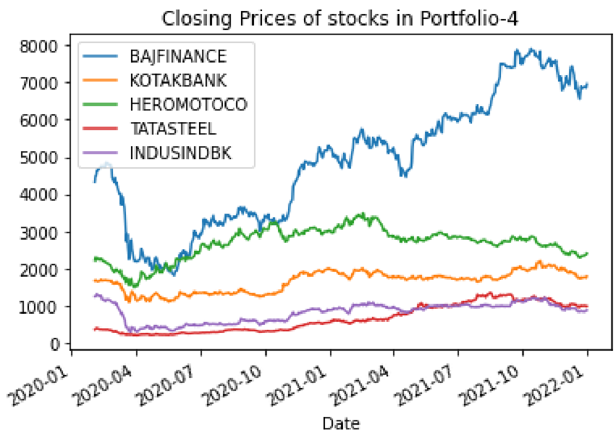
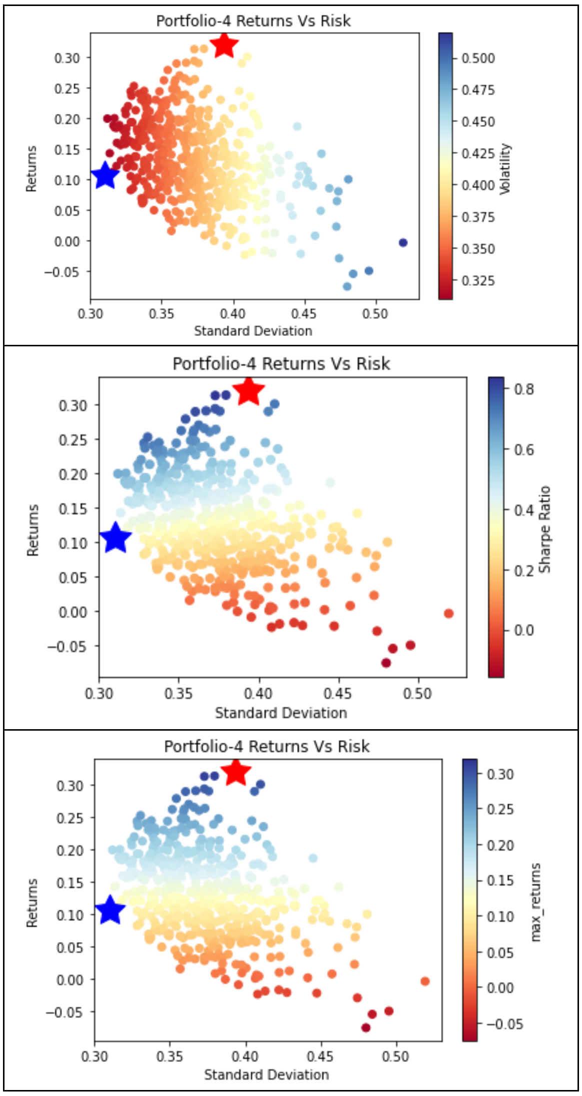


Table-4 : Results for Portfolio-4 based on three models

Model	Returns	Volatility	Weights	
MaxSharpe	0.311864	0.37296	BAJFINANCE	0.33
			KOTAKBANK	0.22
			HEROMOTOCO	0.02
			TATASTEEL	0.42
			INDUSINDBK	0.00
MinVar	0.106361	0.309914	BAJFINANCE	0.06
			KOTAKBANK	0.34
			HEROMOTOCO	0.41
			TATASTEEL	0.14
			INDUSINDBK	0.05
MaxRet	0.318836	0.393619	BAJFINANCE	0.4
			KOTAKBANK	0.13
			HEROMOTOCO	0.0
			TATASTEEL	0.43
			INDUSINDBK	0.04

The returns in Minvar approach is approximately 0.11 with a risk of 0.31. Thus the risk is very much less than the benchmark 0.39. But the risk in Sharpe's portfolio is just 0.37 but the return is 0.31 which is reasonably close to the benchmark 0.32. Hence the objective of the risk averting investor may be maximizing Sharpe' Ratio rather than minimizing the risk.

Figure-8 : Graphical display of the result-Portfolio-4



With CIPLA,NTPC, BPCl, TATASTEEL and INDUSINDBK, portfolio-5 is constructed and the graphical display of the closing prices is given in the following figure.

Figure 9 : Distribution of Closing Prices of Stocks-Portfolio-5

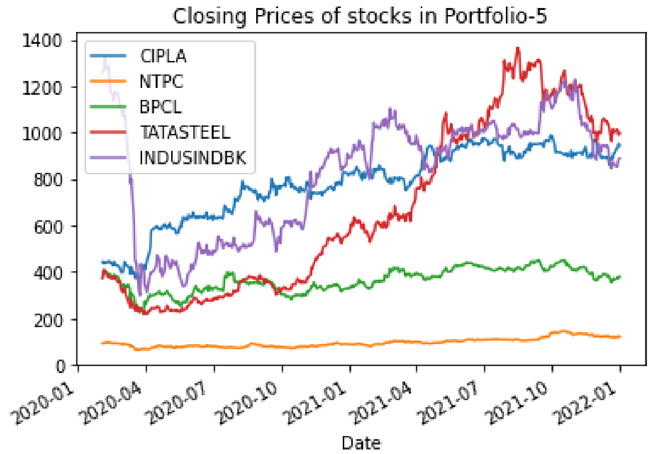
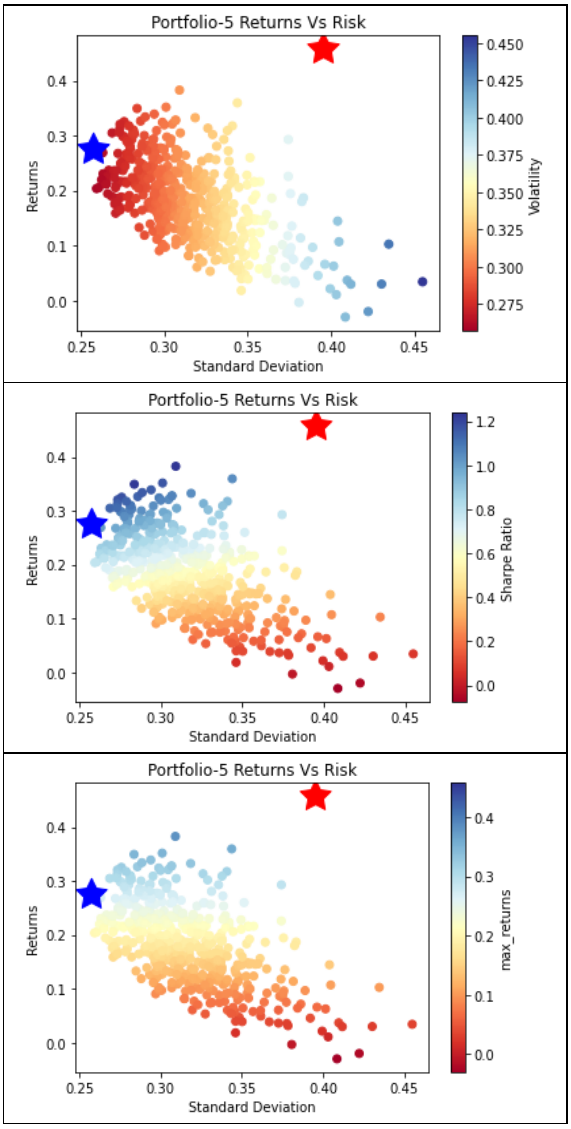


Table-5 : Results for Portfolio-5 based on three models

Model	Returns	Volatility	Weights	
MaxSharpe	0.42602	0.30905	CIPLA	0.35
			NTPC	0
			BPCL	0.15
			TATASTEEL	0.47
			INDUSINDBK	0.03
MinVar	0.274712	0.257271	CIPLA	0.44
			NTPC	0.33
			BPCL	0.1
			TATASTEEL	0.11
			INDUSINDBK	0.03
MaxRet	0.457392	0.395023	CIPLA	0.11
			NTPC	0.01
			BPCL	0.08
			TATASTEEL	0.79
			INDUSINDBK	0.01

The returns in Minvar approach is approximately 0.27 with a risk of 0.26. Thus the risk is very much less than the benchmark 0.40. But the risk in Sharpe's portfolio is just 0.31 but the return is 0.42 which is reasonably close to the benchmark 0.46. Hence the objective of the risk averting investor may be maximizing Sharpe' Ratio rather than minimizing the risk.

Figure-10 : Graphical display of the result-Portfolio-5



IV. CONCLUSION

Three methods of constructing portfolios are considered in this study. The problem is stated in a mathematical form called Linear programming model in which the objective function is a linear function and the constraints are linear equations. The Models differ in the objective functions. The following table is the summary of the results derived for the five portfolios.

Table-6 : Summary of the Results of the Portfolios

Portflio	Minvar Model		MaxRet Model (Benchmark)		MaxSharpe Model	
	Return	Risk	Return	Risk	Return	Risk
1	0.41	0.25	0.48	0.30	0.44	0.26
2	0.38	0.23	047	0.26	0.45	0.24
3	0.25	0.24	0.39	0.31	0.37	0.28
4	0.11	0.31	0.32	0.39	0.31	0.37
5	0.27	0.26	0.46	0.40	0.43	0.31

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