



CONSTRUCTION OF OPTIMAL PORTFOLIO USING SHARPE'S SINGLE INDEX MODEL

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ABSTRACT

Portfolio of securities can comprise combination of financial securities. The combination may be equity stock, debit securities/ bonds, preference stock, or money market instruments. The well balanced portfolio of securities will give a minimum risk with a maximum return. Constructing an optimal portfolio is a difficult task for the individual inventors. Investor can minimise the risk and maximize return by investing on optimal portfolio of securities. But, construction of optimal portfolio is a difficult task when more assets are under evaluation. William Sharpe has simplified the process of construction of portfolio by relating the return in a security to a single market index with his Single Index model. The aim of the study is to construct optimal portfolio using Sharpe's Single Index model taking 15 stocks listed at Bombay Stock Exchange (BSE). With use of simple random sampling the researcher selected 15 stocks from the top 100 stocks listed at BSE. Seven stocks were occupied space in the optimal portfolio of stocks. They are DIVI's Laboratories (39.17%), Wipro (12.77%), Nestle India (21.12%), Asian Paints (14.96%), Cipla (6.63%), Bajaj Finance (3.84%), and JSW Steel (1.51%).

Keywords: Construction, Optimal Portfolio, Sharpe's Single Index Model, BSE

1. INTRODUCTION

Sharpe's Single Index Model was developed by William Sharpe for the construction of portfolio considering less number of inputs than Markowitz model. The major assumption of Sharpe's Single Index Model is that the co-variation of the security can be explained by one single factor known as Index. One version of the model which is called as Market Model uses the market index such as S & P 500 as the factor. The market model states that the security's performance is related to its portfolio's performance according to the beta of security. The model firstly ranks the securities and arranged on the basis of each stock's excess return to beta ratio. Then cut off rate is calculated and it is compared with excess return to beta ratio for deciding whether to invest in that security or not. Finally, it helps determine the proportion of investment shall be made on the select securities for the portfolio.

It is a complicated task of selecting good investments by considering the trade-off between risk and return along with the combination of various types of investments for the Investors. A rational investor always seeks to minimize risks and maximize returns on investment in an optimal portfolio. In other words, investors would like to maximize return at a specified level of risk or earn same percentage of return with low level of risk. This is possible through construction of optimal portfolio of assets or securities.

The idea behind the study is application of theoretical knowledge about construction of portfolio in the real life situations and develop optimal portfolio which diversify the risk. William Sharpe developed the Single Index Model (SIM) to make easy and construct optimal portfolio. Most of the fund managers use Sharpe's model for construction of portfolio.

2. REVIEW OF LITERATURE

Review of literature involves review of published literature. It provides theoretical knowledge for the research and enlarges knowledge of the researcher. In this paper, researchers have reviewed papers published and some of them are as follows:

Nalini, R. (2014) carried out the portfolio construction and proportion of investment by using Sharpe's single index model of 15 companies from BSE during 2009 to 2017. Out of 15 stocks four stocks were included in portfolio - ITC (70.88%), TCS (10.08%), Dr Reddy's Laboratories (17.41%) and Bajaj Auto (1.63%).

Poornima, S and Ramesh, A.P. (2015) have analyzed that optimal portfolio by using Sharpe's Single Index Model by considering 20 stocks selected one from each industry during the period from January 2010 to December 2015 taking Banking and IT sector. The study reveals that only three companies are selected for the portfolio construction. From banking sector Bank of Baroda (12%) and Axis Bank (38%) and IT sector Ramco Systems Company (50%) is selected to portfolio construction.

Shah, C.A. (2015) in his paper titled Construction of optimal using Sharpe index model and companies for BSE 15 securities. The purpose of study is to construct optimal portfolio using Sharpe index model. Top 15 companies are taken for consideration in the research on the basis of market capitalization. The researcher obtained data from www.bseindia.com. The research concluded that out of 15 companies an investor can invest in HDFC Bank, ICICI Bank, TCS, and TATA Motors.

Murthy, J. (2016) attempted to construction of Portfolio using Sharpe Single Index Model. The purposes of this study, 14 Metal stocks are selected from the iron and steel industry and these stocks are constituent of the Nifty Metal index. The monthly data for the stock price period of January 2012 to December 2016 have considered. This study reveals that only 2 companies stocks constitute the optimal portfolio which is Vedanta (86.37%) and Tata steel (13.62%).

Archana, H.N. and Srilakshmi, D. (2020) constructed an optimal portfolio by using Sharpe's Single Index model by considering 10 stocks from different sectors from the list of 30 stocks listed at BSE. The closing price data for the study obtained from 01.01.2019 to 31.12.2019. 10 stocks were selected to construct an optimal portfolio and those are Nestle India, Bharati Airtel, TCS, Bajaj Finance, Reliance, Infosys, Kotak Bank, Titan, ICICI Bank and Asian Paints respectively.

Research Gap:

From the review of literature is found that there are research studies on optimal portfolio considering stocks from banking sector, information technology sector, and fast moving consumer goods (FMCG) sectors. But, no study was taken place during 14-1-2018 to 14.03.2022. Therefore, the present study.

Objective of the Study:

The purpose of the study is to construct an optimal portfolio using the Sharpe's single index model.

Methodology:

The study is desk and analytical research. It is purely based on secondary data. The monthly closing stock price of the 15 companies' listed at BSE is obtained for four years from 14.01.2018 to 14.03.2022.

Sample Design:

As on 31-12-2021 there are 5246 companies listed at BSE under different sector and it represents the population of the study. The target population of the study comprises top 100 companies by market capitalization. With the use of simple random sampling the researchers selected 15 companies, namely ICICI Bank Ltd (ICICI), Bajaj Finance Ltd (Bajaj), Asian Paints Ltd. (Asian Paints), JSW Steel Ltd. (JSW), Ambuja Cements Ltd. (Ambuja), Sun Pharmaceutical Industries Ltd. (Sun Pharma), HCL Technologies Ltd. (HCL), TATA Consultancy Services Ltd. (TCS), WIPRO Ltd. (Wipro), Cipla Ltd. (Cipla), Vedantha Ltd. (Vedantha), DIVI'S Laboratories Ltd. (DIVI'S Lab), Nestle India Ltd. (Nestle), HDFC Life Insurance Company Ltd. (HDFC Insurance), and TATA Motors Ltd. (Tata Motors). Here onwards these companies are referred with the short names given in bracket.

Analysis and Discussion:

The data is analysed by using Mean return, risk, Beta, excess return to beta ratio and Sharpe's Single Index model.

Return and Risk:

Average monthly return of select securities is calculated by using historical prices and showed in Table1. This return is calculated by using the formula:

$$R_i = [(Monthly\ Closing\ Price - Monthly\ Opening\ Price) / Monthly\ Opening\ Price] * 100.$$

The risk and mean return of the sample stocks is given in Table -1.

Table 1: Mean Return and Risk (Beta) of Sample Companies Stock

Securities Name	Mean Return (Ri) in %	Beta (β)
ICICI	1.8283	1.3161
Baja Finance	3.8612	1.8848
Asian Paints	2.169	0.5672

JSW	2.4858	1.1501
Ambuja	0.6191	0.8735
Sun Pharma	1.2858	0.6875
HCL	1.1662	0.8465
TCS	0.9539	0.5961
WIPRO	1.7857	0.2576
Cipla	1.5249	0.3602
Vedantha	1.298	1.5607
DIVIS Lab	3.176	0.4206
Nestle	1.8586	0.3138
HDFC Insurance	0.6993	0.8689
TATA Motors	1.7515	1.819

Source: Calculated using Monthly closing prices of sample stocks

Return: Table 1 shows the mean returns of the 15 companies' stock. Mean return fluctuated between the lowest 0.6191 per cent (Ambuja) and the highest 3.8612 per cent at Bajaj finance. It registered lot of volatility. The mean return was highest at Bajaj finance with 3.8612 per cent followed by DIVIS (3.176 per cent) and JSW (2.4858 per cent). Though these companies are earning highest return but they may be high risky also. Therefore, the risk of the sample stocks calculated.

Risk: In order to know the market risk faced by each security, the beta values of sample Companies stock returns are calculated. A beta below 1 indicates that a volatile investment whose price movements are not highly correlated with the market. The 15 sample companies ICICI, Bajaj finance, JSW, Vedantha and Tata motors has the beta value more than 1 which means they are high risky and volatile when compared to BSE market. The remaining companies' (Asian paints, Ambuja cements, Sun Pharma, HCL, TCS, Wipro, Cipla, DIVIS, Nestle and HDFC Insurance) beta is less than 1, indicating they are less risky. Bajaj finance has the highest Beta and return is also more. On the opposite side, Wipro stock is less risky with reasonable good return. Nestle and Cipla stocks are less risky and the return is more.

Just knowing return does not help, it would be better if compared with risk-free rate and arrive excess return. Investing on equity stock is risky, so investor expects premium (excess return) for investing on equity stock. Therefore, we calculate excess return to beta ratio to ranking the stocks as per their Risk and Return.

Excess Return to Beta Ratio:

The Excess Return to beta ratio measures the additional return on a stock per unit of systematic risk. It means for every rupee of systematic risk how much will be the return. Excess Return to Beta ratio is calculated by using the formula.

$$\text{Excess Return to Beta Ratio} = (\text{Mean Return of Stock} - \text{Risk-free Rate}) / \text{Beta}$$

The Risk-free rate is taken as the interest rate on the 10 years government Bond is 6.83%. The monthly average of risk-free rate is 0.569167% for the period under study. Table 2 gives the excess return to beta ratio and ranking.

Table 2 Excess Return to Beta Ratio and Ranking of Stocks

Security	Ri	Rf	Beta(β)	Ri-Rf	Ri-Rf/ β	Rank
ICICI	1.8283	0.56917	1.3161	1.2591	0.9567	9.00
Baja Finance	3.8612	0.56917	1.8848	3.2920	1.7466	6.00
Asian Paints	2.169	0.56917	0.5672	1.5998	2.8206	4.00
JSW	2.4858	0.56917	1.1501	1.9166	1.6665	7.00
Ambuja	0.6191	0.56917	0.8735	0.0499	0.0572	15.00
Sun Pharma	1.2858	0.56917	0.6875	0.7166	1.0424	8.00
HCL	1.1662	0.56917	0.8465	0.5970	0.7053	10.00
TCS	0.9539	0.56917	0.5961	0.3847	0.6454	12.00
WIPRO	1.7857	0.56917	0.2576	1.2165	4.7226	2.00
Cipla	1.5249	0.56917	0.3602	0.9557	2.6533	5.00
Vedantha	1.298	0.56917	1.5607	0.7288	0.4670	13.00
DIVIS Lab	3.176	0.56917	0.4206	2.6068	6.1979	1.00
Nestle	1.8586	0.56917	0.3138	1.2894	4.1091	3.00
HDFC Insurance	0.6993	0.56917	0.8689	0.1301	0.1498	14.00
TATA Motors	1.7515	0.56917	1.819	1.1823	0.6500	11.00

Table 2 shows that DIVI'S Lab stock has the highest excess return to beta ratio of 6.1979 per cent with first rank and followed by Wipro, Nestle, Asian paints and Cipla. Ambuja cement stock has the lowest of 0.0572 per cent. The ranking of stocks done based on an excess return to the beta ratio reveals that DIVI'S Lab stock ranks first; the Ambuja cement stock ranks the last. The selection of the stock depends on a unique cut-off rate such that all stocks with highest beta ratio included and stocks with lowest ratio are left out the construction an optimal portfolio. Analyst cannot consider all stock for construction of portfolio. Only stocks up to the highest 'C' will be considered. Therefore, we calculate 'C' values.

Cut-off Point

The cut-off value is calculated by using the following equation and the values are given in Table 3.

$$C_i = \frac{\sum_{i=1}^i (R_i - R_f) \beta_{im}}{\sigma_m^2 \sum_{i=1}^i \sigma_{ei}^2} \div \frac{\sum_{i=1}^i \beta_{im}}{1 + \sigma_m^2 \sum_{i=1}^i \sigma_{ei}^2}$$

Where,

σ_m^2 = variance of the market index

σ_{ei}^2 = variance of stock movement that is not associated with the movement of market index i.e. stocks unsystematic risk

The Point will be selected as a Cut-off point after which cumulative value of C_i start declining. Those securities which have value of C_i or equal to cut off point will be selected in optimal portfolio.

Table 3 it is seen that JSW stock has the highest C value 1.5528 that is cut-off rate for the portfolio. All the securities which are before the cut-off point including the company at cut-off point 'C' value will be considered for the construction of optimal portfolio. They are DIVI's Lab, Wipro, Nestle, Asian paints, Cipla, Bajaj finance and JSW. But, the investor cannot invest equally on these stocks. So, the researcher needs to calculate the proportion of investment to be made optimal investment on each stock.

Table 3 'C' Values of Sample Stocks

Security	Ri-Rf*β	σ2ei	(Ri-Rf)β/ σei	∑(Ri-Rf)βi / σ2ei	βi2/σ2ei	∑βi2/ σ2ei	C*
DIVIS Lab	1.096	9.843	0.111	0.111	0.017	0.017	0.579
Wipro	0.313	1.186	0.022	0.133	0.004	0.022	0.678
Nestle	0.404	7.164	0.056	0.189	0.013	0.036	0.902
Asian Paints	0.907	12.878	0.07	0.26	0.024	0.061	1.106
Cipla	0.344	8.715	0.039	0.299	0.014	0.076	1.198
Bajaj Finance	6.204	9.089	0.682	0.982	0.39	0.467	1.532
JSW	2.204	11.513	0.191	1.174	0.114	0.581	1.552
Sun Pharma	0.492	1.029	0.047	1.221	0.045	0.627	1.523
ICICI	1.657	9.528	0.173	1.395	0.181	0.809	1.418
HCL	0.505	8.915	0.056	1.452	0.08	0.89	1.364
Tata Motors	2.15	14.42	0.149	1.601	0.229	1.119	1.238
TCS	0.229	7.433	0.03	1.632	0.047	1.167	1.216
Vedantha	1.137	5.659	0.2	1.833	0.43	1.597	1.034
HDFC	0.113	7.814	0.014	1.847	0.096	1.694	0.989
Ambuja Cements	0.043	18.666	0.002	1.85	0.04	1.735	0.969

Portfolio of Securities:

Seven companies' stock consists of portfolio. They are DIVI's Lab, Wipro, Nestle, Asian paints, Cipla, Bajaj finance and JSW.

Proportion of Investment:

Just shorting or finalizing the companies' stock to be the part of portfolio is not enough, but also necessary to find out the proportion of investment to be made on each stock. Therefore, the proportion of investment to be made on the selected seven stocks is calculated. Proportion of investment on each stock is symbolically:

$$X_i = Z_i \div \sum Z_i$$

While the first equation (X_i) indicates the weights on each security, so they sum to 1.

$$Z_i = \frac{\beta_{im} (R_i - R_f)}{\sigma_{ei}^2 + \beta_{im}^2} - C^*$$

Z_i determines the relative investment in each security. Proportion of investment on select seven stocks is presented in Table 4.

Table 4: Proportion of Investment on Select Stock

Security	Beta(β)	σ_{ei}^2	$R_i - R_f / \beta_i$	C^*	Z_i	$\sum Z_i$	W_i (%)
DIVIS Lab	0.42	7.433	6.197	0.579	0.262	0.262	39.17
Wipro	0.257	9.528	4.722	0.678	0.085	0.348	12.77
Nestle	0.313	5.659	4.109	0.902	0.141	0.49	21.12
Asian paints	0.567	7.164	2.82	1.106	0.1	0.59	14.96
Cipla	0.36	8.915	2.653	1.198	0.044	0.635	6.63
Bajaj finance	1.884	14.186	1.746	1.532	0.025	0.66	3.84
JSW	1.15	12.878	1.666	1.552	0.01	0.67	1.51

Out of total funds available with an investor, the highest portion 39.17 per cent (see table 4) needs to be invested on DIVIS Lab which also has very high return among the selected sample stocks. 21.12 per cent of funds shall be invested on Nestle. The total portion of investment on DIVIS Lab and Nestle is more than half of the funds with 60.29 per cent. The remaining fund shall be made on the stock of Nestle (21.12%), Asian paints (14.96%), Cipla (6.63%), Bajaj finance (3.84%) and JSW (1.51%) respectively.

Portfolio Return on Historical Base

Individual stock's return ranges between the lowest 1.52 per cent (Cipla) and the highest 3.86 per cent (Bajaj finance). Individual security returns from these stocks as well as their respective returns on portfolio is also present in Table 5.

Table 5 Return on Portfolio

Stock	Monthly Stock Returns (%)	Proportion (W_i -%)	Monthly Return on Portfolio (%)
DIVIS Lab	3.176	39.17	1.244
Wipro	1.7857	12.77	0.228
Nestle	1.8586	21.12	0.392
Asian Paints	2.169	14.96	0.324
Cipla	1.5249	6.63	0.96
Bajaj Finance	3.8612	3.84	0.148
JSW	2.4858	1.51	0.037
Total Monthly Return on Portfolio		$\sum X_i = 100.00$	3.3333

Table 5 presents the proportion of investment, individual security return and the portfolio. The returns on the portfolio are calculated considering the proportion of investment in each security. The higher return on portfolio is from DIVIS Lab i.e. 1.244 per cent and the lowest is JSW i.e. 0.037 per cent. The average monthly stock return of the seven stocks is 2.409 per cent.

When we calculate return on portfolio shall be more than the average return. To know whether construction of optimal portfolio is resulting benefit or not we calculated portfolio return using historical monthly return and proportion of investment. Table 5 shows that portfolio return (3.33 per cent) is higher than the average monthly return of the select seven stock indication construction of optimal portfolio helps in maximising return and diversifying risk. Hence, Sharpe's Single Index model helps investors and fund managers in deciding about the securities to be included in his portfolio to drive the best benefits of diversification.

3. FINDINGS

From the analysis and discussion, the following findings have been drawn.

- On the basis of monthly return, among 15 select stocks for the study, Bajaj finance stock has recorded the highest monthly return of 3.86 per cent and Ambuja cement has the lowest return of 0.62 per cent.
- The stock of Bajaj Finance Ltd is highly volatile, since its Beta value is highest with 1.8848 among 15 stocks under evaluation.
- After risk, return and excess return to the Beta, cut off values, seven stocks (DIVI's Lab, Wipro, Nestle, Asian paints, Cipla, Bajaj finance and JSW) are selected for inclusion in the optimal portfolio.
- With regard to the proportion of investment on each stock, the highest portion 39.17 per cent goes to DIVI'S Lab followed by Nestle 21.12 per cent. The total portion of investment on DIVI's Lab and Nestle is more than half of the funds with 60.29 per cent.
- The average monthly stock return is 2.409 per cent and portfolio return 3.33 per cent showing construction of portfolio helps investor to diversify risk and maximize return.
- If an investor invests in the seven stocks portfolio, his/her total monthly expected portfolio return is 3.333 per cent. Hence, Sharpe's Single Index model helps investors and fund managers in deciding about the securities to be included in his portfolio to drive the best benefits of diversification.

4. CONCLUSION

Investment shall be always made on various investment avenues through the study of risk return of each investment avenue under evaluation and need to construct optimal portfolio. Therefore, if an investor would like to invest on various assets, have to measure risk and return on the basis of historical data, find out the assets to be included and the proportion of investment on each asset. Developing optimal portfolio helps investor in terms of minimising risk or maximising the return with same level of risk. Portfolio need to be continuous monitored and balanced as and when required either by changing the number of stocks or proportion of investment on same stock or both. The task of constructing an optimal portfolio would be tedious task when more number of stocks considered for evaluation. But, Sharpe's Single Index model helps made the job of portfolio construction is easy. Just determining optimal portfolio does not help, for final decision investor should consider various other factors affecting the securities return.

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