Original Research

CONSTRUCTION OF OPTIMAL PORTFOLIO USING SHARPE SINGLE INDEX MODEL : STUDY ON BSE 200

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Abstract :

American Economist and Nobel Prize winner Harry Markowitz was the first to introduce creation of optimal portfolio in his Modern Portfolio Theory. Modern portfolio theory of Dr. Harry was mainly based of the risk and return analysis. The model given by the Modern Portfolio Theory was Complex and required a lot of data to work with. Sharpe Single Index was extension of Harry Markowitz's theory which was made by William Sharpe after Studying Markowitz Research. The model provided by the William Sharpe was simple and are widely used. The Sharpe Single Index Model does not require many data inputs like Markowitz model. Sharpe's Single Model is based on the assumption that the covariances in the securities return can be explained by single factor, that is Index. The current study attempts to construct optimal portfolio of the stocks listed in the BSE 200 using Sharpe Single Index Model. For the optimal portfolio construction monthly closing of the selected stocks and Index are taken from the period of October 2015 to October 2021, 364-day T-Bill rate was used as proxy for the risk-free rate. The current study identified 17 stocks eligible for the construction of the optimal portfolio.

Keywords: *Single Index Model, Optimal Portfolio, Cut-off Rate, Beta, risk and return, excess return to beta*

Introduction :

A portfolio consists of various combinations of financial instruments that are available in the market like commodities, bonds and stocks. The art and the process of creating and managing portfolio is known as portfolio management. The portfolio management's main goal while creating a portfolio is to create an optimal portfolio. The portfolio which gives maximum return with least risk taken is known as optimal portfolio. The investors' goal of investing is to get maximum return with least risk, but once invested time bears the result and this market are highly volatile. Hence, to get consistent return that fulfills the investment objective of the investor, strong investment strategy and timely review of the portfolio is required. In market there are many investment avenues that are available to the investors and equity market is one the most widely used avenue

and provides a greater return that any other investment avenue. This paper is an attempt to study the stock listed in the BSE 200 to construct an optimal portfolio using William's Model.

An investor should not invest all in the single desired scrip, putting whole investment in a single basket is not a recommended idea. Single Index model was developed to simplify the optimal portfolio construction from the existing model, this model was made my William Sharpe after him studying the research of the Nobel prize winner Harry Markowitz. This model was constructed based on the observation made by William, that over a period of time price movement of the stocks are similar to that of Index where the stocks are listed, meaning when Index like BSE 200 rises or falls the scrip prices also rises or falls. The William Shape's model assumes that the covariances in the securities return can be explained by single factor, that is Index. William Sharpe gave a model for selecting appropriate stocks and including it in optimal portfolio, below shows steps for construction of optimal portfolio using Single Index Model.

Steps for Construction of Optimal Portfolio :

- Calculate the mean return, beta (β), standard deviation and residual variance $\left(\sigma_{ei}^2\right)$ of each stock and Benchmark Index

- Calculate Excess Return to Beta Ratio and then rank the stocks From Highest Excess Return to Beta Ratio to lowest.

- Calculate the cutoff rate using formula

$$Ci = \sigma m^2 \frac{\sum_{i=1}^{N}\left(R_i \boxed{} - R_f\right)\beta_i / \sigma_{ei}^2}{1 + \sigma m^2 \sum_{i=1}^{N}\left(\beta i^2 \boxed{} \sigma_{ei}^2\right)}$$

- Stock arranged in rank, after Cutoff rate is calculated, stock with highest cutoff rate and stock above it selected for construction of optimal portfolio

- Weightage of portfolio is decided using the formula : $X_i = \dfrac{z_i}{\sum_{i=1}^{N} z_i}$

where $Z_i = \dfrac{\beta_i}{\sigma_{ei}^2}\left\{\left[\left(R_i - R_f\right)\big/ \beta_i\right] - C^{\boxed{}}\right\}$ ….here C* is optimal Cut-off rate.

Review of Literature :

1. Mahabub Basha S. & M.S. Ramaratnam(2017) explored the selection of stock from NIFTY Mid-Cap 150, Nifty Mid-Cap 150 represents the companies based on full market capitalization from Nifty 500 ranked from 101-250 in Nifty 500. For this study the secondary data are collected, and these data are monthly closing prices of the Nifty Mid Cap 150 from July 2011 to June 2016(84 months). 7% risk-free rate was assumed for the study. After calculation for optimal portfolio 25 companies were selected for portfolio construction out of 150. Study believes that construction of optimal portfolio is a road for fund manager, investors and other institutions for taking right investment decisions. Study concludes by advising that the inclusion of the fundamental analysis of the individual securities would, to a greater extent improve the portfolio performance.

2. Prakash Basanna & Namita P. Konnur (2018) Constructed the optimal portfolio using the Sharpe's Single Index Model for NIFTY 50 Stocks. Data collected are of Secondary in nature. Timeframe of data used is 4 years from April 2014 to March 2019 and for construction of portfolio daily average of daily opening and closing price of stocks were used. 364-day monthly treasury bill rate of the financial year 2014-19, 7.15% is used as risk-free rate of return. Out of 50 Stocks, only 8 Companies are selected for optimal portfolio construction as per model.

3. Dr. R. Nalini(2014) studied 15 companies from S&P BSE SENSEX and the data collected were secondary data. For optimal portfolio construction the daily closing price of 15 companies stocks were used and timeframe for data collection was 2009-2014. Risk-free rate of return was assumed at 8%. Out of 15 companies (HDFC, TCS, DR.Reddy's Lab, BAJAJ Auto, ITC, ICICI Bank, Infosys, Larsen & Toubro, WIPRO, Maruti Suzuki, Cipla, ONGC, Hero Moto, HUL) 4 companies were eligible for portfolio construction.

4. Dr. J. Murthy(2018) studied stocks from NIFTY Metal Index, data is of secondary nature and period of data is 4 years(2012-16). 14 metal stocks are used for study and monthly opening and closing data have been used. 0.565% is considered as risk-free rate of return for one month based on the portfolio on 364 days GOI treasury bill. Out of 14 stocks only 2 are selected for creation of the optimal portfolio. Selected two stocks for the optimal portfolio have beta above 1, showing that stock investment is better performing that its broader market.

5. Nitin Tanted, Varun Deshlehara and Vijay Parmar(2013) studies to build optimal portfolio belonging to the manufacturing sector in India using Single Index Model. Sample Size of the study is 12 stocks and its daily return from April 2003 to March 2013 (10 Years) data is collected. 7% 91-day government T-Bill is used as proxy for the Risk-Free rate of return. From 12 Stocks 6.5% were included for the optimal portfolio creation. The study concludes that model is scientific in nature as it considers total risk and the market analyst can rely on this model considering the market fundamentals and economic factors.

Need of the Study :

The investor ready to invest in securities market always faces the dilemma of choosing the suitable stocks from large number of securities available in the market and when securities is decided it is hard to decide how much an investor allocate funds over collection of different securities. Construction of optimal portfolio is a challenge that investors face and Sharpe's Single Index Model helps to arrive at a conclusion for creation of optimal portfolio.

Objectives of the Study :

1. Observing Risk and Return of stocks listed in BSE 200
2. Construction of optimal portfolio using Sharpe's Single Index Model
3. Calculation of the proportion of investment to be made in portfolios each stock.

Research Methodology :

The current study is a descriptive quantitative study and the data used in this study is of secondary nature, price of stocks and index data were collected from BSE's website. For portfolio construction monthly closing

price of the stocks for 6 years from Oct 2015 to Oct 2021 were used. Only 167 stocks from BSE 200 are used for study, other stocks data were not enough for selected timeframe of this study. For risk-free rate the 364 day T-bill rate was used as proxy. Here 3.826% is risk free rate.

Analysis and Results :

Step 1. Mean Returns, Beta, Standard Deviation, Excess Return to Beta ratio :

The data in Table 1 shows Mean Returns, Beta, Standard Deviation, Excess Return to Beta ratio of listed companies. High Mean returns of companies are Ruchisoya (420%) followed by Adanitrans (134%) and Deepak Nitrate (93%). Similarly, companies with least returns were Yesbank (-36%) and Idea (-15%). Out of 167 companies 147 companies gave positive returns. Company with highest and least beta was IndusInd Bank (2.141) and Ruchisoya (-2.48) & Dr Reddy (0.195). The stocks with negative beta are not selected for optimal portfolio using Sharpe Model. Here 3.286% is used as risk-free rate and excess return is calculated by subtracting risk-free rate from mean return. Then excess return to beta ratio is given to all stocks and ranks are assigned from highest to lowest ratios. Abbott India was ranked 1 and Lupin, Yesbank and Ruchisoya were ranked at the bottom.

Step 2. Ranking and Cut-off rate Calculation :

In Table 1 ranks are assigned to stocks and in Table 2 stocks are arranged rank wise and cut-off rate of each stock are calculated. In this study cut-off rate was 0.4078, the stocks above the cut-off rate are selected for the construction of optimal portfolio and stock below are rejected. In the study 17 stocks were with and above cut-off rate. For calculation of the cut-off rate market variance of (0.00281159519537923) is used. This list gives investor an quick perspective whether to hold or not hold stock.

Step 3. Optimal Portfolio Construction with proportion of investment :

The Table 3 shows z-value of each stocks, which is ratio at which each stock investment can be made is shown. Dividing z- value with total z-value, shows proportion of investment in percentage form.

Table 1

No.	Scrip Code	Company	Ri	SD	(Beta) β	Ri – Rf	Ri – Rf/β	Rank
1	500209	INFY	0.1330	0.0934	0.7608	0.0947	0.1245	91
2	500010	HDFC	0.1838	0.0743	1.0999	0.1455	0.1323	89
3	500875	ITC	-0.0327	0.0746	0.6840	-0.0710	-0.1038	159
4	500034	BAJFINANCE	0.5030	0.1729	1.9331	0.4647	0.2404	45
5	532540	TCS	0.1213	0.0945	0.6781	0.0830	0.1224	92
6	532215	AXISBANK	0.1467	0.0971	1.4575	0.1084	0.0744	116
7	500112	SBIN	0.2249	0.1155	1.5451	0.1866	0.1208	93
8	532898	POWERGRID	0.0922	0.0675	0.5734	0.0539	0.0940	107
9	500247	KOTAKBANK	0.2367	0.0749	0.9399	0.1984	0.2111	54
10	500696	HINDUNILVR	0.2223	0.0569	0.2246	0.1840	0.8193	2
11	500510	LT	0.0909	0.0886	1.1167	0.0526	0.0471	122

12	532755	TECHM	0.2335	0.0848	0.6898	0.1953	0.2831	36
13	500312	ONGC	-0.0173	0.1044	1.2646	-0.0556	-0.0440	150
14	507685	WIPRO	0.1000	0.1026	0.3423	0.0617	0.1803	70
15	532978	BAJAJFINSV	0.6030	0.1332	1.7738	0.5647	0.3184	28
16	500180	HDFCBANK	0.1199	0.0866	0.9711	0.0816	0.0840	114
17	500114	TITAN	0.4487	0.0928	0.9582	0.4104	0.4283	14
18	511243	CHOLAFIN	0.2747	0.1599	1.7027	0.2364	0.1388	85
19	508869	APOLLOHOSP	0.2973	0.1052	0.8676	0.2591	0.2986	30
20	500087	CIPLA	0.0854	0.0811	0.4488	0.0471	0.1049	101

Table 2

Rank	Company	$\dfrac{(R_i - R_f)}{\beta}$	σ_{ei}^2	$\dfrac{(R_i - R_f)}{\beta}\sigma_{ei}^2$	$\sum\dfrac{(R_i - R_f)}{\beta}\sigma_{ei}^2$	$\dfrac{\beta^2}{\sigma_{ei}^2}$	$\sum\dfrac{\beta^2}{\sigma_{ei}^2}$	Ci	Status
1	ABBOTINDIA	1.05	0.005	9.81862	9.81862	9.3135	9.3135	0.0269	in
2	HINDUNILVR	0.82	0.003	13.33824	23.15686	16.2791	25.5927	0.0607	in
3	DEEPAKNI	0.77	0.010	104.41873	127.57559	134.9402	160.5329	0.2471	in
4	DIVISLAB	0.66	0.008	19.22365	146.79924	29.1147	189.6476	0.2692	in
5	ADANITRANS	0.66	0.030	86.01952	232.81876	131.1870	320.8346	0.3441	in
6	MINDTREE	0.60	0.016	8.69336	241.51212	14.4313	335.2659	0.3495	in
7	NAUKRI	0.50	0.007	56.35712	297.86924	113.0801	448.3459	0.3705	in
8	PIDILITIND	0.48	0.004	37.08441	334.95365	78.0256	526.3716	0.3797	in
9	COROMANDEL	0.47	0.007	27.32750	362.28115	58.7047	585.0763	0.3851	in
10	NESTLEIND	0.47	0.003	26.34771	388.62886	56.6387	641.7149	0.3896	in
11	ADANIENT	0.46	0.027	62.37251	451.00137	137.0134	778.7283	0.3976	in
12	MPHASIS	0.45	0.006	56.38489	507.38626	124.7551	903.4835	0.4030	in
13	PGHH	0.44	0.002	17.75681	525.14307	40.3145	943.7979	0.4041	in
14	TITAN	0.43	0.006	65.13307	590.27614	152.0735	1095.8715	0.4067	in
15	ASIANPAINT	0.42	0.004	38.49659	628.77273	92.2188	1188.0902	0.4073	in
16	HONAUT	0.42	0.005	38.76067	667.53340	93.3953	1281.4855	0.4077	in
17	IPCALAB	0.41	0.008	12.64406	680.17746	30.8319	1312.3174	0.4078	in
18	ATUL	0.40	0.004	66.18596	746.36342	165.2254	1477.5429	0.4071	Out
19	TORNTPOWER	0.40	0.009	11.12229	757.48571	27.8783	1505.4212	0.4070	Out
20	TATACONSUM	0.39	0.006	61.00794	818.49365	155.7449	1661.1661	0.4058	Out

Table 3

Optimal Portfolio

No.	Company	β	$\dfrac{R_i - R_f}{\beta}$	σ_{ei}^2	$\dfrac{\beta^2}{\sigma_{ei}^2}$	Ci*	Z	Proportion Of Investment
1	ABBOTINDIA	0.2263	1.0542	0.0055	9.3135	0.4078	26.6075	13.955%
2	HINDUNILVR	0.2246	0.8193	0.0031	16.2791	0.4078	29.8302	15.646%
3	DEEPAKNI	1.1622	0.7738	0.0100	134.9402	0.4078	42.4998	22.291%
4	DIVISLAB	0.4725	0.6603	0.0077	29.1147	0.4078	15.5594	8.161%
5	ADANITRANS	1.9968	0.6557	0.0304	131.1870	0.4078	16.2875	8.543%
6	MINDTREE	0.4808	0.6024	0.0160	14.4313	0.4078	5.8420	3.064%
7	NAUKRI	0.9197	0.4984	0.0075	113.0801	0.4078	11.1395	5.843%
8	PIDILITIND	0.5513	0.4753	0.0039	78.0256	0.4078	9.5536	5.011%
9	COROMANDEL	0.6178	0.4655	0.0065	58.7047	0.4078	5.4848	2.877%
10	NESTLEIND	0.4136	0.4652	0.0030	56.6387	0.4078	7.8612	4.123%
11	ADANIENT	1.9114	0.4552	0.0267	137.0134	0.4078	3.4011	1.784%
12	MPHASIS	0.8953	0.4520	0.0064	124.7551	0.4078	6.1564	3.229%
13	PGHH	0.2898	0.4405	0.0021	40.3145	0.4078	4.5448	2.384%
14	TITAN	0.9582	0.4283	0.0060	152.0735	0.4078	3.2560	1.708%
15	ASIANPAINT	0.5730	0.4174	0.0036	92.2188	0.4078	1.5554	0.816%
16	HONAUT	0.7161	0.4150	0.0055	93.3953	0.4078	0.9435	0.495%
17	IPCALAB	0.5084	0.4101	0.0084	30.8319	0.4078	0.1403	0.074%
							190.6630	100%

Note: In Table 1 and Table 2 calculation of only 20 companies is shown, 147 other companies' calculation were done in same way to create optimal portfolio shown in Table 3.

Findings :

1. From the 167 companies selected for study, all the companies are giving positive returns except for 20 companies BEL, GAIL, PFC, HINDPETRO, OIL, ONGC, EMAMILTD, CONCOR, BPCL, ITC, PNB, BHEL, EICHERMOT, GLAXO, COALINDIA, LUPIN, IOC, UNIONBANK, IDEA & YESBANK.

2. The sample data shows that from the 167 companies selected for study, 85 companies have Beta value more than 1 and 82 companies have beat value less than 1, meaning over half stock have more than market risk.

3. Out of 167 securities of which the data are analyzed and calculated, 17 stocks are eligible for the creation of optimal portfolio.

Conclusion :

Construction of an optimal portfolio is a first step that a portfolio manager takes and provides a path to the same for making sound investment decision. The main focus of the current study was to construct an optimal

portfolio for the stocks listed in BSE 200 using Sharpe Single Index Model. Here 167 stock were studied and only 17 stocks were selected for construction of optimal portfolio. Highest proportion of investment for Abbott India (23%) and lowest for IPCA Labs (0.074%)

To improve the effectiveness of the optimal portfolio fundamental analysis of each stocks can be done. Macro-economic Factors, Global trends or other economic factors or trend may be the driving force of some securities price movements. The study of such stocks and factor affecting it can be studied and this kind of micro study will increase the effectiveness of the financial decision of an investors and improve performance of the portfolio. Time to time review of whole portfolio, market study and factors affecting the stocks to adjust the portfolio will be necessary to achieve the long-term financial goal.

Limitation of the Study :

1. The study is only confined to the stocks that belong in the BSE 200
2. In this study data is confined to the time period of 2015 to 2021, as the market are highly volatile in nature this data may not hold its advantage for another period.
3. Here monthly closing period is used for study, volatile stock's average price movement when average is taken of either high and low price or opening and closing price may differ from closing.

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