Analysis of deviations from Security Market Line in BSE 100 stocks

Uday Kumar Jagannathan* Princy Beniwal**

ABSTRACT

Capital asset pricing model (CAPM) sheds light on how assets ought to be priced in the capital markets, the Security market line (SML) provides a graphical representation of it. Roll (1977) in his findings debated about the usage of SML for either asset pricing or performance measurement. The present study aimed to analyse the deviations from SML in Bombay Stock Exchange (BSE) 100 stocks. This research focused to analyse deviations in BSE 100 stocks from SML and construct an equally weighted portfolio from assets which are above SML. Further, it analysed the return and standard deviation of the equal weighted portfolio comprising stocks above the SML against two different market indices.Further, a portfolio using weights from prior year but returns, variances and covariances from current yearwas constructed in order to examine whether such a portfolio would out-perform the market indices or the equally weighted portfolio.With 4 years data, two types of portfolios and 2 different market indices, the mean daily return from a total of 16 (4x2x2) distinct portfolios were compared against the mean daily return of two the market indices. Secondary data includedsplit adjusted BSE 100 constituent daily stock prices over a five-year period from 2013 to 2017. Linear regression,expected return, beta calculation,variance, covariance calculation and hypothesis testing were performed in order to calculate the daily standard deviation andmean return of the prior year weight portfolios. Results show that neither the equal weighted portfolio nor the prior year weighted portfolio returns were statistically different from the returns recorded by either of the market indices.

JEL Classification: G11, G12

Key Words: *CAPM, Equally weighted portfolio, Prior year weighted portfolio, SML*

INTRODUCTION

In the late 60's, practitioners many of them implemented Willian Sharpe (1964) and John Lintner (1965) by optimising their computing power which was deemed superior at that time. Though the academicians were in the nascent stage of investigating into the validity of the CAPM, it was put to work by initiating investments into assets that had high beta i.e. high-risk assets.

Empirical studies related to CAPM such as Roll (1969) and Blume (1968) provided formidable sustenance of security market line (Fama, 1970). Later on, formal studies were conducted to test the CAPM's validity and provided quite promising outcomes (Fama and MacBeth, 1973).There were, later other studies that indicated the shortcomings of CAPM's Security market line such as Fama and French (1992), Basu (1977 and 1983) and Roll (1977). Roll (1977) suggested that the CAPM theory would collapse with restrictions on short selling. This created a controversy on the use of SML as a performance and asset pricing tool. Merton (1987) elaborated that systemic risk was proportionally related to the expected return when the investors are unable to completely diversify their portfolios. The Markowitz portfolio model CAPM was based on the premise that the investors tend to look for the "mean-variance efficient portfolio" in order to be risk averse. Therefore, the expected return calculation using CAPM can be given by:

$E(R_i) = R_f + \beta_i\,(E(R_m) - R_f)$

$E(R_i)$ – Expected retu

R_f – Risk-free return

* Assistant Professor Faculty of Management and Commerce Ramaiah University of Applied Science, Bengaluru, E-mail : Ujagannathan.ms.mc@msruas.ac.in

** MBA (Finacne) Ramesh University of Applied Science. Bengaluru

R_m – Market risk premium

β_i– risk (beta) for firm i

CAPM can be practically used for approximating the capital cost of firms. It can be also used for testing the performance of portfolios. The present research endeavours to analyze deviations in BSE 100 stocks from SML and construct a portfolio from assets which are above SML. SML was constructed using theoretical beta and equally weighted portfolio. Further, a portfolio using weights from prior year but returns, variances and covariances from current year was constructed in order to examine whether such a portfolio would out-perform the market indices or the equally weighted portfolio.

REVIEW OF LITERATURE: Many studies on several markets have shown that multipletechniques are used for analysis of CAPM andsome of them have shown positive results. The typical form of CAPM was established by Mossin (1968), Lintner (1965) and Sharpe (1964). Many researchers like Black (1972), (1993) and Fama and MacBeth (1973) support the standard form of CAPM.MacBeth and Fama (1973), and Black (1973, 1993) have shown acceptance towards the CAPM.

After 1970s, Banz, (1981) found that the firm size was related to deviation in CAPM. Basu, (1983) in his study stated that earnings yield could be the reason for deviation. In Rosenberg et al. (1985)findings it was mentioned that one of the reason for deviation could be book value to equity ratio.Bhandari (1988)stated that deviation were related to leverage. Whereas Roll (1992) found that the deviations were related to industrial structure.Using historical data to forecast the future wasn't much practical in reality (Roll (1997)). The finding of this study was that (1) return and risk are linearly related. (2) The CAPM can be applied to bonds as well and to every asset that existed. (3) The predicted slope of the SML was usually less than the theoretically showed.

Studies done by Fama and French(1992, 1996),Jensen and Scholes (1972), and Black (1972) concentrated on problems related to CAPM.The research findings have been critically evaluated and debated over the period of time.Study conducted by Fama- French(2004) concludes that historical beta and returns are not correlated. The findings of this study contradict the CAPM, indicating that higher beta stocks give higher returns then lower beta stocks.

As compared to western countries capital markets there are only few studies conducted in Indian contest on CAPM. Manjunatha (2009) in his research mentioned that studies done by Yalwar (1988) andVarma (1988) accept the CAPM. He also mentioned that studies conducted by Vaidyanathan(1995), Mallikarjunappa and Manjunatha (2006, 2007), Basu (1977)have opposing views on CAPM model and weren't satisfied about the strength of CAPM in Indian Capital markets. Ansari (2000) believed very scarce amount of research has been done to understand and CAPM on Indian capital markets and therefore no conclusion can be derived exist on this model.Studies conducted in Bangladesh Hasan,Kamil, Mustafa and Baten (2012) shows that CAPM wasn't applicable in the Bangladesh capital market. The evidence from the research conducted using entire and sub periodby Kant (2011) found that market index and individual stock excess return were highly positively related. Murugesan (2013) argued that considering efficient market hypothesis it was not possible to predict future prices using CAPM model.

Problem Statement:

To analyse deviations in BSE 100 stocks from SML and construct a portfolio from assets which are above SML and analyse the sensitivity of the portfolio to different market indices. In addition, construct a portfolio profile using weights from prior year and current year variances, covariances and returns to test if it performs superior to the market or not.

Problem Formulation:

Security market Line:

SML is represented graphically by plotting expected returns on the X axis versus risk (beta) on the Y axis. The expected return is calculated theoretically using CAPM given by:

$$E(R_i) = R_f + \beta_i\,(E(R_m) - R_f)$$

The securities above the SML are considered to be undervalued and securities below the SML are considered to be overvalued. A python algorithm was developed to plot the security market line graph. Then stocks above the SML are taken to construct an equally weighted portfolio for the next year which was tested against the market index.

Calculating the prior year weights for the portfolio:

Let w denote the n X 1 vector of weights to each of the n risky assets, $\sum$ is the n X n variances-covariances of the n assets, and E(r) ≡ E is the n X 1 expected returns

of the n assets. The portfolio optimization problem has a solution as long as the covariance matrix $\sum$ is not singular (and hence it is invertible). In finance terms, this assumption means that there are no redundant assets. Moreover $\sum_i^n wi = wT^1 = 1$, where 1 is a n X 1vector of ones, portfolio returns and variance are denoted by

$$\sum_i^n w_i E(r_i) = w^T E = E(r_p) \equiv \mu$$

$$\sigma_p^2 = w^T \sum w.$$

Formally, the risk-averse investor wants to minimize the variance of his portfolio returns for every level of expected return

$$\min_w w^T \sum w$$

s.t. $w^T E = \mu$ and $w^T 1 = 1$

OBJECTIVES OF STUDY:

Several studiesthat don't support CAPMhave been carried out in Indian capital markets as well as in the western countries But the use of SML as a performance measurement tool is still controversial. The present study aims to analyse the deviations from SML in BSE 100 stocks. This research focuses to analyse deviations in BSE 100 stocks from SML and construct an equally weighted portfolio from assets which are above SML. Further it analysed the sensitivity of the portfolio against different market indices. This study also constructs a portfolio profile using weights from prior year and current year covariances.Ahypothesis testis conducted to check whether SML is a valid technique for performance measurement. The primary objectives are:

i. To plot the security market line and identify the securities which are above security market line

ii. To construct equal weighted and prior year weighted portfolios from assets which are above security market line

iii. Analyse the returns and standard deviations of the portfoliosrelative totwo different market indices

iv. To formulate and testhypotheses to verify portfolio performance relative to the market indices

v. To conclude on findings of portfolio performance relative to the market indices

METHODOLOGY:

Secondary data was used for this research. The data were collected from secondary sources such as BSE, National stock exchange (NSE), quandl data base, reports and websites of selected companies. Furthermore, books, journals, websites, articles and other publications were also considered for the study. The data were collected from BSE 100 index consisting of 100 largest and most liquid Indian companies within the Standard & Poor's (S&P)BSE Large & Mid Cap. Daily stock data was collected for five years from 2013 to 2017. The stocks with missing data i.e. stock price which were not present between 2013 to 2017 were excluded from the analysis. The market index chosen was BSE 500consisting of the top 500 companies listed at BSE Ltd. All the major industries in the Indian economy are covered in this index. In addition, an alternate index, NIFTY 50 index was also selected which is the market index based on India's benchmark board.For testing performance of the equally weighted portfolio against the market indices, the present study was carried out to analyze the deviation from security market line of constituent BSE 100 stocks. The selection of multiple years and two different market indices lends robustness to the research.

The theoretical SMLwas plotted for each year from 2013 to 2017 both included and upon this SML, the actual return and betas for each constituent of the Bombay stock exchange (BSE) 500 with complete data was plotted for each of the years between 2013 to 2017. Deviations from the SML were captured for each year and equally weighted as well as prior year weighted portfolios were constructed using the positively deviant stocks. However, along with prior year weights, current year covariances were considered for the portfolio constructed with prior year weights. The results of these equally weighted as well as prior year weighted portfolio were recorded and compared with market portfolio in question. All the data were tabulated and observation was made as to whether the constructed portfolio outperform the market portfolio in question. Finally, hypothesis testwas performed to verify portfolio performance relative to the market indices.

Tools for analysis:

Tools used for analysis include:

Several python libraries were used in the study - numpy for numerical python relating to numerical calculations, matplotlib for plotting graphs and

figures, statsmodels for running regressions and calculating betas for securities, datetime for date and time related calculations, quandl for retrieval of stock price data, pandas for reading quandl data as well as for internal data operations within the algorithm and finally convex optimizer to obtain prior year weights for portfolios.

A python algorithm was developed to collect five years data (2013-2017) from quandl and used to calculate the stock and market returns. Only stocks without any missing data and were split adjusted appropriately. The developed algorithm was used to plot the SML graph and to identify the securities above the SML. Once the securities above SML were identified an equally weighted was constructed with those securities for the next year. Further,portfolioswere constructed using weights from prior year. This process was repeated for all the four years. Further, this portfolio was tested if it has bet the market portfolioor not. Finally a hypothesis for deviations of the portfolios from the market portfolio was formulated and tested.

Formulation of Hypotheses:

Hypothesis 1:

- H_0: Equally weighted portfolio return is same as the market (BSE 500) portfolio return
- H_1: Equally weighted portfolio return is not same as the market (BSE 500) portfolio return

Hypothesis 2:

- H_0: Prior year weighted portfolio return is same as the market (BSE 500) portfolio return
- H_1: Prior year weighted portfolio return is not same as the market (BSE 500) portfolio return

Hypothesis 3:

- H_0: Equally weighted portfolio return is same as the market (NIFTY 50) portfolio return
- H_1: Equally weighted portfolio return is not same as the market (NIFTY 50) portfolio return

Hypothesis 4:

H_0: Prior year weighted portfolio return is same as the market (NIFTY 50) portfolio return

H_1: Prior year weighted portfolio return is not same as the market (NIFTY 50) portfolio return

DATA ANALYSIS AND RESULTS:

1) Security Market Line:

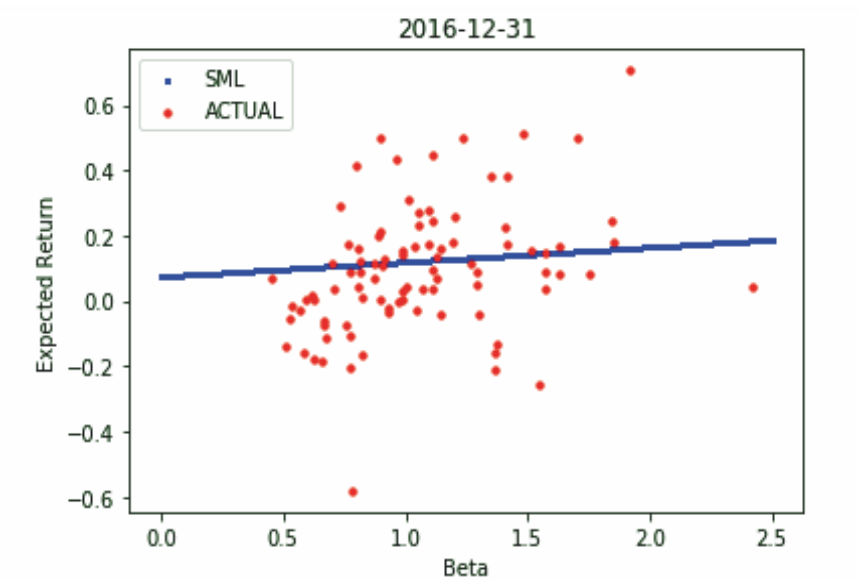

Figure 1: Security market line plot for 2016 – Beta versus yearly mean

Firstly, for illustrative purposes, the SML graph for the year 2016 is shown in Figure 1. It shows different levels of risk (beta) plotted against the expected return.

The red dots represent actual return and blue line represents security market line calculated theoretically using CAPM. The securities above the SML are undervalued and below the SML are overvalued. An

Table 1: Portfolio performance against BSE 500

Year	Equally weighted Portfolio Return (daily)	Standard deviation (daily)	Number of stocks in portfolio	Market Index Return (daily)	Standard Deviation (daily)	T-test value	P-value
2014	0.0014	0.0132	37	0.0013	0.0083	-0.304	0.763
2015	0.0022	0.0175	79	0.0000092	0.0101	0.597	0.552
2016	0.0012	0.0088	37	0.0002	0.0097	1.586	0.120
2017	0.0011	0.0092	39	0.0012	0.0060	0.815	0.420
Mean	**0.0015**	**0.0122**		**0.0007**	**0.0085**		

equally weighted portfolio was constructed with the stocks above SML and their performance in 2017was tested against the performance of the market indices in 2017.

As observed from Figure 1 above there are 37 stocks above the security market line in 2016. An equally weighted portfolio was constructed to test its performance in 2017 against the performance of the market indices in 2017.

The above Table 1 has been constructed with daily return and standard deviation data for equal weighted portfolios constructed in years 2014 to 2017 for stocks above the SML in 2013 to 2016 respectively. The number of stocks above SML for each portfolio is given in the table which changes every year. The table also captures mean daily returns and standard deviation data for the BSE 500 market index. It can be inferred from Table 1 that the mean equally weighted portfolio returnis superior to mean market return for the time period 2014 to 2017 by 0.0008.It can be observed from the table that volatility as well return was highest in the year 2015 for the equally weighted portfolio.In hypothesis testing, p-value is used to determine the significance of results. It can be inferred from the table that for all the four years p-values are greater than 0.05 therefore there are no statistically significant deviations from the market portfolio.

It can be inferred from data in Table 2 that the daily mean equally weighted portfolio returnis superior to mean daily market return for the time period 2014 to 2017 by 0.0009. The table also captures returns and standard deviation data for the NIFTY 50 market index. It can be observed from the table that volatilityas well as return was highest in the year 2015 for the equally weighted portfolio. For market portfolio the highest return was in the year 2014 and highest volatility was in year 2015. It can be inferred that the p-values are greater than 0.05 except in the year 2017 therefore there are no statistically significant deviations from the market portfolio.

The above Figure 3 shows the risk return trade-off for the year 2017. Daily returns were plotted against the standard deviation (risk) of the randomly generated portfolios from 01-01-2017 to 31-12-2017. Although randomized portfolios are not used in the analysis the above figure 3 shows the general range of returns and standard deviations for portfolios constructed in 2017.

Table 2: Portfolio performance against NIFTY 50

Year	Equally weighted Portfolio Return	Standard deviation	Number of stocks in portfolio	Market Index Return	Standard Deviation	T-test value	P-value
2014	0.0014	0.0133	38	0.0012	0.0079	1.596	0.117
2015	0.0022	0.0175	79	0.0002	0.0102	1.412	0.160
2016	0.0012	0.0088	37	0.0002	0.0094	-0.717	0.475
2017	0.0011	0.0092	39	0.0010	0.0057	2.183	0.033*
Mean	**0.0015**	**0.0122**		**0.0006**	**0.0083**		

The above Figure 4 shows the risk-return profile for portfolios constructed in 2017 using the weights from prior year but variance, covariance and returns from current year. The * represents market portfolio (BSE 500) and + represents the equally weighted portfolio (BSE 100) of stocks. The curve represents the prior year weighted portfolio profile being constructed using weights from prior year.

It can be inferred from **Table 3** that thedailymean prior year weighted portfolio returnis superior to mean market return for the time period 2014 to 2017 by 0.00015. The table also captures returns and standard deviation data for the BSE 500 market index. It can be

2. Randomized portfolio of 2017:

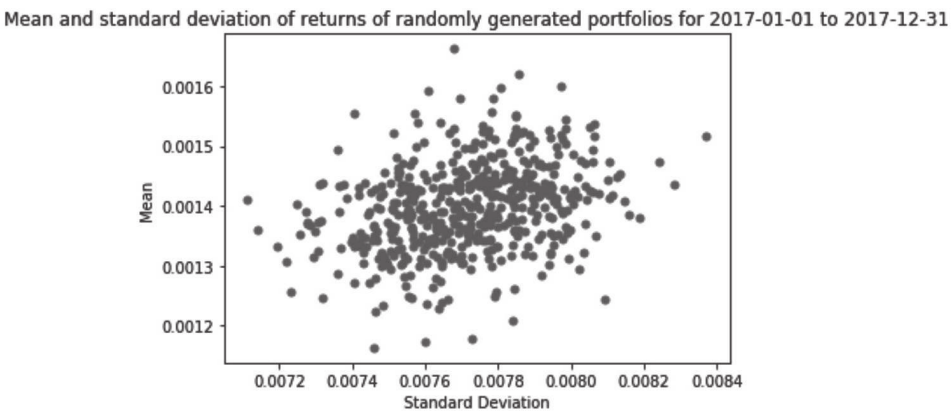

Figure 3:Daily Mean and standard deviation of returns of randomly generated portfolios for 01-01-2017 to 31-12-2017

observed from the table that volatilitywas highest in the year 2015 for both prior year weighted portfolio and market portfolio. The return was highest in the year 2014 for both the portfolios. It can be inferred from the table that the p-values are greater than 0.05 except in the year 2015 therefore there are no statistically significant deviations from the market portfolio.

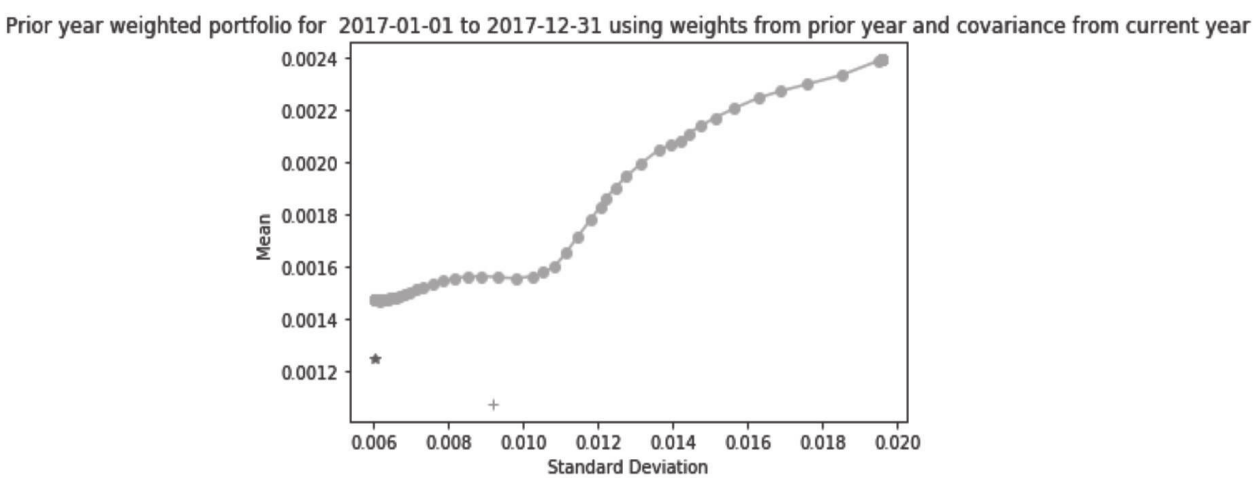

Figure 4: Prior year weighted portfolio for year 2017 Daily mean return versus Standard Deviation

It can be inferred from Table 4 that the mean prior year weighted portfolio returnis superior to mean market return for the time period 2014 to 2017 by 0.00026. The table also captures daily returns and standard deviation data for the NIFTY 50 market index. It can be observed from the table that volatilitywas highest in the year 2015 for both prior year weighted portfolio and market portfolio. The returnwas highest

Table 3: Prior year weighted portfolio for BSE 500

Year	Daily Returns of Portfolio using prior year weights	Daily Equally weighted Standard deviation	Number of stocks in portfolio	Daily Market Return	Daily Market Standard deviation	T-test value	P-value
2014	0.00240	0.0132	37	0.00210	0.0083	-0.901	0.368
2015	0.0080	0.0175	79	0.00090	0.0101	2.157	0.031*
2016	0.0024	0.0088	37	0.00030	0.0097	0.279	0.782
2017	0.00157	0.0092	39	0.00150	0.0060	1.909	0.063
Average	**0.00383**	**0.0122**		**0.000368**			

in the year 2014 for both the portfolios. It can be inferred from the table that the p-values are greater than 0.05 except in the year 2015 therefore there are no statistically significant deviations from the market portfolio.

Out of the total 16 observations across four years, two portfolio profiles and two market indices (4x2x2), only two observations are statistically significant.

DISCUSSION:

Results of Hypotheses Testing

(1) The p-value for majority of the years, with either type of portfolio in comparison to either market index was found to be greater than 0.05 therefore there are no statistically significant deviations from the market portfolio. Hence, the equally weighted portfolio returns are statistically similar to market (BSE 500) portfolio returns. Therefore, the null hypothesis H0is accepted.

Table 4: Prior year weighted portfolio for NIFTY 50

Year	Daily Returns of Portfolio using prior year weights	Daily Equally weighted Standard deviation	Number of stocks in portfolio	Daily Market Return	Daily Market Standard deviation	T-test value	P-value
2014	0.00241	0.0133	38	0.00201	0.0079	-0.677	0.501
2015	0.00071	0.0175	79	0.00081	0.0102	1.260	0.210
2016	0.00025	0.0088	37	0.00028	0.0094	-1.495	0.139
2017	0.00148	0.0092	39	0.00152	0.0057	0.123	0.902
Average	**0.00374**			**0.000348**			

(2) The p-value for majority of the years, with either type of portfolio in comparison to either market index was found to be greater than 0.05 therefore there are no statistically significant deviations from the market portfolio. Hence, the prior year weighted portfolio returns are statistically similar to market (BSE 500) portfolio returns. Therefore, the null hypothesis H0 is accepted.

(3) The p-value for majority of the years, with either type of portfolio in comparison to either market index was found to be greater than 0.05 therefore there are no statistically significant deviations from the market portfolio. Hence, the equally weighted portfolio returns are statistically similar to market (NIFTY 50) portfolio returns. Therefore, the null hypothesis H0is accepted.

(4) The p-value for majority of the years, with either type of portfolio in comparison to either market index was found to be greater than 0.05 therefore there are no statistically significant deviations from the market portfolio. Hence, the prior year weighted portfolio returns are statistically similar to market (BSE 500) portfolio returns. Therefore, the null hypothesis H0is accepted.

CONCLUSION:

Investment analysis is a continuous process of evaluating the investment for profitability and to check if it's the best fit for a portfolio.Roll (1977) in his findings debated about the usage of SML for either asset pricing or performance measurement. Studies done by Fama and French(1992,1996),Jensen and Scholes (1972), and Black (1972) concentrated on problems related to CAPM.Basu and Chawla (2010) found weak evidence for CAPM in the Indian Stock market and that the excess returns and beta are negatively related.

Therefore, from the analysis and resultsit leads to a conclusion that the constructed portfolios are not statistically significantly different from the market indiceshence accepting the null hypothesis. The equally weighted portfolio returns were statistically similar to market portfolio returns. Further the portfolio profile which was constructed using the weights from prior year and covariances from the current year. Hence, it can be concluded that SML is not a good performance measurement tool for the set of data which was used for this research.

Research Implications:

The study on deviations from SMLhelps to test if the SML is a good performance measurement tool. Using the CAPM, theoretical and actual returns can be plotted against the beta (risk) .The portfolio constructed using SML doesn't show any deviations from the market portfolio, and the returns are statistically similar. A study of this kind provides information that it is futile to pick stocks based on SML. This study will definitely help the investors to be aware of the limitation associated with the use of SML for portfolio selection.

Limitation and Future Scope:

This research has been conducted to analyse the deviations from SML in BSE 100 stocks. This study was limited to some selected stocks (BSE 100) and market indices (BSE 500 and NIFTY 50) for the period of 5 years from 2013 to 2017. Stock were adjusted for splits and stocks with missed data were removed from analysis.This study wasbased on CAPM to plot SML. The study will definitely help the investors to avoid choosing stocks on the basis of SML technique. It can be further extended for a longer time period for better results. In addition, stocks below the SML can also be interrogated using short portfolios.

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