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Research Article

Portfolio Construction Using Markowitz's Portfolio Theory: A Study of Selected Stocks of BSE 100

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Abstract: *A portfolio is a collection of various financial assets that a person holds, and portfolio construction is the process of selecting the financial assets that best match the person's investing goals and risk tolerance. Consequently, building a portfolio is a difficult task. This study aimed to simplify the process for investors by demonstrating how to build a two-asset portfolio while keeping Prof. Henry Markowitz's Modern Portfolio Theory in mind. From the BSE 100 Index, 10 large-cap stocks were chosen for the study. Additionally, the selected stocks' correlation with one another was discovered, and the stocks with the lowest connection with one another were found. On the indicated equities, a two-security portfolio building has been done. The four combinations with two companies, each with the lowest variance, standard deviation, and highest Sharpe at various allocated weights, were found.*

Keywords: *Correlation, Portfolio Optimization, Return, Risk, Sharpe, Standard Deviation, Variance.*

I. INTRODUCTION

Investments are made with the objective of generating income or capital appreciation. The two essential components of every investment are risk and return. Investment risk is the potential for volatility in the actual return (Nalini, 2014). It tends to get very difficult to select the right combination of stocks that gives the maximum return at minimum risk, and a rational investor always strives to do the same in an optimal portfolio.

Before moving further, it is important to understand the meaning of a portfolio. According to the definition of a portfolio, it is a collection of varied assets that an investor owns. This group of financial assets can include equity funds, debt funds, gold, real estate, derivatives, bonds, cash equivalents etc. It is, therefore, important to create a portfolio to diversify the risk and maximize the return.

There are two approaches to the portfolio theory. One is traditional, and another one is Modern Portfolio Theory. In the traditional approach, investor's needs for income and capital growth are addressed, and suitable stocks are chosen to match these objectives (Nalini, 2014). The Modern Portfolio Theory (MPT) was propounded by Henry Markowitz. According to MPT, investors should aim to take the least amount of risk possible while generating the highest possible return. MPT is a useful tool for investors since it enables them to select various types of investment for the goal of investment diversification and then create one portfolio by considering all of the investments.

The subject of Portfolio Optimization has brought a lot of attention and academic effort in designing and analyzing the portfolios of various sectors. Since stock prices are volatile, and it is typically very difficult or impossible to predict their future volatilities and values, optimizing stock portfolios is a particularly challenging problem (Sen and Dutta, 2022). Investor's interest in equity portfolio performance that is optimized to have the lowest variance has increased over the past few years. Minimum-variance strategies consider the financial crisis's heightened emphasis on risk management as well as the historical tendency of low-volatility equities to produce returns that are on par with or better than the market (Clarke et al., 2011).

The present study is an attempt to apply the theoretical concept of portfolio management to a real-world scenario by taking the stocks of large-cap companies and forming a well-balanced, optimized and diversified portfolio.

II. REVIEW OF LITERATURE

The process of building a portfolio is complicated, and numerous studies have been conducted to forecast how to build or optimize a portfolio. Different approaches have been identified for the same. Modern Portfolio Theory, propounded by Henry Markowitz, is a framework for selecting and constructing an investment portfolio with maximized predicted portfolio returns while simultaneously minimizing investment risk, Kanta (2021). In the study, Kulali (2016) adopted Markowitz's mean-variance strategy, which seeks to balance expected return and risk as effectively as feasible. Many studies also criticized the theory of the Modern portfolio, propounded the extension to the MPT, and gave ways of portfolio construction.

The work of Sen and Dutta (2022) focused on the superiority of maximization of the Sharpe ratio. As per their study, four sectors out of the six selected sectors gave the highest returns when the portfolio was constructed using the Sharpe ratio maximization strategy. Further, from the empirical research of Rout and Panda (2020), one may be able to predict, to some extent, the return on a specific asset based on changes in the market. The method used in their study, as per the discussion, would result in a portfolio that offers the best risk-return trade-off of any other portfolio in question.

III. PROBLEM STATEMENT

The investor is facing the problem the problem of picking the stock from the large-cap stocks and then investing in those stocks which are least correlated so that the portfolio of the investor can be diversified. Therefore, the present study will help the investor make a portfolio diversified by picking those stocks that are negatively correlated.

IV. OBJECTIVES OF THE STUDY

- Primarily, the study aims to validate Markowitz's portfolio theory by constructing optimal portfolios.
- The study also strives to calculate the CAGR, standard deviation, and mutual correlations of the selected securities.
- Further, the study seeks to construct a 2-security portfolio.

V. RESEARCH METHODOLOGY

The study is Descriptive in nature. The study is based on secondary data, and the required data has been extracted from sources like investing.com and moneycontrol.com. Five sectors from the BSE 100 Index were identified, viz, Pharmaceutical, Banking, Cement, Textiles and Consumer Goods. Further, 2 companies from each sector were identified for the analysis. Then, the 10-year historical data is sorted and used for further analysis.

The steps followed are:

a. Calculating Returns using the formula
(Current Return/Previous Return)-1

b. Calculating CAGR (Compound Annual Growth Rate) using the formula
(Ending value / Beginning value) $^{1/\text{No. of years}}$ - 1

c. Calculating Variance using the formula

$$\sigma_p^2 = w_a^2\sigma_a^2 + w_b^2\sigma_b^2 + 2w_a w_b \sigma_{ab}$$

d. Calculating Standard Deviation using the formula

$$Portfolio\ \ Standard\ Deviation = \sqrt{w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1 w_2 Cov_{1,2}}$$

e. Calculating Co-Variance using the formula
Beta * Variance of Market

f. **Calculating Beta using the formula**
□□ **= Cov (r_i,r_m) / Var(r_m)**

g. Calculating Mean using the formula
Average of Total Return

h. Calculating the Sharpe Ratio using the formula
Sharpe Ratio=Rp −Rf/ σp

VI. CONCEPTUAL FRAMEWORK

A) Parameters used during the analysis of large-cap securities

a. CAGR:
The Compound Annual Growth Rate (CAGR) is the Rate of Return (ROR) that would be required for an investment to grow from its beginning balance to its ending balance, assuming the profits were reinvested at the end of each period of the investment's life span.

b. Standard Deviation:
A measure of total risk, expressed as a percentage showing by how much the actual returns from a security vary from the mean return.

c. Correlation:
A measure of association between the stock price movements of two securities. The values range from -1 to +1, where +1 shows the highest positive association and -1 shows the most negative relationship.

d. Portfolio Theory:
The Modern Portfolio Theory (MPT) is a practical method for selecting investments in order to minimize overall risk while getting reasonable returns. The proponent of the MPT was Dr. Harry Markowitz.

VII. DATA ANALYSIS AND INTERPRETATION

For the study, we took out the monthly returns of the stocks of the selected companies for a period of 10 years. This data is from 1st June 2013 to 1st June 2023.

Table 1: Monthly returns of the selected companies

Dates	BSE 100	Sun Pharma	Divi's Labs	HDFC	ICICI	Ultra Tech	Shree Cement	Vardhman Textiles	Cantabil Retail	Nestle	Britannia
01-06-2013	-3.15%	-3.54%	1.68%	-4.56%	-7.32%	-0.70%	-4.60%	2.06%	-11.68%	-8.44%	-7.17%
01-07-2013	-1.64%	11.86%	-5.72%	-8.80%	-15.00%	-2.31%	-6.47%	5.14%	16.13%	8.79%	4.18%
01-08-2013	-4.56%	-7.85%	6.10%	-2.61%	-11.55%	-19.70%	-17.93%	8.44%	-5.56%	-7.43%	0.43%
01-09-2013	5.07%	14.00%	-2.36%	-0.02%	10.02%	22.96%	14.71%	9.13%	2.94%	6.06%	17.18%
01-10-2013	9.56%	2.60%	0.52%	14.44%	26.68%	8.65%	7.77%	5.35%	-2.57%	7.58%	13.97%
01-11-2013	-1.48%	-5.89%	18.49%	-2.68%	-4.74%	-3.09%	-0.97%	10.21%	5.57%	-8.14%	-6.70%
01-12-2013	2.41%	-0.77%	6.02%	0.69%	2.86%	-7.45%	-1.29%	-3.83%	2.78%	3.11%	5.10%
01-01-2014	-4.04%	3.59%	7.72%	-5.54%	-10.01%	-3.18%	2.05%	-4.22%	-18.92%	-4.77%	-4.06%
01-02-2014	2.72%	9.27%	8.09%	6.14%	5.58%	7.77%	5.87%	-3.93%	15.00%	-3.86%	0.47%
01-03-2014	7.56%	-10.79%	-3.77%	12.19%	19.33%	18.97%	20.51%	2.16%	-1.45%	3.27%	-4.94%
01-04-2014	0.12%	10.15%	0.80%	-4.08%	-0.05%	-7.36%	0.77%	-4.87%	10.88%	-4.72%	2.32%
01-05-2014	9.38%	-3.82%	-7.81%	10.56%	13.94%	17.60%	19.74%	11.04%	17.77%	3.49%	1.95%
01-06-2014	5.41%	12.98%	14.79%	3.43%	0.00%	9.00%	6.51%	27.92%	5.18%	0.15%	14.45%
01-07-2014	0.74%	15.22%	0.97%	1.50%	3.85%	-6.83%	1.57%	-0.90%	-6.00%	3.62%	13.63%
01-08-2014	2.78%	8.08%	5.81%	1.12%	5.67%	5.16%	6.94%	-5.96%	33.03%	17.04%	8.92%
01-09-2014	-0.01%	0.32%	15.32%	3.39%	-7.79%	3.07%	6.83%	0.56%	-3.08%	-0.32%	12.09%
01-10-2014	4.59%	-1.37%	4.02%	4.67%	13.26%	-2.81%	8.28%	-0.72%	-5.65%	4.31%	9.61%
01-11-2014	3.11%	-0.71%	-7.57%	4.96%	7.94%	-2.40%	-1.44%	-3.89%	48.50%	-0.18%	7.73%
01-12-2014	-3.18%	-1.60%	-0.66%	-0.57%	0.59%	7.28%	4.88%	8.13%	-6.31%	2.47%	11.57%
01-01-2015	6.38%	10.87%	1.39%	13.03%	2.31%	17.54%	16.41%	-4.11%	26.24%	11.43%	2.63%
01-02-2015	1.03%	-0.54%	-1.21%	-0.76%	-4.32%	-0.08%	-1.22%	16.03%	6.82%	-1.51%	10.87%
01-03-2015	-4.31%	12.21%	4.00%	-4.21%	-8.75%	-8.36%	-0.51%	6.45%	0.80%	-0.85%	3.09%
01-04-	-	-8.10%	-3.70%	-	5.06	-7.27%	-5.18%	19.98%	17.92%	-	1.61%

2015	3.31 %			3.29 %	%					5.20 %	
01-05-2015	2.75 %	2.80%	5.52%	6.26 %	-4.21 %	11.65%	7.67%	-1.73%	12.76%	4.20 %	16.22 %
01-06-2015	-1.01 %	-9.48%	3.12%	1.56 %	-2.93 %	0.50%	3.02%	6.02%	-12.43%	-7.46 %	8.41%
01-07-2015	2.24 %	-5.89%	4.63%	4.10 %	-1.79 %	5.29%	0.56%	18.28%	10.37%	-0.04 %	14.22 %
01-08-2015	-6.15 %	9.11%	20.78%	-7.48 %	-8.07 %	-7.99%	-5.14%	13.84%	-11.79%	-5.79 %	-7.20%
01-09-2015	-0.54 %	-3.26%	-5.95%	3.96 %	-2.82 %	-7.53%	9.03%	2.69%	-4.80%	6.26 %	5.26%
01-10-2015	1.44 %	2.37%	3.16%	2.63 %	2.50 %	7.61%	4.68%	-22.40%	25.14%	-2.69 %	4.68%
01-11-2015	-1.37 %	-17.81%	-0.25%	-1.92 %	-1.05 %	-2.66%	-9.96%	6.15%	-13.34%	-4.97 %	-9.39%
01-12-2015	0.19 %	12.22%	0.71%	0.63 %	-4.62 %	-0.78%	3.36%	7.91%	0.34%	-0.83 %	1.36%
01-01-2016	-5.51 %	6.47%	-1.21%	-3.12 %	-11.99 %	1.47%	-8.71%	-5.47%	48.65%	-5.73 %	-9.48%
01-02-2016	-7.53 %	-2.06%	-16.71%	-7.28 %	-17.43 %	-2.09%	-3.78%	-5.50%	-19.80%	-8.71 %	2.82%
01-03-2016	10.74 %	-4.16%	3.62%	10.14 %	24.50 %	16.62%	23.25%	4.25%	-2.12%	15.09 %	-3.01%
01-04-2016	1.77 %	-0.99%	6.54%	5.81 %	0.02 %	-2.00%	2.61%	12.34%	11.27%	-0.44 %	6.79%
01-05-2016	3.80 %	-5.99%	5.09%	4.22 %	3.64 %	2.12%	3.56%	-2.68%	-2.60%	6.18 %	-5.29%
01-06-2016	1.85 %	0.12%	0.78%	-0.46 %	-2.04 %	5.65%	10.19%	12.62%	0.27%	6.39 %	1.88%
01-07-2016	5.05 %	8.66%	7.94%	6.01 %	9.43 %	8.61%	10.76%	14.44%	-1.26%	10.43 %	6.28%
01-08-2016	1.87 %	-6.62%	10.47%	3.55 %	-1.96 %	8.73%	6.15%	-8.11%	-5.59%	-8.46 %	17.88 %
01-09-2016	-1.75 %	-4.15%	-2.68%	-1.48 %	-2.10 %	-4.25%	-0.51%	6.42%	-2.14%	-2.00 %	-2.52%
01-10-2016	0.73 %	0.75%	0.04%	-1.42 %	9.79 %	2.94%	-0.59%	7.03%	10.13%	8.00 %	-1.61%
01-11-2016	-5.02 %	-5.07%	-9.11%	-4.32 %	-4.33 %	-9.50%	-7.95%	-3.15%	-12.24%	-9.88 %	-8.30%
01-12-2016	-1.10 %	-11.34%	-33.23%	0.38 %	-3.66 %	-9.69%	-5.42%	0.53%	-3.62%	-3.63 %	-5.12%
01-01-2017	5.31 %	0.29%	-10.65%	6.87 %	5.39 %	13.80%	5.13%	13.93%	1.17%	-3.11 %	8.50%
01-02-2017	4.07 %	7.51%	8.55%	7.94 %	2.73 %	2.13%	4.59%	5.28%	12.61%	7.07 %	3.26%
01-03-2017	3.30 %	1.29%	-17.82%	3.82 %	0.25 %	5.77%	5.78%	-1.03%	5.22%	6.81 %	4.76%

01-04-2017	1.85%	-6.57%	0.61%	6.92%	0.50%	6.25%	13.18%	-1.76%	5.61%	0.32%	7.23%
01-05-2017	2.68%	-21.97%	-7.09%	5.91%	17.17%	-0.99%	-6.55%	0.33%	-17.55%	-0.68%	-2.60%
01-06-2017	-0.76%	10.59%	10.88%	1.16%	-2.20%	-5.57%	-5.87%	-12.34%	-1.35%	0.99%	4.57%
01-07-2017	5.89%	-4.11%	3.87%	7.94%	4.08%	2.44%	10.00%	7.36%	9.27%	0.40%	6.15%
01-08-2017	-1.13%	-9.66%	3.71%	-0.47%	-1.42%	-1.51%	-5.60%	-0.01%	-7.09%	5.20%	7.41%
01-09-2017	-1.38%	4.76%	22.71%	1.58%	-6.95%	-3.64%	5.54%	8.80%	3.22%	1.71%	3.12%
01-10-2017	5.94%	9.98%	3.06%	0.32%	8.30%	14.24%	2.18%	-2.88%	4.28%	-0.02%	7.03%
01-11-2017	-0.66%	-2.43%	18.37%	2.39%	2.62%	-4.32%	-9.24%	1.02%	22.88%	5.94%	2.87%
01-12-2017	3.03%	5.71%	5.28%	1.16%	2.01%	2.61%	4.74%	4.80%	27.16%	2.55%	-1.40%
01-01-2018	3.53%	1.50%	-5.62%	7.09%	12.40%	1.37%	-4.58%	-5.25%	1.60%	-4.85%	-0.92%
01-02-2018	-4.85%	-7.59%	-1.27%	-6.11%	-11.18%	-5.16%	-3.11%	4.28%	18.44%	4.01%	6.68%
01-03-2018	-3.33%	-7.46%	6.47%	0.41%	-11.20%	-4.96%	-2.98%	-9.65%	-14.53%	5.64%	-0.27%
01-04-2018	6.19%	6.61%	9.84%	2.81%	2.17%	4.11%	4.10%	0.61%	13.28%	14.68%	10.77%
01-05-2018	-1.01%	-9.09%	-12.14%	9.85%	0.40%	-9.13%	-0.05%	2.13%	-5.77%	2.67%	7.70%
01-06-2018	-0.48%	16.74%	-1.25%	-1.31%	-3.54%	1.80%	-7.60%	-3.00%	-6.93%	1.56%	4.48%
01-07-2018	5.81%	1.09%	10.38%	3.46%	10.33%	10.20%	9.69%	0.56%	1.66%	7.43%	5.38%
01-08-2018	3.36%	15.10%	13.87%	-5.45%	12.73%	6.69%	11.11%	-9.74%	20.99%	9.86%	3.11%
01-09-2018	-7.29%	-4.42%	0.33%	-2.74%	-10.99%	-9.27%	-11.20%	-8.35%	4.14%	-16.16%	-13.85%
01-10-2018	-4.30%	-7.09%	13.39%	-4.68%	16.43%	-13.73%	-17.46%	-0.63%	-3.74%	4.29%	-2.87%
01-11-2018	4.29%	-15.00%	-3.21%	10.74%	-0.03%	14.12%	18.57%	5.77%	-9.25%	5.90%	12.14%
01-12-2018	0.38%	-12.52%	3.13%	0.25%	1.41%	0.25%	4.47%	4.77%	-0.74%	3.62%	-1.29%
01-01-2019	-0.95%	-1.17%	1.55%	-1.95%	1.18%	-12.04%	-8.50%	-3.07%	12.55%	3.26%	2.49%
01-02-2019	-0.60%	4.65%	9.72%	0.05%	-4.24%	8.72%	5.45%	-7.46%	63.10%	-7.35%	-4.26%
01-03-2019	7.47%	7.60%	3.13%	11.26%	14.35%	4.47%	12.20%	7.91%	24.31%	3.46%	0.72%

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01-05-2019	1.48%	-10.38%	-8.75%	4.72%	3.84%	3.00%	9.24%	-2.49%	-16.68%	5.35%	1.38%
01-06-2019	-1.12%	-2.08%	0.40%	0.89%	3.27%	-4.30%	1.18%	-3.06%	18.38%	3.78%	-6.46%
01-07-2019	-5.87%	6.42%	2.33%	-7.95%	-2.92%	-4.62%	-7.60%	-14.02%	-7.87%	-2.09%	-5.09%
01-08-2019	-0.63%	5.60%	-0.32%	-0.80%	-3.32%	-6.68%	-7.82%	-4.23%	-1.71%	11.79%	3.74%
01-09-2019	3.96%	-13.54%	2.20%	10.13%	5.60%	6.86%	1.92%	8.27%	1.95%	8.27%	9.07%
01-10-2019	3.61%	11.28%	5.49%	0.21%	6.80%	-4.30%	5.41%	-4.24%	-6.43%	7.54%	10.87%
01-11-2019	1.20%	3.74%	1.73%	3.60%	10.61%	2.69%	5.15%	-0.90%	20.23%	-3.38%	-6.42%
01-12-2019	0.77%	-3.85%	3.33%	-0.19%	5.23%	-4.91%	-3.02%	10.90%	12.83%	2.31%	-0.96%
01-01-2020	-1.25%	0.35%	5.81%	-3.62%	-2.45%	9.17%	13.06%	3.85%	-12.95%	3.86%	5.78%
01-02-2020	-6.54%	-14.07%	7.81%	-3.92%	-5.61%	-4.49%	-1.60%	1.34%	24.35%	2.67%	-7.21%
01-03-2020	-23.23%	-5.56%	-5.62%	-26.80%	-34.58%	-22.88%	-22.40%	-40.27%	-34.21%	3.37%	-9.49%
01-04-2020	14.79%	31.98%	17.37%	16.21%	17.07%	8.55%	12.45%	3.44%	22.06%	9.84%	17.67%
01-05-2020	-2.55%	2.28%	2.70%	-5.04%	-12.58%	10.45%	5.44%	1.47%	-8.92%	-2.08%	6.81%
01-06-2020	7.35%	-0.53%	-4.88%	12.03%	5.83%	-0.18%	10.68%	-1.48%	27.05%	-2.03%	6.58%
01-07-2020	7.19%	12.43%	14.86%	-3.10%	-1.29%	5.90%	-5.82%	2.54%	2.25%	-3.79%	6.15%
01-08-2020	2.89%	-2.49%	18.80%	7.99%	13.87%	-5.30%	-6.60%	26.79%	3.29%	-3.51%	-2.61%
01-09-2020	-0.78%	-3.47%	-2.00%	-3.23%	-10.15%	3.61%	-0.14%	-4.78%	7.34%	-0.13%	1.92%
01-10-2020	2.89%	-6.94%	3.05%	9.66%	10.61%	13.02%	6.87%	-4.50%	1.41%	7.77%	-8.46%
01-11-2020	11.35%	9.83%	14.88%	21.74%	20.44%	5.00%	11.37%	6.33%	4.01%	2.88%	4.59%
01-12-2020	8.04%	15.80%	6.51%	-0.27%	13.11%	10.03%	-0.38%	33.34%	12.00%	4.16%	-1.62%
01-01-2021	-2.15%	-1.00%	-12.28%	-3.20%	0.41%	0.77%	-5.29%	-3.96%	-2.62%	-7.20%	-2.02%
01-02-2021	6.71%	1.51%	-0.07%	10.32%	11.28%	14.82%	16.52%	13.81%	2.94%	-5.69%	-3.97%
01-03-2021	0.95%	0.39%	7.77%	-2.66%	-2.74%	10.18%	11.20%	9.68%	-0.81%	6.66%	7.86%

01-04-2021	-0.20%	9.55%	11.93%	-5.45%	3.29%	-6.91%	-5.32%	-9.42%	-1.93%	-5.00%	-4.94%
01-05-2021	6.66%	2.08%	3.21%	7.38%	10.29%	6.99%	-1.18%	9.90%	5.27%	8.47%	0.34%
01-06-2021	1.18%	1.08%	5.06%	-1.21%	-4.73%	0.99%	-0.17%	5.66%	5.90%	-0.09%	5.88%
01-07-2021	0.62%	14.58%	11.32%	-4.82%	8.22%	12.50%	2.64%	39.67%	-2.35%	0.15%	-6.31%
01-08-2021	7.86%	2.60%	5.45%	10.92%	5.30%	2.76%	0.14%	-3.65%	-11.72%	9.92%	16.89%
01-09-2021	2.91%	3.03%	-7.21%	0.89%	-2.51%	-5.60%	2.23%	0.77%	71.40%	-0.04%	-1.23%
01-10-2021	0.23%	-2.91%	7.39%	-0.82%	14.48%	3.21%	-0.92%	4.82%	-0.33%	-2.31%	-7.05%
01-11-2021	-3.36%	-5.09%	-5.29%	-5.61%	-10.97%	-2.60%	-8.91%	4.56%	6.72%	0.83%	-3.34%
01-12-2021	1.77%	12.13%	-4.15%	-0.92%	3.63%	2.12%	3.46%	13.64%	26.97%	2.87%	1.68%
01-01-2022	-0.04%	-1.33%	-13.78%	0.39%	6.62%	-4.97%	-10.11%	4.09%	-2.59%	-5.99%	-1.99%
01-02-2022	-3.26%	1.10%	5.65%	-3.96%	-5.93%	-8.94%	0.53%	6.37%	-8.24%	-4.99%	-3.03%
01-03-2022	3.99%	8.47%	3.34%	3.03%	-1.64%	0.49%	-1.70%	-14.83%	24.54%	-1.29%	-6.52%
01-04-2022	-0.84%	1.52%	2.34%	-5.80%	1.82%	0.41%	8.59%	0.10%	30.50%	5.36%	2.46%
01-05-2022	-3.91%	-7.35%	-20.32%	0.19%	1.07%	-8.24%	-15.06%	-34.25%	-6.81%	-2.94%	11.36%
01-06-2022	-5.17%	-3.45%	1.11%	-2.88%	-5.94%	-7.94%	-13.60%	-7.45%	-4.07%	-1.56%	-5.21%
01-07-2022	9.47%	13.57%	5.47%	6.45%	15.80%	16.89%	7.13%	14.02%	6.93%	10.63%	12.56%
01-08-2022	3.95%	-5.33%	-5.34%	3.61%	8.44%	1.93%	7.81%	9.95%	32.92%	2.99%	-3.98%
01-09-2022	-3.55%	6.24%	1.64%	-4.29%	-2.79%	-6.33%	-4.80%	1.40%	-12.97%	-4.04%	2.65%
01-10-2022	4.73%	7.05%	-2.10%	5.20%	5.30%	7.42%	8.18%	-0.36%	-10.23%	6.50%	-2.06%
01-11-2022	3.67%	2.80%	-5.65%	7.51%	4.94%	5.41%	4.84%	3.78%	-7.11%	-1.29%	15.59%
01-12-2022	-3.44%	-4.18%	0.28%	1.15%	-6.55%	-1.66%	-2.29%	-5.26%	7.83%	-2.52%	-1.06%
01-01-2023	-2.66%	3.43%	-2.79%	-1.47%	-6.66%	1.87%	1.77%	-8.20%	-6.96%	-2.98%	0.27%
01-02-2023	-2.22%	-7.54%	-14.82%	-0.14%	2.77%	2.45%	10.14%	1.47%	-16.42%	-1.88%	3.33%
01-03-2023	0.36%	2.73%	0.00%	0.53%	2.64%	4.91%	0.25%	-4.55%	-10.50%	5.54%	-3.13%

01-04-2023	4.11%	0.38%	15.60%	4.86%	4.62%	-0.86%	-7.03%	8.27%	22.17%	10.50%	5.37%
01-05-2023	3.19%	-1.04%	5.67%	-4.54%	3.35%	4.22%	3.54%	1.37%	3.31%	-0.30%	2.26%
01-06-2023	1.21%	1.25%	3.25%	-1.21%	-1.48%	5.85%	3.98%	9.54%	2.00%	5.90%	8.33%
For further analysis, we have found the standard deviation, variance, co-variance, and beta of the selected companies.											
SD	0.04791	0.08266	0.08636	0.06190	0.08970	0.08071	0.08204	0.10417	0.16196	0.05840	0.06933
Variance	0.00230	0.00689	0.00746	0.00383	0.00805	0.00651	0.00673	0.01085	0.02623	0.00341	0.00481
Co-Variance		0.00124	0.00074	0.00241	0.00333	0.00258	0.00257	0.00188	0.00217	0.00122	0.00138
Beta		0.54091	0.32129	1.04982	1.45259	1.12280	1.12175	0.81820	0.94677	0.52945	0.60318

Table 2: Correlation Table

	Sun Pharma	Divi's Labs	HDFC	ICICI	UltraTech	Shree Cement	Vardhman Textiles	Cantabil Retail	Nestle	Britannia
Sun		0.3439754	0.02418	0.125291	0.2188225	0.166498907	0.105056474	0.24978411	0.200845	0.241974
Divi		1	0.052568	0.117614	0.0895173	0.07993958	0.237694559	0.106231699	0.155829	0.073751
HDFC				0.684457	0.5060446	0.588717813	0.237294067	0.190345193	0.305002	0.361457
ICICI					0.4810164	0.465696825	0.311876381	0.155170735	0.358156	0.153172
Ultra Tech						0.764638581	0.30314662	0.127979733	0.32532	0.300543
Shree Cement							0.268946028	0.158085789	0.382684	0.338004
Vardhman Textiles								0.074895322	0.069677	0.108845
Cantabil Retail									0.118243	-0.0101
Nestle										0.362758
Britannia										

The next step was to form a correlation table of all the 10 securities. We have considered the combination of those companies, with a correlation of less than 0.2. As we know, correlation values vary from +1 to -1. Here, +1 means a strong positive relation, and -1 means a strong negative relation. Therefore, the ones which have been colored green represent the securities with a lower correlation. The lower the correlation, the lower the risk of the portfolio. In the next part of the study, we have identified 3 companies with the maximum number of correlations with other companies. The companies are:

- Divi's Lab
- Cantabil Retails
- Sun Pharma

A) Correlation Data

Table 3: Divi's Labs

Companies	Correlation
HDFC	0.05
ICICI	0.12
Ultra Tech	0.09
Shree Cement	0.08
Cantabil Retail	0.11
Nestle	0.16
Britannia	0.07

Source: *Authors' compilation*

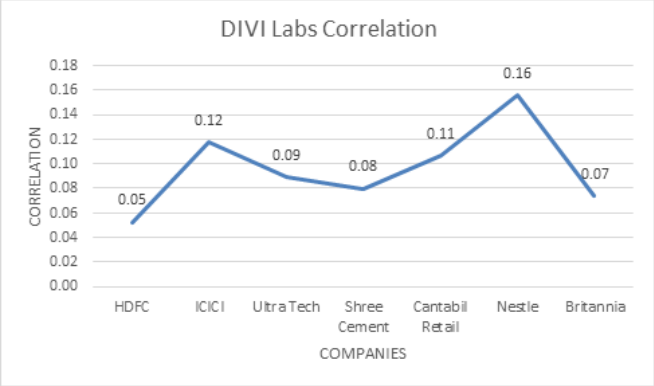

Figure 1: DIVI Labs

Source: *Authors' compilation*

Table 4: Cantabil Retail

Companies	Correlation
Divi	0.11
HDFC	0.19
ICICI	0.16
Ultra Tech	0.13
Shree Cement	0.16
Vardhman Textiles	0.07

Source: *Authors' compilation*

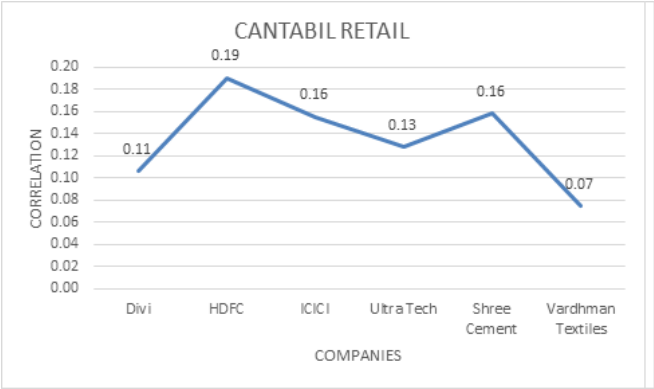

Figure 2: Cantabil Retail

Source: *Authors' compilation*

Table 5: Sun Pharma

Companies	Correlation
HDFC	0.02
ICICI	0.13
Shree Cement	0.17
Vardhman Textiles	0.11

Source: *Authors' compilation*

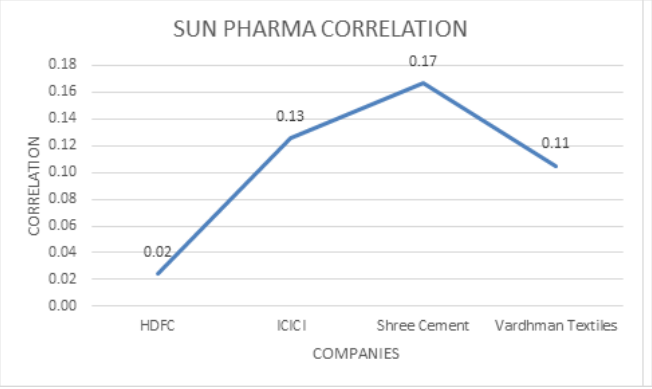

Figure 3: Sun Pharma

Source: *Authors' Compilation*

B) Two Asset Portfolio

Table 6: Two Test Portfolio

	Mean	Variance	Std Deviation	Co-var
Divi's Lab	2.04%	0.00746	0.08636	0.00074
HDFC	1.45%	0.00383	0.06190	0.00241
Sun Pharma	0.86%	0.00689	0.08266	0.00124
Cantabil	4.60%	0.02623	0.16196	0.00217
Britannia	2.44%	0.00481	0.06933	0.00138
Vardhman	2.14%	0.01085	0.10417	0.00188

For a better understanding of portfolio development, we have now created two asset portfolios. We combined two companies and assigned weights (in percentage) ranging from 0% to 100% to each company before determining the proportion in which we obtained the lowest variance, standard deviation, and maximum Sharpe.

a. The very first combination taken is Divi's Lab and HDFC

Table 7: Divi & HDFC

DIVI's Lab	HDFC	Mean	VAR	STDEV	Sharpe
0%	100%	1.45%	0.003832	0.061901	-85.59%
10%	90%	1.51%	0.003404	0.058343	-89.81%
20%	80%	1.57%	0.00279	0.052821	-98.08%
30%	70%	1.63%	0.002733	0.052275	-97.98%
40%	60%	1.69%	0.002573	0.050721	-99.83%
50%	50%	1.75%	0.002822	0.053125	-94.20%
60%	40%	1.80%	0.003298	0.057426	-86.13%
70%	30%	1.86%	0.003999	0.063238	-77.28%
80%	20%	1.92%	0.004926	0.070186	-68.79%
90%	10%	1.98%	0.006079	0.077967	-61.18%
100%	0%	2.04%	0.007458	0.086357	-54.55%

Source: *Authors' Compilation*

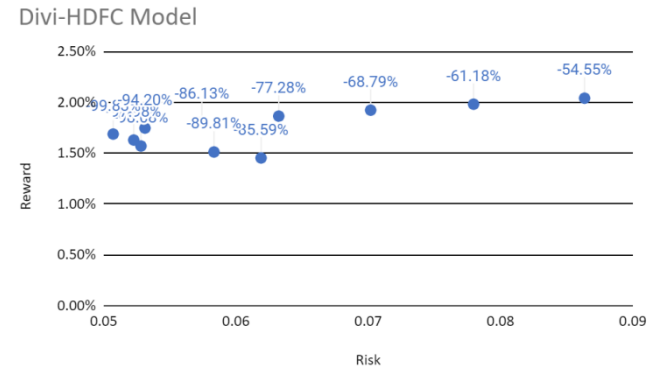

Figure 4: Divi-HDFC Model

Source: *Authors' compilation*

From the above table, we can conclude that while picking these two stocks in a portfolio, one should try to give 40% weightage to Divi's Lab stock and 60% weightage to HDFC's stock.

b. The next combination taken was Cantabil and Vardhman

Table 8: Cantabil & Vardhman

Cantabil	Vardhman	Mean	VAR	STDEV	Sharpe
0%	100%	2.14%	0.010852	0.104175	-44.23%
10%	90%	2.39%	0.009278	0.096324	-45.29%
20%	80%	2.63%	0.008396	0.091629	-44.93%
30%	70%	2.88%	0.008205	0.090581	-42.74%
40%	60%	3.12%	0.008706	0.093304	-38.86%
50%	50%	3.37%	0.009898	0.099488	-33.98%
60%	40%	3.61%	0.011782	0.108543	-28.88%
70%	30%	3.86%	0.014357	0.11982	-24.12%
80%	20%	4.11%	0.017624	0.132755	-19.92%
90%	10%	4.35%	0.021582	0.146909	-16.33%
100%	0%	4.60%	0.026232	0.161964	-13.30%

Source: *Authors' compilation*

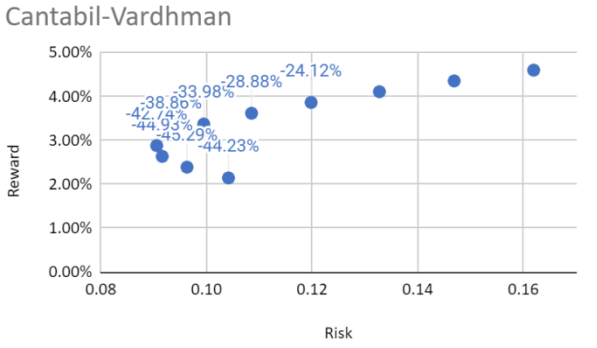

Figure 5: Cantabil-Vardhman Model

Source: *Authors' compilation*

According to the analysis, it would be reasonable to allocate 30% of one's portfolio to Cantabil and 70% to Vardhman. It should be noted that the combination of 30%-70% does not have the highest Sharpe but the lowest Variance and Standard deviation, which is why we chose this combination to support the MPT.

c. Further, we have taken Sun Pharma and HDFC

Table 9: Sun Pharma & HDFC

Sun	HDFC	Mean	VAR	STDEV	Sharpe
0%	100%	1.45%	0.003832	0.061901	-85.59%
10%	90%	1.39%	0.003195	0.056522	-94.78%
20%	80%	1.33%	0.002767	0.052605	-102.95%
30%	70%	1.28%	0.002549	0.050491	-108.42%
40%	60%	1.22%	0.002541	0.050408	-109.77%
50%	50%	1.16%	0.002742	0.052364	-106.79%
60%	40%	1.10%	0.003153	0.056147	-100.64%
70%	30%	1.04%	0.003773	0.061421	-92.95%
80%	20%	0.98%	0.004602	0.067839	-85.02%
90%	10%	0.92%	0.005641	0.075108	-77.58%
100%	0%	0.86%	0.00689	0.083005	-70.90%

Source: *Authors' Compilation*

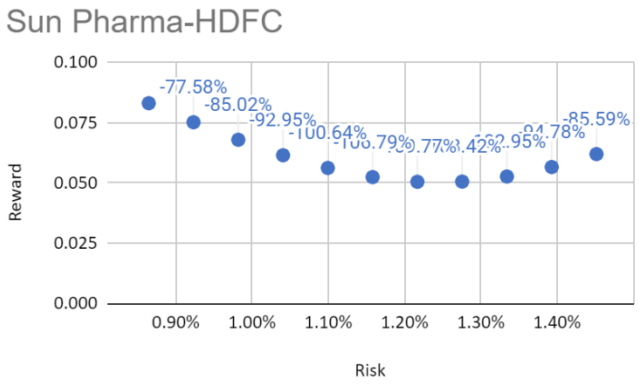

Figure 6: Sun Pharma-HDFC Model

Source: *Authors' compilation*

The above analysis indicates that we should opt for 40% of Sun Pharma's stock and 60% of HDFC's stock as it has the lowest Variance and Standard deviation and highest Sharpe.

d. Last but not the least combination taken was Divi- and Britannia

Table 10: Divi & Britannia

DIVI'S	Britannia	Mean	VAR	STDEV	Sharpe
0%	100%	2.44%	0.004807	0.069332	-62.22%
10%	90%	2.40%	0.004047	0.063616	-68.43%
20%	80%	2.36%	0.003515	0.059286	-74.10%
30%	70%	2.32%	0.00321	0.056661	-78.24%
40%	60%	2.28%	0.003134	0.055981	-79.90%
50%	50%	2.24%	0.003285	0.057315	-78.73%
60%	40%	2.20%	0.003664	0.060531	-75.20%
70%	30%	2.16%	0.004271	0.065351	-70.26%
80%	20%	2.12%	0.005105	0.071451	-64.82%
90%	10%	2.08%	0.006167	0.078533	-59.48%
100%	0%	2.04%	0.007458	0.086357	-54.55%

Source: *Authors' compilation*

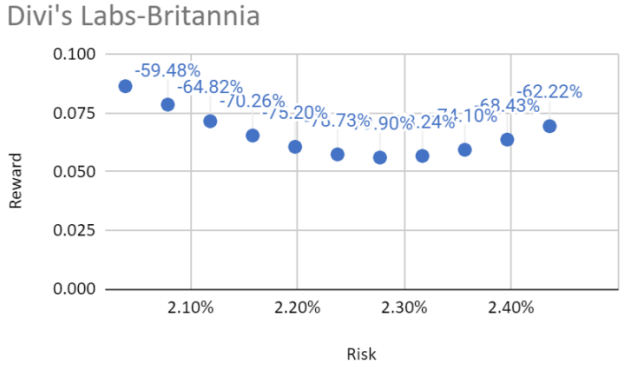

Figure 7: Divi Labs-Britannia

Source: *Authors' Compilation*

From the above table, it is evident that we should choose a 40%-60% combination for Divi's Labs and Britannia, respectively. As, it includes the highest Sharpe and lowest Variance and Standard deviation.

VIII. FINDINGS AND CONCLUSION

Optimal portfolio construction can be a challenging task; therefore, this study aimed to make that easy and developed a two-asset portfolio supporting the Modern Portfolio Theory by Markowitz. It is evident from our study that risk can be reduced moderately. It is shown that low-correlated assets can be paired to construct portfolios, which is the core idea of diversification, to produce low-risk portfolios.

The study also demonstrated how two asset portfolios, which provide the investor with the best returns at the lowest risk, can be created by varying the weights of two securities in a portfolio.

Having a correlation -1 between 2 securities is ideally not possible. If that happens the risk might turn out to be zero in that case. It is evident that Markowitz's portfolio theory is a conceptually and practically sound method of portfolio construction for 2 to 3 securities. Due to the large amount of data required as the number of securities in the portfolio increases, the practical applicability of using the method without advanced computing technology becomes less.

In this study, the selected companies with a correlation less than 0.2 are Divi's labs, HDFC, Sun Pharma, Cantabil Retail, Britannia, and Vardhman Textiles. 4 Combinations have been formed for the portfolio are-

1. DIVI-HDFC with a 40:60 ratio.
2. Cantabil-Vardhman with a 30:70 ratio.
3. Sun Pharma-HDFC with a 40:60 ratio.
4. DIVI-Britannia with a 40:60 ratio.

The Indian capital market still has a lot of potential to diversify its investment strategies. As a result, the findings of this study may be helpful to investors looking for a strategy for stock market investments. Additionally, investment bankers, portfolio managers, etc., may find use for the results.

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