An Empirical Study on construction of Optimum portfolio using Harry Markowitz Model [A Case Study with special reference to Dow Jones Industrial Average (S&P DJIA Indices)]

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Abstract:

A Portfolio is a combination of different investment assets mixed and matched for the purpose of achieving an investor's goal. A portfolio is a professional way to display projects and prevents them from getting lost, dirty or damaged. The key to creating an efficient portfolio is reaching desired goal by using as little resources as possible. The ideal investment is to pick a low risk stock with hopes of big returns. That is nearly impossible. In the game of investing, high risk equals high return and vice versa. Harry Markowitz's Modern Portfolio Theory explains that by diversification, the potential risk can be dispersed throughout portfolio. This means balance a high risk stock with a low risk stock, as well as investing in different sectors.

The paper attempts to study on "An Empirical Study on Construction of Optimum portfolio using Harry Markowitz Model". The study is analytical in nature and used secondary data analysis to attain its objectives. The secondary data consists of the annual reports of Dow Jones Industrial Average index-30 companies covering the last 20 years from 1999 to 2019.Various other reports like magazines, journals, published books and official websites are

also referred to for the present study. The statistical tools applied for data analysis in the present study are Percentages, Simple Average, Weighted Averages, Variance, Standard Deviation, Covariance, Coefficient of Variation, ratios, portfolio return and portfolio variance. The result depicts that optimum portfolio containing Apple (AAPL), IBM, Intel (INTC), Johnson & Johnson (JNJ), and MMM (3M) can be built.

Key words: Liquidity Ratio (LR), Asset Turnover Ratio (ATR), Return on equity (ROE), Interest Coverage Ratio (ICR), & Net Profit Margin (NPM).

A Portfolio is a combination of different investment assets mixed and matched for the purpose of achieving an investor's goal. A portfolio is a professional way to display projects and prevents them from getting lost, dirty or damaged. The key to creating an efficient portfolio is reaching desired goal by using as little resources as possible. The ideal investment is to pick a low risk stock in hopes of big returns. That is nearly impossible. In the game of investing, high risk equals high return and vice versa. Harry Markowitz's Modern Portfolio Theory explains that by diversification the potential risk can be dispersed throughout portfolio. This means balance a high risk stock with a low risk stock, as well as investing in different sectors.

Here is a right way and a wrong way to build a securities portfolio. Like horse racing, where you may do well short term by picking horses by the color of their silks. Share market is an arena which fascinates each and every individual who is craving for more money. Trading in stocks is quiet simple; an investor has to possess some basic knowledge of the security that he will be trading.

Building a portfolio is not as simple as putting random pieces of work into a folder, and requires time, thought and organization. Building a stock portfolio is very difficult to do because it takes a lot of study. But, in the end, the ability of the stock market to grow over time will most likely lead to reaching goals. This ensures people who view portfolio can see talents instantly and are more likely to be impressed by what they see.

Conceptual framework of Portfolio:

Globalization of the financial market has led to a manifold increase in investment. New markets have been opened; new instruments have been developed and new services have been launched. India has a well-established capital market mechanism where in effective and efficient transfer of money capital or financial resources from the investing class to the entrepreneur class in the private and public sector of the economy occurs. The numbers of acts are passed to boost the revolutionary change.

Investment means buying securities or other monetary or paper (financial) assets in the money markets or capital markets, or in fairly liquid real assets, such as gold as an investment, real estate, or collectibles. Valuation is the method for assessing whether a potential investment is worth its price. These investments assets are then expected to provide income or positive future cash flows, but may increase or decrease in value giving the investor capital gains or losses.

"Portfolio is a combination of securities such as stocks, bonds and money market instruments. The process of blending together the broad asset classes so as to obtain optimum return with minimum risk is called portfolio construction". A large numbers of portfolios can be formed from a given set of assets. Each portfolio has risk return characteristics of its own. Portfolio theory originally developed by Harry Markowitz shows that portfolio risk, unlike portfolio return, is more than a simple aggregation of the risk of individual assets. This depends on the interplay between the returns on assets comprising the portfolio. As investors construct a portfolio of investment rather than invest in a single asset. This section extends the analysis of risk and return associated with portfolio investments.

Diversification of investments helps to spread risk over many assets. A diversification of securities gives the assurance of obtaining the anticipated return on the portfolio. In a diversified portfolio some securities may not perform as expected, but others may exceed the expectation and making the actual return of the portfolio reasonably close to the anticipated one. Keeping a portfolio of a single security may lead to a greater likelihood of the actual return somewhat different from that of the expected return. Hence, it is a common practice to diversify securities in the portfolio.

Risk and Return of Portfolio:

Portfolio Expected Return:

The expected rate of return on a portfolio is the weighted average of the expected/average rates of return on assets comprising the portfolio. The weights, which add up to 1, reflect the fraction of total rate of return on each assets and the relative share of each asset in the portfolio. Symbolically the expected return for an-asset portfolio is defined by

$E(r_p) = \Sigma w_i E(r_i)$ or $AR(r_p) = \Sigma w_i AR(r_i)$

Where $E(r_p)$ or $AR(r_p)$ = Expected/ average return from portfolio

                       w_i = Proportion invested in asset

                       $E(r_i)$/ $AR(r_i)$ = Expected/ average return for asset

Portfolio Risk (Two assets Portfolio):

Total risk is measured in terms of variance (σ^2 pronounced sigma square) or standard deviation (σ pronounced sigma) of returns. Unlike portfolios expected return, portfolio variance (or standard deviation) is not the weighted average of variance (or standard deviation) of returns on individual assets (securities) in the portfolio. The overall risk of the portfolio includes the interactive risk of an asset relative to the others, measured by the covariance of returns. The covariance, in turn, depends on the **correlations** between returns on assets in the portfolio. The minimum Variance portfolio is also called the **optimum portfolio**. However, investors do not necessarily strive for the minimum variance portfolio. A risk-averse investor will have a trade-off between risk and return. The choice of a particular portfolio will depend on risk preference. General formula for estimating optimum weights of two securities X and Y so that the portfolio variance is minimum:

$$W^* = \sigma^2_y - COV_{xy} / \sigma^2_x + \sigma^2_y - 2COV_{xy}$$

Where W^* is the optimum portion of investment in security X. Investment in Y will be (1-W)

The total risk of a portfolio made up of two assets:

$$\sigma^2_p = (w_1 * \sigma_1)^2 + (w_2 * \sigma_2)^2 + 2 w_1 * w_2 (r_{12} * \sigma_1\sigma_2)$$

The total risk of a portfolio made up of six assets:

$$\sigma^2_p = (w_1 * \sigma_1)^2 + (w_2 * \sigma_2)^2 + (w_3 * \sigma_3)^2 + + (w_4 * \sigma_4)^2 + (w_5 * \sigma_5)^2 + 2 w_1 * w_2 (Cov._{12}) + 2 w_1 * w_3 (Cov._{13}) + 2 w_1 * w_4 (Cov._{14}) + 2 w_1 * w_5 (Cov._{15}) + 2 w_2 * w_3 (Cov._{23}) + 2 w_2 * w_4 (Cov._{24}) + 2 w_2 * w_5 (Cov._{25}) + 2 w_3 * w_4 (Cov._{34}) + 2 w_3 * w_5 (Cov._{35}) + 2 w_4 * w_5 (Cov._{45})$$

Statement of the Problem:

One aspect of financial engineering is the development of portfolio management strategies. Portfolio Construction is one of the important components of Portfolio management. It is vital task which requires skill of analytical bent of mind with adequate knowledge. It is a complex process passing through various phases, the most important being selection of securities. While selecting securities, the various parameters are considered, the most significance is objectives of investors. Keeping in view adequate diversification in portfolio, principle of dominance – maximum return with given level of risk and minimum risk with given level of return – is followed. Obviously, diversification/the asset allocation process refers to the process of investing money in different financial assets. Different stages of the asset allocation process, e.g., strategic and tactical asset allocation are described. Asset allocation process is an iterative process since a continuous monitoring of the portfolio characteristics is essential. There is no generally accepted methodology for this problem.

The first step of the elaboration of an asset allocation strategy is the definition of the risk measure. However, not all risk measures are well suited for the derivation of optimal asset allocation strategies. Following lack of time, unsound knowledge, insufficient diversification, and quick reaction to market sentiments, investors burnt their fingers in their investment. The investment decisions are derived from the portfolio optimization. A portfolio optimization is only possible once a model of the portfolio return and risk is built. Various models have been developed namely Harry Markowitz, William F. Sharpe and Arbitrage Pricing Theory. Based on these models, portfolio return and risk and its characteristics are computed.

Hence, an attempt is made to "**An Empirical Study on Construction of Optimum Portfolio using Harry Markowitz Model".** The findings of this undoubtedly help investors, academicians, and budding mutual fund/ portfolio managers.

Objectives of the Study:

1. To select securities of DJIA based on fulfilment of parameter of weighted average of Liquidity Ratio (LR), Asset Turnover Ratio (ATR), Return on equity (ROE), Interest Coverage Ratio (ICR) and Net Profit Margin (NPM);
2. To construct the optimal portfolio computing portfolio return and risk using what if analysis for Harry Markowitz Model;

Research Design:

In view of the objectives of the study listed above, exploratory research design has been adopted. Exploratory research is one, which largely interprets the already available information, and it lays particular emphasis on analysis and interpretation of the existing and available information and it makes use of secondary data.

Research Methodology:

The study is based on secondary data and discussions with concerned personnel. The secondary data consists of annual reports of Dow Jones Industrial Average Index (30 companies) covering the period of last 20years from 1999 to 2019. Various other reports like magazines, journals, published books and official websites are also referred for the present study. While calculating weighted averages, recent years are given more weightages and distant years

are given the least weightages. The company which satisfies the parameter of Assets Turnover (ATR) is $\geq 50\%$, ICR is ≥ 5, LR is ≥ 1, NPM is $\geq 10\%$ and ROE $15\% \geq 15\%$ are chosen for selection of securities. Accordingly Apple (AAPL), IBM, Intel (INTC), Johnson & Johnson (JNJ), and MMM (3M) are satisfied with those parameters**.** For proportion of investment in each selected security is calculated prescribing minimum of 1% and maximum of 96% using what if analysis. Nine hundred and sixty two scenarios of weights are used to arrive at optimum weightage for allocating proportion of amount in each security. Finally, the optimum portfolio is built using Markowitz model.

Sources of data:

Tools of analysis: The data collected for the study is analysed logically and meaningfully to arrive at meaningful conclusions. The statistical tools applied for data analysis in the present study are Percentages, Simple Average, Weighted Averages, Variance, Standard Deviation, Covariance, Coefficient of Variation, ratios, portfolio return and portfolio variance.

Findings:

1. **Wal-Mat (WMT) stands first in the ranking of Weighted Average of Asset Turnover Ratio of 2.4367. It is followed far away by two other companies namely Home Depot (HD) and Walgreen (WBA) having the range of 2.2813 to 1.8873 of ATR, Seventeen other companies including UnitedHealth (UNH), and Nike are in the range of 1.5 to 0.50. Ten companies are less than below 0.5.**

2. **MMM (3M) company has the highest Weighted Average of Interest Coverage Ratio of 562.0253%.followed by Exxom Mobil (XOM) of 39.7333%, Intel (INTC) of 37.188%, Johnson & Johnson (JNJ) of 28.0353%, Apple (AAPL) of 24.5933%, Boeing of 23.6647%, Disney (DIS) of 21.3973%, Cisco (CSCO) of 21.3853%, and IBM of 20.8953%. Nineteen companies are in the min max of 5%-20%. Rest of the companies are not more than 5%.**

3. **Microsoft (MSFT) leads in Weighted Average ranking of Liquidity Ratio of 2.9947, followed by   Cisco (CSCO) with 2.3447, American Express (AXP) with 1.93, McDonald's (MCD) with 1.6247, and Nike (NKE) with 1.579. Eight other companies are in the range of 1% – 1.5%, and fifteen other companies comprising Wal-Mat (WMT), Disney (DIS), P&G, and Walgreen (WBA) are not more than 1%.**

4. **The highest weighted Average of Net Profit Margin of 44.9293% is achieved by Visa which is followed by Pfizer (PFE) by 24.1293%, McDonald's (MCD) by 23.3533%, Intel (INTC) by 23.1347%, JPMorgan Chase (JPM) by 21.9333%,Apple (APPL) by 21.7393%, Microsoft (MSFT) by 21.498%, Goldman Sachs (GS) by20.466%, Disney (DIS) by 19.492%, P&G by 16.806%, MMM (3M) by 16.168%, Cisco (CSCO) by 15.9593%, and Johnson & Johnson (JNJ) by 15.3873%. Five companies having Verizon (VZ), IBM, Coco Cola (KO), Merck (MRK) and American Express (AXP) with range of 15%-10%, rest of the companies are below 10%.**

5. **Verizon (VZ) has the highest weighted Average of ROE with 61.3533%, followed by IBM with 55.1893%, MMM (3M) with 47.6587%, Apple (AAPL) with 42.768%, Nike (NKE) with 33.7833, Microsoft (MSFT) with 28.312%, V Visa with 25.94%, American Express (AXP) with 24.224%,Coca Cola with 23.3027%, UnitedHealth (UNH) with 21.6287%, Intel (INTC) with 21.1707%, Disney (DIS)**

with 20.9027%, and Caterpillar with 20.1787%. Seven companies are in between 20%-15%, rest all are below 15%.

6. While making choice of companies from DJIA; Wal-Mat (WMT), Home Depot (HD),Walgreen (WBA), Nike (NKE),UnitedHealth (UNH),Boeing (BA),MMM (3M),Exxon Mobil (XOM),Apple (AAPL), McDonald's (MCD), IBM (IBM), United Technologies (UTX), Caterpillar (CAT), Disney (DIS), Intel (INTC), Procter & Gamble (PG), DowDuPont Inc (DWDP), Chevron (CVX), Johnson & Johnson (JNJ), and Verizon (VZ), have satisfied the parameter of Assets Turnover (ATR) is greater than or equal to 50%.

7. On making selection of companies from DJIA;MMM (3M),Exxon Mobil (XOM), Intel (INTC), Johnson & Johnson (JNJ),Apple (AAPL), Boeing (BA), Disney (DIS), Cisco (CSCO),IBM (IBM), Procter & Gamble (PG), Caterpillar (CAT),Travelers Companies Inc (TRV), Microsoft (MSFT), Coco Cola (KO), UnitedHealth (UNH), Wal-Mat (WMT), Merck (MRK), DowDuPont Inc (DWDP), Home Depot (HD), Chevron (CVX), Goldman Sachs (GS), Visa, United Technologies (UTX),Verizon (VZ), McDonald's (MCD),Pfizer (PFE), American Express (AXP), and JPMorgan Chase (JPM), have fulfilled the criterion of Interest Coverage Ratio is more than or equal to 5.

8. In picking securities of companies from DJIA, Microsoft (MSFT), Cisco (CSCO), American Express (AXP),McDonald's (MCD), Johnson & Johnson (JNJ), Nike (NKE), Apple (AAPL), IBM (IBM), DowDuPont Inc (DWDP), Intel (INTC), Pfizer (PFE), Merck (MRK), MMM (3M), Coca-Cola (KO), have reached the target of Liquidity Ratio is more than or equal to 1.

9. On selecting companies from DJIA, Visa, Pfizer (PFE), McDonald's (MCD), Intel (INTC), JPMorgan Chase (JPM), Apple (AAPL),Microsoft (MSFT), Goldman Sachs (GS), Disney (DIS), Procter & Gamble (PG), MMM (3M), Cisco (CSCO), Johnson & Johnson (JNJ), Verizon (VZ), Coca-Cola (KO), Merck (MRK), and American Express (AXP), have achieved the target of NPM is greater than or equal to10%.

10. In choosing companies from DJIA, Verizon (VZ), IBM (IBM), MMM (3M), Apple (AAPL), Nike (NKE), Microsoft (MSFT), Visa, American Express (AXP), Coca-Cola (KO), UnitedHealth (UNH), Intel (INTC), Disney (DIS), Caterpillar (CAT), Procter & Gamble (PG), Pfizer (PFE), Johnson & Johnson (JNJ), Cisco (CSCO), United Technologies (UTX),Walgreen (WBA),and Merck (MRK), have succeeded the goal of ROE 15% more or equal to 15%.

11. Apple (AAPL), IBM (IBM), Intel (INTC), Johnson & Johnson (JNJ), and MMM (3M) have been selected on fulfilling all parameters of Assets Turnover (ATR) $\geq 50\%$, ICR ≥ 5, LR ≥ 1, NPM $\geq 10\%$ and ROE $\geq 15\%$.

12. On using permutation and combination, Apple (AAPL), IBM (IBM), Intel (INTC), Johnson & Johnson (JNJ), and MMM (3M) whose weighted average rate of return is the highest at the optimum weightage of 0.96, 0.01, 0.01, 0.01, and 0.01 respectively.

13. On similar usage of permutation and combination, weighted average rate of risk of Apple (AAPL), IBM (IBM), Intel (INTC), Johnson & Johnson (JNJ), and MMM (3M) is the least at the optimum weightage of 0.01, 0.47, 0.01, 0.5, and 0.01 respectively.

14. **Considering coefficient of variation using weighted average rate of return and risk, Apple (AAPL), IBM (IBM), Intel (INTC), Johnson & Johnson (JNJ), and MMM (3M) has the highest consistency at the optimum weightage of 0.1, 0.1, 0.1, 0.51 and 0.46 are found to be fit for optimum portfolio.**

Conclusion:

Portfolio construction is a complex and lengthy process. Once optimum portfolio is built, it does not mean that it comes to an end process. It is a means for implementation and keeps under continuous monitoring and evaluation. Meanwhile there may be hiccups in portfolio due to sudden and unexpected shocks from external forces. Hence, it has to keep a long way for its success with constant watch and revision of portfolio if need arises.

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Appendix-1: Selected Companies based on Ratios

Company	Weightage Average					Remarks
	ROE	NPM	LR	ATOR	IC	
MMM 3M	0.476586667	0.16168	1.126666667	0.906666667	562.0253333	**Selected**
AXP American Express	0.24224	0.127653333	1.93	0.142666667	6.517333333	**Not Selected**
AAPL Apple	0.42768	0.217393333	1.296666667	0.723333333	24.59333333	**Selected**
BA Boeing	-1.10266	0.082453333	0.331333333	0.993333333	23.66466667	**Not Selected**
CAT Caterpillar	0.201786667	0.05788	0.962	0.614	16.4	**Not Selected**
CVX Chevron	0.060366667	0.058706667	0.882666667	0.549333333	9.870666667	**Not Selected**
CSCO Cisco	0.171133333	0.159593333	2.344666667	0.438	21.38533333	**Not Selected**
KO Coca-Cola	0.233026667	0.143866667	1.08	0.423333333	12.72133333	**Not Selected**
DIS Disney	0.209026667	0.19492	0.822666667	0.564	21.39733333	**Not Selected**
DWDP DowDuPont Inc	0.07488	0.052253333	1.252666667	0.553333333	10.762	**Not Selected**
XOM Exxon Mobil	0.09114	0.064793333	0.524666667	0.762	39.73333333	**Not Selected**
GS Goldman Sachs	0.0803	0.20466	0	0.035333333	8.552	**Not Selected**
HD Home Depot	0.07134	0.093646667	0.327333333	2.281333333	10.32	**Not Selected**
IBM IBM	0.551893333	0.11486	1.277333333	0.672	20.89533333	**Selected**
INTC Intel	0.211706667	0.221346667	1.252	0.554666667	37.188	**Selected**
JNJ Johnson & Johnson	0.17406	0.153873333	1.613333333	0.524666667	28.03533333	**Selected**
JPM JPMorgan Chase	0.102726667	0.219333333	0	0.036	5.312	**Not Selected**
MCD McDonald's	-1.355786667	0.233533333	1.624666667	0.683333333	7.172666667	**Not Selected**
MRK Merck	0.154773333	0.13072	1.182	0.457333333	11.22933333	**Not Selected**
MSFT Microsoft	0.28312	0.21498	2.994666667	0.45	14.51266667	**Not Selected**
NKE Nike	0.337833333	0.096793333	1.578	1.598	3.826666667	**Not Selected**
PFE Pfizer	0.193926667	0.241293333	1.214666667	0.306666667	6.748666667	**Not Selected**
PG Procter & Gamble	0.198446667	0.16806	0.722666667	0.554	17.59933333	**Not Selected**
TRV Travelers Companies Inc	0.113313333	0.093326667	0	0.279333333	15.67266667	**Not Selected**
UTX United Technologies	0.165066667	0.088186667	0.862	0.626	7.905333333	**Not Selected**
UNH UnitedHealth	0.216286667	0.048353333	0	1.548666667	11.82333333	**Not Selected**
VZ Verizon	0.613533333	0.148813333	0.862666667	0.510666667	7.438	**Not Selected**
V Visa	0.2594	0.449293333	0	0.304666667	8.415333333	**Not Selected**
WMT Wal-Mart	0.14496	0.0226	0.200666667	2.436666667	11.74133333	**Not Selected**
WBA Walgreen	0.156586667	0.034253333	0.516666667	1.887333333	1.997333333	**Not Selected**

Appendix-2: Return, Risk and coefficient of Variation of Selected Companies

Companies	Return (x̄)	Risk (σ)	Coefficient of Variation (σ/ x̄)
APPL(A)	0.461489785	0.803082539	1.740195698
IBM(B)	0.055346457	0.182059697	3.289455338
INTC©	0.118614785	0.402939772	3.397045088
JNJ (D)	0.09464385	0.184944395	1.954108969
MMM (E)	0.135233467	0.205737355	1.521349404

Appendix-3: Co-variance Matrix of selected companies

	Apple	IBM	INTC	JNJ	MMM
Apple	1	0.084582	0.046355	-0.01608	0.010491
IBM		1	0.225742	2.74E-05	0.034643
INTC			1	-0.02401	0.012918
JNJ				1	0.049578
MMM					1

Appendix-4: Optimum Portfolio returns (Γp)

Securities	Portfolio Retur (Γp)		
_	Weightage	Return ($\bar{x}$)	Γp
Apple	0.96	0.461489785	0.443030194
IBM	0.01	0.055346457	0.000553465
INTC	0.01	0.118614785	0.001186148
JNJ	0.01	0.09464385	0.000946438
MMM	0.01	0.135233467	0.001352335
	1.00		0.447068579

Appendix-5: Optimum Portfolio Risk (σ^2_p)

Securities	Weightage	σ^2_p
		$\sigma^2_p = (w_1 * \sigma_1)^2 + (w_2 * \sigma_2)^2 + (w_3 * \sigma_3)^2 + (w_4 * \sigma_4)^2 + (w_5 * \sigma_5)^2 + 2 w_1 * w_2 (Cov._{12}) + 2 w_1 * w_3 (Cov._{13}) + 2 w_1 * w_4 (Cov._{14}) + 2 w_1 * w_5 (Cov._{15}) + 2 w_2 * w_3 (Cov._{23}) + 2 w_2 * w_4 (Cov._{24}) + 2 w_2 * w_5 (Cov._{25}) + 2 w_3 * w_4 (Cov._{34}) + 2 w_3 * w_5 (Cov._{35}) + 2 w_4 * w_5 (Cov._{45})$
Apple	0.01	
IBM	0.47	
INTC	0.01	**0.017089056**
JNJ	0.5	
MMM	0.01	
	1	

Appendix-6: Optimum Portfolio

Companies	Weightage	Risk (σ)	Return ($\bar{x}$)	Portfolio Risk (σ^2_p)	Portfolio Return (Γp)	C V= (σ/ $\bar{x}$)
APPL(A)	0.01	0.803083	0.46149			
IBM(B)	0.01	0.18206	0.055346			
INTC©	0.01	0.40294	0.118615	**0.017089056**	**0.447068579**	**0.20043**
JNJ (D)	0.51	0.184944	0.094644			
MMM (E)	0.46	0.205737	0.135233			
Total	1					