Administrative Development: A Journal of HIPA, Shimla. Volume VI (2), 2019.

# PORTFOLIO DIVERSIFICATION: ROLE OF CORRELATION IN SETTING DIVERSIFICATION STRATEGY

Reena Shukla [*] & Pooja Mishra [†]

*Abstract*

*Through the entire portfolio construction process, it is vital to reduce exposure to risk by combining a variety of investments so to make balances between the risk and return of various types of investment. Diversification is not only alive and well; it is the best way to smooth out unsystematic risk events. The phrase "diversification" is thrown around quite often when it comes to investing. The only way to achieve real diversification is by investing in different asset classes with low correlation to each other. This paper focuses to statistically analyze the investment decisions involved in constructing a diversified portfolio with special consideration of broad assets allocation strategy (diversification). We here will statistically discuss the importance of correlation in diversification and also throw some light on alternative investment as a risk reduction technique. We also explore the stock market data to analyze the paper.*

**Keywords:** *Alternative Investments; Correlation; Correlation Matrix; Diversification; Investments; Portfolio; Risk and Return.*

## Introduction

### Diversification (Alternative investment strategy)

We should remember that investing is an art form, not a knee-jerk reaction, so the time to practice disciplined investing with a diversified portfolio is before diversification becomes a necessity. By the time an average investor "reacts" to the market, 80% of the damage is already done. Here, more than most places, a good offense is your best defense, and a well-diversified

[*] *Research Scholar, Registration No: 1209072, Department Of Management, I. K. Gujral Punjab Technical University, Jalandhar, Punja, Email-reena.shy@gmail.com*
[†] *Campus Director and Professor, Department Of Management, Aman Balla Group of Institutes, Kotli, Pathankot, Punjab, Email-mishrapooja@yahoo.com*

portfolio combined with an investment horizon over five years can weather most storms. A diversification strategy can help you achieve more consistent returns over time and reduce your overall investment risk. Market volatility should be a reminder for you to review your investments regularly and make sure you consider an investing strategy with exposure to different areas of the markets.

Professionals don't rely merely on their intuition for picking a well-diversified portfolio. They use statistical techniques for finding what are called "uncorrelated assets." Statisticians use price data to find out how the prices of two assets have moved in the past in relation to each other .A correlation matrix makes the task of choosing different assets easier by presenting their correlation with each other in a tabular form .During hard economic times, uncorrelated assets may seem to have vanished, but diversification still serves it purpose..In. all other scenarios, while some assets perish faster than others, some do manage to survive. If all assets went down the drain together, the financial market that we see today would have been dead long ago.

An investor can reduce the risk of his or her investments by investing in two or more assets whose values do not always move in the same direction at the same time. This is because the movements in the values of the different investments will partially cancel each other out. In actual practice, it's difficult to find a pair of assets that have a perfect positive correlation of +1, a perfect negative correlation of -1 or even a perfect neutral correlation of 0. Diversification may not provide complete insurance against disaster, but it still retains its charm as a protection against random events in the market. Due to the size of an individual investor`s asset pool, he or she may not be able to tolerate short term fluctuations in the stock market. Portfolio that has greater percentage of alternatives may have greater risks. Especially, those including, arbitrage, currency, leveraging and commodities. These additional risks can offset the benefit of diversification. Although the asset allocation among different asset categories generally limits the risk and exposure to any one category, the management may favor an asset category that performs poorly related to a other asset categories. Some of those risks include general economic risk, geopolitical risk, commodity price volatility, counter party and settlement risk, derivatives risk, emerging market risk,

foreign securities risk, high-yield bond exposure, on investment-grade bond exposure commonly known as junk bonds, index investing risk, industry concentration risk, leveraging risk, market risk, prepayment risk, liquidity risk, real estate investment risk, sector risk, short sales risk, temporary defensive positions and large cash position.

The effective way to address this issue is diversification. When we having core strategy of alternative investments, you may have the potential to better diversify your source of return and manage risk. Historical alternative have low liquidity, limited access, lack of transparency etc .but now it become more popular, more widely available, more liquid and more transparent. Alternative tend to have lower correlation than traditional investment, providing better diversification potential.

- Such as managed future, their investments are generally composed of commodities and currencies, which tend to move perform counter cyclically to stocks and bonds and when added to a portfolio could act as a hedge against inflation.
- Volatility is another example which has a negative correlation to the stock market.

## Role of correlation in setting diversification strategy

Thumb rule: The correlation coefficient that indicates the strength of the relationship between two variables can be found using the following formula 1:

**Formula 1:**

$r_{xy}$ =The correlation Coefficient of the linear Relationship between the variables x and y

$x_i$ = The values of the x-variable in a sample

$\bar{x}$ = The mean of the values of the x variable

$y_i$ = The value of the y variable in a sample

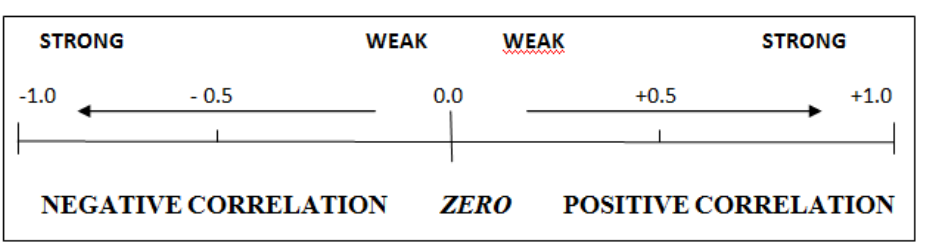
Diversification is usually quantified by correlation, that is, the degree to which the movement of one investment or asset class allows for interferences about how other investment or asset class will move. Correlation is a statistic that measures the degree to which two variables move in relation to each other or Correlation statistically measures the degree of relationship between two variables in terms of a number lies between +1 and -1. In finance, the correlation can measure the movement of a stock with that of a benchmark index, such as the Beta.

1. Correlation coefficients are used to measure the strength of the relationship between two variables. This measures the strength and direction of a linear relationship between two variables.
2. Values always range between -1 (strong negative relationship) and +1 (strong positive relationship). Values at or close to zero imply weak or no relationship. Correlation coefficient values less than +0.8 or greater than -0.8 are not considered significant.

**$-1 \leq r \leq 1$**

**Correlation Coefficient**

**Show Strength and Direction of Correlation**




However, a correlation coefficient with an absolute value of 0.9 or greater would represent a very strong relationship. This statistic is useful in finance. For example, it can be helpful in determining how well a mutual fund performs relative to its benchmark index, or another fund or asset class. By adding a low or negatively correlated mutual fund to an existing portfolio, the investor gains diversification benefits. Low correlation leads to diversification (alternate assets and alternate investment strategies) .The investors can find another asset class with the same return and standard deviations but with an even more low correlation with stocks than of-course investor could achieve even greater diversification benefits. We will rarely

see the perfect correlation of 1.0 or -1.0.whenever the correlation is below 1.0 than it definitively provides some diversification.

## Literature review

(Black and Litterman 1992); explain the importance of optimization of portfolio, in their study, they explained the article with the assumption that optimization of the portfolio depends on the risk taking capacity of the investor. (Berk, 2005); observed that there are major five myths while constructing and optimizing portfolio, investors should overcome these myths and they can make perfect portfolio. (Clarke, De Silva and Murdock, 2005); focused on factor approach to asset allocation; here they explained various factors that can affect different asset classes and while allocating investment the investors should keep these factors in their mind. (Haber and Andrew, 2009); they examined the role of short term correlation in portfolio diversification; they explained that diversification can play a vital role in portfolio risk reduction. (Elton, Gruber, Brown and Goetzmann, 2011); explained in their book that the risk can be optimized by analyzing the investment and investors should go through with the modern theory of portfolio while making decisions about optimization of the portfolio. ( Bluementhal, 2014); observed that, in this volatile era of market nothing is certain in financial world so the investors should rationally operate their portfolio by using different risk reduction techniques like correlation matrix, correlation between different asset classes, etc. (Jean, Nov20, 2017); In his article he had explained and criticizes various theories like modern portfolio theories. He made a study at Rwanda social security board and found there the effect of diversification on portfolio risk management. His study focused on diversification and its result on portfolio risk.

## Research gap, objective, data collection and analyzing tools of the study

By reviewing the literature of various researches, it has been observed that they all have focused on analyzing the techniques and theories but not on proposing optimized strategies for diversification. Our research paper is exploratory in nature. By statistically analyzed the data, our objective is to explore, different best fit portfolio diversification strategies and also to explain the role of correlation in choosing alternative asset classes.

For the purpose of this study (to formulate diversification strategies) we used data base of Indian stock market (BSE), like daily closing prices of stocks , average return percentage of different indexes, financial magazines, made assumptions from various previous research work, etc and by using statistical tool (correlation coefficient), we analyzed the data with various combination of different asset classes.

## Assumptions

PART-1

- Lower correlation - Better diversification
- Higher correlation- less effect.

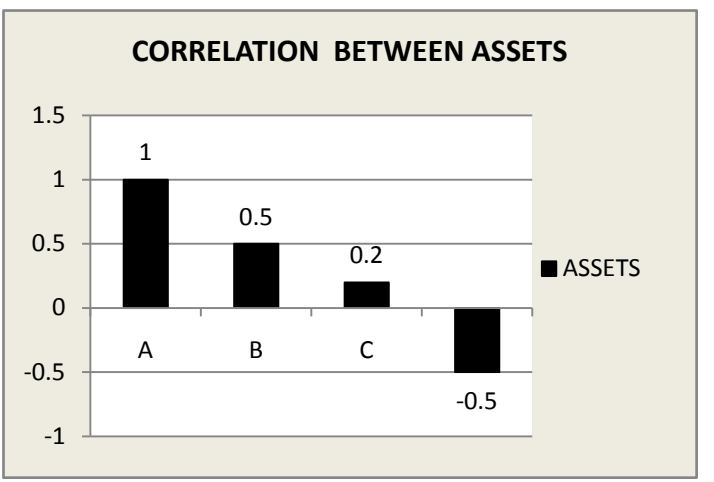



*Figure 1: Comparison of assets on the basis of correlation*

The assumption is being tried to explain in Figure 1 with the correlation of each asset class. As illustrated in Figure 1, On the grounds of Low and high correlation .Higher the Correlation, Lowe the diversification Effect, lower the correlation greater the diversification effect. For example: If you looking for a Diversification for asset A in your portfolio, Asset C and Asset D would be must better choices than Asset B. Correlation is a statistical measure that indicates the extent to which two or more Variables fluctuate together. Two different investments with a correlation of 1.0 will move in exact look step Investment with a correlation of zero will not move at all in relation to each other and investment with a Correlation of -1 will move in opposite direction.

## ASSUMPTION PART- 2

1. Higher the return on investment depends upon risk taking capability of the investors, higher the risk, higher the return. Risk and returns are positively correlated.
2. Investors estimates risk on the basis of variance of returns.

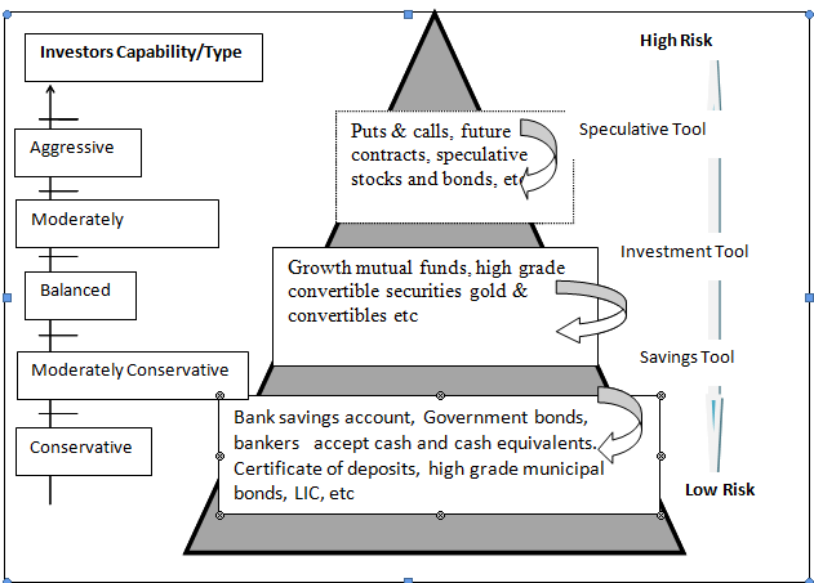



*Figure 2: Different Investment tools and investors has been segregated according to their risk nature, (self-creation)*

As shown in Figure 2, in this volatile ever changing market, there are different investment assets like speculative investment tools, savings tools, etc according to their volatile nature and all of above it all depends on investors nature (risk taking capability), that which assets class suits them most but the universal investors practices shows that those who takes high risk, will reward with high return. For example Aggressive investors often likely to invest in speculative stocks but on the other hand conservative investors often usually invest in low risky investment and they don`t want to lose their principal amount of investment. Aggressive investors always believe in hit and trial method and they usually invest for very short period. Risk and

return are positively correlated. As we move up in the pyramid, the risk will also goes up.

**Example 1:**

Let`s take an example to analyze the assumption 2 (Higher the risk, Higher the return), on the basis of correlation, Compute the degree of risk from the coefficient of correlation and also find out the least risky combination of correlation of return with proportion of 50%.

**r = - 1, r = 1, r = 0**

| Security | Expected return | Standard deviation |
|---|---|---|
| Stock A | 5 | 2 |
| Stock B | 15 | 8 |

**If, r = -1,** $P = \sqrt{(0.5)^2(2)^2 + (0.5)^2(8)^2 + (2)(0.5)(0.5)(-1)(2)(8)} = \sqrt{9} = 3$

**If, r = 0,** $P = \sqrt{(0.5)^2(2)^2 + (0.5)^2(8)^2 + (2)(0.5)(0.5)(0)(2)(8)} = \sqrt{17} = 4.2$

**If, r = 1,** $P = \sqrt{(0.5)^2(2)^2 + (0.5)^2(8)^2 + (2)(0.5)(0.5)(1)(2)(8)} = \sqrt{25} = 5$

**Results:** The least risky portfolio combination is, when correlation -1 hence it has been proved that low correlation has less risk and ones can easily diversify the portfolio by viewing the risk level.

**Example 2:** (Investors estimates risk on the basis of variance of returns).

**Category A** - Fixed Income funds;

**Category B**-Currencies and commodities;

**Category C** -Stocks of midcap companies.

Investment category %: Category A =50%, Category B=25%, Category C =25%

## Calculation of Portfolio Variance

**Table 1: Calculation of portfolio co- variance/standard deviation squared (covariance as a diversification tool)**

| | | Returns | | | | | | |
|---|---|---|---|---|---|---|---|---|
| State of economy | Probability | Category | | | Expected return | Return deviation | Squared deviation | Product (Probability *squared deviation) |
| | | A | B | C | | | | |
| Boom | 0.5 | 10% | 15% | 20% | 13.75% | 4.375% | 0.001914 | 0.000957 |
| Bust | 0.5 | 8% | 4% | 0% | 5% | -4.375% | 0.001914 | 0.000957 |
| | | | | | | | Co-variance-0.191% | |

- Expected return:
- Boom: (0.5x10%) + (0.25 *15%) + (0.25*20%) =13.75%
- Bust: (0.5*8%) + (0.25*4%) +0.25*0%) = 5%
- Portfolio Expected return= 0.5*13.75%+0.5*5%=9.375%
- Standard deviation = Expected return –Portfolio expected return
- Boom: 13.75%-9.375%= 4.375%
- Bust: 5%-9.375%= -4.375%

Portfolio variance is a measure of a portfolio`s overall risk and it also define the risk –axis of the efficient frontier. As shown in table-1, Co-Variance = 0.191%, It shows there is weak correlation between all the three categories (A, B, C), Probability is 50% in both the state of economy, whether it is boom or bust. They are not effectively correlated to each other. Investor can choose independent diversification strategy. Adding assets with a negative covariance to a portfolio reduces the overall risk. Diversifiable risk cannot significantly be reduced beyond including 30 different stocks in a portfolio.

Role of correlation in setting diversification strategies (as a tool for portfolio risk reducer) Portfolio Analysis and Diversification Strategies

Table 2: Assumed portfolio of ABC Investor, 2019 as per different asset classes (Self Creation)

| Asset Classes | Oil Drilling & Explora-tion | Banks Pvt Sector | Mining & Minerals | Power Generation | Media & Entertainment | Computer Software | Cigarette |
|---|---|---|---|---|---|---|---|
| STOCK | ONGC (169.25) | Yes Bank (139.55) | Vedanta (169.35) | NTPC (135.3) | NDTV (34.75) | Infosys (754.90) | ITC Ltd (280.20) |
| **Mutual funds** | Reliance Arbitrage fund-Direct (G) 2.UTI Arbitrage Fund(G) | | | | 8.2% per year 6.5% per year | | |
| **Commodity & Currencies** | Commodities 1.Gold:32,736 2.Silver:36,820 3.Natural-gas:166.40 | | | | Currencies 1.USDINR : 69.39 | | |
| **fixed income** | SBI (Public sector unit bond):8.75% | Mahindra Finance FD:9.1% | NSC (5 Years) :8% | India Bulls consumer Finance Ltd-NCD:10.60% | Sukanya Samridhi Account:8.60 % | ICICI Saving Account | |
| **Loans , Property & ULIP** | NIL | | | | | | |

A snap shot of investment percentage of different classes in Table: 2

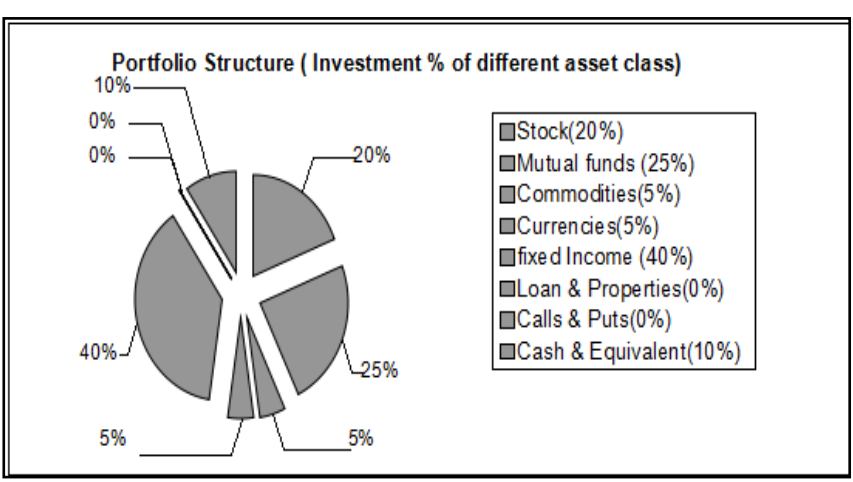



Figure 3 : Segregation of different asset classes as per risk level of investment in a portfolio, http://www.moneycontrol.com

As shown in Table 2 and illustrated in Figure-3. The Portfolio has been Structured as per the assumptions part-2 as explained above in the paper. We have considered the risk and return factor assumption. Around about 50% of investment is in fixed income group like NSC, Sukanya Samridhi, FD, RD, Savings, etc and as we all know that Higher the risk, Higher the return and in the highly volatile speculative market era ,the investor with low risk taking can`t put investment in puts and calls option. Portfolio contains stocks of different sector companies and mutual funds. Both are medium risky investments. It covers 45% of investment and a very less has been invested in currencies and Commodities (10%). In overall view of the structured Portfolio, it seems a very well planned portfolio of medium risk taker investor and the principle amount of the investment is to put the investment in a safer zone.

**Diversification strategy1: Switching to another sector stocks**

*Source: http://www.moneycontrol.com*

The daily (for 3 months) adjusting prices of two stocks have been used for calculating the correlation coefficient between the two stocks (ONGC AND ITC).

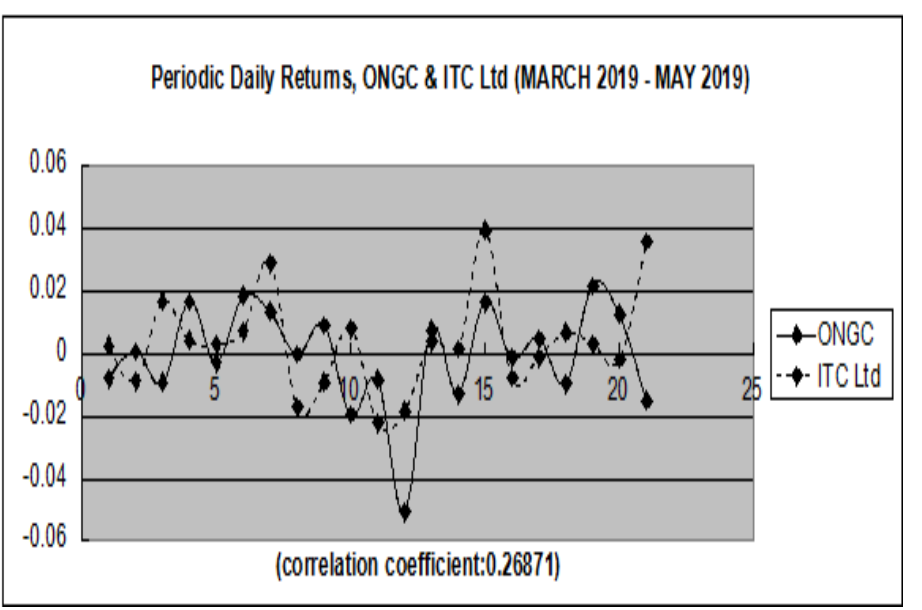



Figure 4 : Correlation coefficient between two sectors stock, ONGC & ITC

As illustrated in Figure 4 above, we graph periodic daily return using actual data for the month March, 2019 – May, 2019 of the two stocks of different sectors, one is ONGC (oil and drilling exploration) and another is ITC Ltd (cigarette). The purpose of taking stocks of two different sectors is reduce the risk factor by diversifying the portfolio .The daily date wise closing prices of the stocks has been recorded as a data (See Appendix)

In order to have a keen glance at the price fluctuation level of both the stocks .Periodic daily returns of both the stocks being calculated to get correlation digit. As we can Figure out both the stocks have peak Fluctuations, Positive and negative on some dates? By viewing the Figure, we came to the conclusion that stocks have weak correlation, (0.26871). Correlation indicates that stocks have a weak strength/correlation. As we all aware that Return on Securities is independent of one another and correlation makes a relation with two or more assets. The correlation coefficient is 0.26871. So the investor will not move to other alternate assets to diversify the risk but the investors could switch to another sectors stock or to another assets class by viewing to have higher return.

### Diversification strategy 2 -Correlation matrix and portfolio variance

A well diversified (high conviction) portfolio typically consists of about 10-15 stocks but we just decided to have a 5 stock portfolio so it would not to be messing with sheer size portfolio. The size of the variance covariance matrix for a 5 stock portfolio will be 5 x 5 =25

Table 3: Correlation matrix of 5 stocks (see appendix)

| CORRELATION MATRIX | | | | | | |
|---|---|---|---|---|---|---|
| Time Period: 1-04-2019 -30-06-2019, Source: http//:www.bseindia.com | | | | | | |
| | Industry | Oil Drilling & Exploration | Cigarettes | Banks Pvt Sector | Power Generation | Media & Entertainment |
| | | 1 | 2 | 3 | 4 | 5 |
| | | ONGC | ITC | YES BANK | NTPC | NDTV |
| 1 | ONGC | 0.951219512 | 0.104753113 | 0.29181058 | 0.236197908 | -0.032174277 |
| 2 | ITC | 0.104753113 | 0.951219512 | 0.123769534 | 0.331146001 | 0.167842633 |
| 3 | YES BANK | 0.29181058 | 0.123769534 | 0.951219512 | 0.208641829 | -0.311464464 |
| 4 | NTPC | 0.236197908 | 0.331146001 | 0.208641829 | 0.951219512 | -0.031301793 |
| 5 | NDTV | -0.032174277 | 0.167842633 | -0.311464464 | -0.031301793 | 0.951219512 |

Correlation matrix is a tool to diversifying the portfolio. As shown in Table 3, there is a Correlation Matrix of different stocks. The matrix displays symmetrically similar values above and below the diagonal but there gains and losses occurred at different times that are why there are different correlation coefficients for each pair of stocks (see Appendix). Here is how we read the correlation matrix. Each stock is a row in the matrix and each stock is repeated in the column.

Let`s see how different sectors stock correlated. If we looking for correlation ONGC to NDTV which Is -0.032(1,5). They are negatively correlated and move in off direction same like these stocks, YES To NDTV (-0.03114) and NTPC to NDTV (-0.0313).These correlation values give indication to diversification. Here we have two diversification strategies. First is to switch to another sectors stock especially in case of NDTV because it has negative average daily returns (-1.0743%, see appendix) and moreover it is negatively correlated with YES BANK AND NTPC. In another diversification strategy we can add some low volatile bonds to a stock portfolio that helps to create more efficient returns. The correlation coefficient matrix values highlighted with bold digits have weak positive correlation and here we can again think of diversification to maximize the return value.

**Portfolio risk (For Calculation See Appendix)**

| M1 | | | | |
|---|---|---|---|---|
| ONGC | ITC | YES BANK | NTPC | NDTV |
| 0.006930664 | 0.005600316 | 0.011846056 | 0.005956971 | 0.000398189 |

| M2 | Portfolio Co variance = 0.7374% | Covariance can show only the direction between two assets, it cannot be used to calculate the strength of the relationship between the prices. |
|---|---|---|
| 0.000192087 | Low risk –Low diversification | |

**Diversification strategy 3-Anaysis of correlation between stock market indexes of volatile market: leads to fix diversification strategy.**

Which of these asset classes provides the best diversification potential when added to a portfolio of stocks and bonds?

Table 4: Correlation coefficient between different Indexes Proxy: leads to fix Diversification Strategy. Source: http://www.moneycontrol.com, http://www.bseindia.com

| Time period: 1/1/2019-17/06/2019 (6 months) Benchmark: S&P BSE SENSEX | | |
|---|---|---|
| INDEX Proxy | Correlation with S & P BSE SENSEX | Correlation coefficient with S & P low volatility Index |
| S & P BSE Metal | 0.5808 | -0.0399 |
| S &P BSE OIL & GAS | 0.9104 | 0.9190 |
| S & P BSE POWER | 0.9316 | 0.9020 |
| S & P BSE IPO | 0.0085 | 0.0136 |
| S & P PSU | 0.9515 | 0.5834 |
| S & P BSE India Infrastructure Index | 0.9510 | 0.9411 |
| S & P BSE 10 Year Sovereign Bond | -0.0004 | 0.1029 |
| S & P BSE India utilities bond Index | 0.4277 | O.4917 |

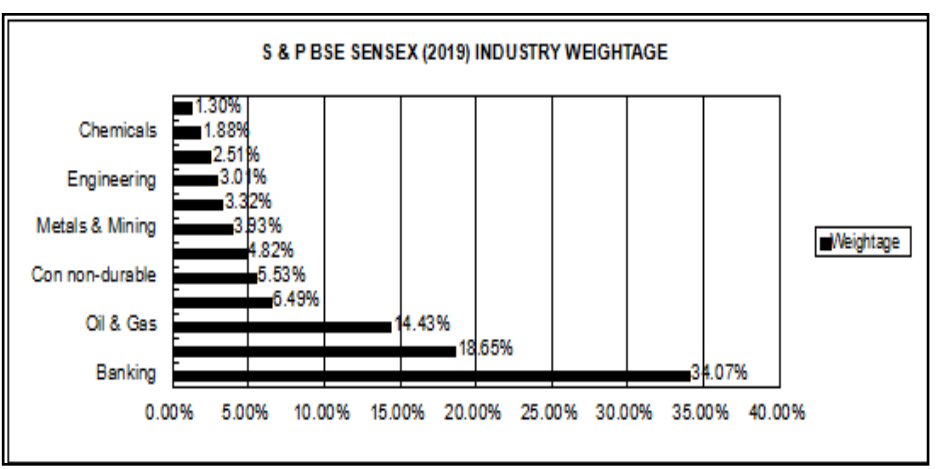



Figure 5: S & P BSE SENSEX 2019, Industry wise weightage,
*Source: http:// www.moneycontrol.com*

**Examine the portfolio**

From Table 4 & Figure 5, We Can able to answer the various questions like:

1. **Are there any possibilities of adding alternative investment in portfolio or holding the examined stock?**
2. **What would be the market trend as it has negative correlation with market ups and down?**

As illustrated in Figure 5, there are so many industries stock and all of these have different weightage in index. According to that, as shown in Table 4, they have correlation with stock market index as per their industry weightage. S & P BSE Metal have positive correlation (0.5808) with BSE SENSEX but negative correlation (-0.0399) with Volatility Index. As a explanation of it, Metal Index doesn't goes with volatility, so better to go for diversification. Likewise S & P BSE India Infrastructure Index has positive Correlation (0.9510) and (0.9411) with BSE SENSEX Index and Volatility Index respectively, so there is no scope for diversification. If we see sovereign bond, it has negative correlation (0.0004) with S & P BSE Sensex and positive with volatility index (0.1029 ) so there is a scope for diversification and the investor can switch from BSE SENSEX and can go for another better option so that investor can able to minimize their portfolio risk. As far concern of market trend, often volatility index is known as "Fear Index", it is the standard measure of volatility risk for investors. The impact of positive and negative returns must be opposite in signs, but similar in magnitude.

**Least consideration:** Shortcomings of the study

Correlation changes in different markets risks and inflation risks. The pluses of diversification are many. No doubt, it Reduces portfolio risk, hedges against market volatility, offers higher returns long-term. However, there are drawbacks, too like Limits gains short-term, Time-consuming to manage, Incurs more transaction fees, commissions (since buying and selling many different holdings incurs more transaction fees and brokerage commissions). Sometimes during the down markets, not only traditional assets classes move in the same direction but they move more closely together .In other words, their diversifying effects broke down just when they were needed

most. There are so many issues with non-correlation as an investment strategy because asset classes are too broad, not all portfolios are alike and there are different types of correlation.

During periods of heightened volatility, such as the 2008financial crises, stocks can have a tendency to become more correlated, even if they are in different sectors. International markets can also become highly correlated during times of instability still, correlation can change over time. It can only be measured historically. Two assets that have had a high degree of correlation in the past can become uncorrelated and begin to move separately. This is also one shortcoming of MPT (Modern portfolio theory), it assumes stable correlations among assets.

## Conclusion

It is always being a matter of discussion that investors should try to explore low correlation in their portfolio, in order to diversify the risk. In this volatile era of market, it often brings dramatically different outcomes for different investment. Sometimes market drops and eventually bounces back. In that moment investors never know whether the drop is temporary or permanent .The investors steadier returns make feel better and the only way out is diversification in order to avoid drastic risk .In this paper we have tried to weave the concept of correlation and diversification into a broader discussion on assembling of portfolio of assets .correlation analysis is a simple tool that investors can rely on when making portfolio allocation decisions. Correlation analysis can be extended in a number of ways , some of them we have briefly touched Some investors might define diversification based on the number of holdings in a portfolio while others might based it on how many different colourful pie slices (e.g. Large/Mid/Small Cap Value /Growth Domestic / International etc) Can appear on a portfolio allocation chart. The fact of the matter is that neither of these Metrics achieves diversification unless the holdings in the portfolio have low levels of correlation to one another. The correlation co-efficient is -1.0 which indicates that there is a perfect negative correlation exists between the securities and they tend to move in the off direction. Combining a variety of equity assets classes with varying correlations along with dozen of bonds, did a good job of providing enough diversification for portfolio. The nearer

and the shorter the time frame, greater the likelihood that the investment will move from uncorrelated to correlated. Price momentum is a major focus of this paper. Tactical investment strategy tries to seek profit from price momentum. A key indicator of diversification potential is the correlation statistics. There is large number of portfolio, which could be called feasible but only those were selected which are superior in terms of risk and return characteristics. By considering given amount of portfolio risk, investor's attempts to maximize portfolio expected return. The crux of the paper is that lesser the correlation better will be the diversification and risk can be reduced to lower level with lesser standard deviation, between the assets.

## References

### Journals

1. Bender, J., Briand, R., and Nielsen, F. (2010). Portfolio of Risk Premia: A New Approach to Diversification. Journal of Portfolio Management: 36(2)
2. Berk, Jonathan B. (2005). Five Myths of Active Portfolio Management. The Journal of Portfolio Management Spring 2005: 31(3).27-31.
3. Black, F., and Litterman, R. (1992). Global Portfolio Optimization. Financial Analysts Journal, 48 (5), ABI/INFORM GLOBAL: pp.28-43.
4. Clarke, R. G., De Silva, H., and Murdock, R. (2005). A Factor Approach to Asset Allocation. Journal of Portfolio Man¬agement: 32(1) 10 - 21.
5. Elnekave, R. (2019). A Risk Management System that works. The Journal of Investing: 28(4) 30-38.
6. Haber, J., and Andrew, B. (2009). Examining the Role of Short Term Correlation in Portfolio Diversification. Journal Grazio Business Review: 12(3).
7. Jean, B.H. (Nov20, 2017). Effect of Diversification on Portfolio Risk Management at Rwanda Social Security Board. Business and Economic Journal (open Access): 8 (4):325.
8. Lee, J., Stefek, D. (2008). Do risk factors eat alphas? .The Journal of Portfolio Management: 34 (4).12-25.

### Books

1. Alcock, J., and Satchell, S. (2018). Asymmetric Dependence in Finance: Diversification, correlation and Portfolio Management in Market Downturns (1st Edition). John Wiley and Sons.
2. Elton, E., Gruber, M., Brown, S., and Goetzmann, W. (2011). Modern Portfolio Theory and Investment Analysis ( Eighth Edition). John Wiley and Sons Inc.
3. Litterman, R. (2003). Modern Investment Management – An Equilibrium Approach. Goldman Sachs, John Wiley and Sons Inc.
4. Schneeweis, T., Crowder, G., and Kazemi, H. (2010). The New science of Asset Allocation Risk Management in a Multi-Asset World, John Wiley and Sons Inc.

## Thesis

1. Kamala.1993 "Diversification as a Corporate Strategy: Indian Scenario, PhD Thesis, Manipur University, India, 1993, PP 203-230.
2. Olusi, Olasupo.2005 "Exchange Rate Risk and Equity Portfolio Diversification", PhD Thesis, Durham University, UK, 2005.
3. Swami, Lyer K. "An Empirical Study of Stock Volatility and Asset Pricing in Indian Stock Market during 2009 -2014, PhD Thesis, Tilak Maharashtra Vidyapeeth, India, 20-09- 2015.

## Online Articles, Lectures and Notes

1. Berrada, T. SFI Associate Professor of finance, University of Geneva, Coursera, "Portfolio and Risk Management" and "The Impact of Correlation - The benefits of Diversification",Online Lectures.
2. Blumenthal, S, CEO, CMG. "Understanding Correlation and Diversification", Article, online, Capital Management Group.
3. Manoj Singh. "Protecting Portfolios using correlation Diversification", Article, Financial Theory, Investopedia.
4. Zerodha Versity, Module 9 (Risk Management and Trading Psychology, Chapter-5 (Risk part 4)-Correlation Matrix and Portfolio Variance.

## Websites

- http://www.socscistatistics.com (Pearson Correlation Coefficient Calculator)
- www.investopedia.com
- http://www.moneycontrol.com
- http://www.business-standard.com
- http://shodhganga.inflibnet.ac.in
- http://www.bseindia.com, http://asiaindex.co.in
- https://www.coursera.com
- https://jpm.iijournals.com


## APPENDICES

### 1. PERFORMANCE OF INDICES (Reference Data of Table 4)

Time Period: 1/1/2019-17/06/2019 (6 Months) Calculation Benchmark: S&P BSE SENSEX

| Index | RETURN % |
|---|---|
| S & P BSE SENSEX | +9.70% |
| S & P BSE Metal | -5.80% |
| S &P BSE OIL & GAS | +12.20% |
| S & P BSE POWER | +2.80% |
| S & P BSE IPO | +11.60% |
| S & P PSU | +9.50% |
| S & P BSE AUTO | -13.30% |
| S & P BSE BANKEX | +14.50% |
| S & P BSE TECK | +6.70% |
| LIC Infrastructure Direct (G) | +13.6% |
| UTI Arbitrage Fund | +3.4% |
| SBI ETF Sensex | +10.2% |
| L & T Triple ACE Bond Fund | +7.1% |
| Kotak Liquid Schemed (G) | +3.6% |
| S & P BSE India Infrastructure | +4.05% |
| S & P BSE 10 Year Sovereign | 16.51% |
| S & P BSE India Utilities Bond | 8.31% |

*SOURCE: http://www.moneycontrol.com; http://asiaindex.co.in*

| (January – June ,2019) Benchmark: S&P BSE SENSEX | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | S &P BSE SENSEX | S & P Low Volatility Index | S & P BSE Metal | S &P BSE OIL & GAS | S & P BSE POWER | S & P BSE IPO | S & P PSU | S & P BSE India Infrastructure | S & P BSE 10 Year Sovereign | S & P BSE India Utilities Bond Index |
| Jan | 36256.6 | 775.3 | 10958.6 | 13612.3 | 1880.8 | 1768.6 | 6904.46 | 186.2 | 511.03 | 509.54 |
| Feb | 35867.4 | 769.7 | 10766.5 | 13802.1 | 1828.6 | 1756.0 | 6736.42 | 184.6 | 512.3 | 507.06 |
| Mar | 38672.9 | 801.9 | 11355.1 | 15269.7 | 2034.4 | 1757.8 | 7640.47 | 208.3 | 515.5 | 515.35 |
| Apri | 39031.5 | 807.3 | 11513.1 | 15357.8 | 1969.5 | 1726.1 | 7446.22 | 204.1 | 518.36 | 515.94 |
| May | 39714.2 | 819.3 | 10756.4 | 15734.4 | 2010.1 | 1746,4 | 7825.82 | 212.5 | 530.9 | 530.9 |
| June | 38960.7 | 807.9 | 10622.4 | 14694.8 | 1975.2 | 1746.9 | 7505.68 | 206.4 | 536.62 | 536.62 |

*SOURCE: http://www.moneycontrol.com, http://asiaindex.co.in*

## 2. Reference data of figure : 4

| Calculation of correlation –coefficient between two stocks (march,2019- may,2019) source: http://www.bseindia.com | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ONGC | | ITC | | | ONGC | | ITC | |
| Date | Price | Return | Price | Return | Date | Price | Return | Price | Return |
| 1-Mar-19 | 148.16 | | 272.97 | | 16-April- | 160.45 | 0.0252 | 301.43 | 0.0056 |
| 5-Mar-19 | 154.02 | 0.0388 | 277.27 | 0.0156 | 18-April- | 160.6 | 0.0009 | 298.68 | -0.0092 |
| 6-Mar-19 | 153.82 | -0.0013 | 280.3 | 0.0109 | 22-April- | 157.9 | -0.0170 | 296.13 | -0.0086 |
| 7-Mar-19 | 151.01 | -0.0184 | 284.65 | 0.0154 | 23-April- | 163.75 | 0.0364 | 297.7 | 0.0053 |
| 8-Mar-19 | 149.45 | -0.0104 | 286.51 | 0.0065 | 24-April- | 168.65 | 0.0295 | 300.69 | 0.0100 |
| 11-Mar-19 | 152.04 | 0.0172 | 287.44 | 0.0032 | 25-April- | 168.85 | 0.0012 | 298.83 | -0.0062 |
| 12-Mar-19 | 150.89 | -0.0076 | 288.96 | 0.0053 | 30-April- | 168.4 | -0.0027 | 295.69 | -0.0106 |
| 13-Mar-19 | 148.81 | -0.0139 | 289.36 | 0.0014 | 2-May-19 | 168.9 | 0.0030 | 299.27 | 0.0120 |
| 14-Mar-19 | 150.1 | 0.0086 | 289.95 | 0.0020 | 3-May-19 | 170.25 | 0.0080 | 298.53 | -0.0025 |
| 15-Mar-19 | 155.02 | 0.0323 | 285.33 | -0.0161 | 6-May-19 | 170.15 | -0.0006 | 301.23 | 0.0090 |
| 18-Mar-19 | 153.68 | -0.0087 | 288.03 | 0.0094 | 7-May-19 | 171.7 | 0.0091 | 296.23 | -0.0167 |
| 19-Mar-19 | 156.01 | 0.0150 | 293.82 | 0.0199 | 8-May-19 | 168.9 | -0.0164 | 295 | -0.0042 |
| 20-Mar-19 | 150.89 | -0.0334 | 293.28 | -0.0018 | 9-May-19 | 169.4 | 0.0030 | 294.21 | -0.0027 |
| 22-Mar-19 | 151.39 | 0.0033 | 292.59 | -0.0024 | 10-May-19 | 166.3 | -0.0185 | 292.15 | -0.0070 |
| 25-Mar-19 | 157.65 | 0.0405 | 289.5 | -0.0106 | 13-May-19 | 164.1 | -0.0133 | 283.86 | -0.0288 |
| 26-Mar-19 | 160.05 | 0.0151 | 287.88 | -0.0056 | 14-May-19 | 164.15 | 0.0003 | 288.82 | 0.0173 |
| 27-Mar-19 | 160.1 | 0.0003 | 287.59 | -0.0010 | 15-May-19 | 162.7 | -0.0089 | 291.47 | 0.0091 |
| 28-Mar-19 | 155.9 | -0.0266 | 294.3 | 0.0231 | 16-May-19 | 165.9 | 0.0195 | 289.21 | -0.0078 |
| 01-April- | 157.25 | 0.0086 | 291.66 | -0.0090 | 17-May-19 | 167.3 | 0.0084 | 295.73 | 0.0223 |
| 2-April-19 | 157.5 | 0.0016 | 292.3 | 0.0022 | 20-May-19 | 176 | 0.0507 | 301.23 | 0.0184 |
| 3-April-19 | 155.45 | -0.0131 | 290.5 | -0.0062 | 21-May-19 | 174.7 | -0.0074 | 300.15 | -0.0036 |
| 4-April-19 | 155.25 | -0.0013 | 289.2 | -0.0045 | 22-May-19 | 177 | 0.0131 | 299.75 | -0.0013 |
| 5-April-19 | 156.55 | 0.0083 | 289.01 | -0.0007 | 23-May-19 | 174.15 | -0.0162 | 288.2 | -0.0393 |
| 8-April-19 | 158.1 | 0.0099 | 287.2 | -0.0063 | 24-May-19 | 174.4 | 0.0014 | 290.45 | 0.0078 |
| 9-April-19 | 157.55 | -0.0035 | 290.7 | 0.0121 | 27-May-19 | 173.6 | -0.0046 | 290.85 | 0.0014 |
| 10-April- | 158 | 0.0029 | 280.1 | -0.0371 | 28-May-19 | 175.3 | 0.0097 | 288.9 | -0.0067 |
| 11-April- | 158.6 | 0.0038 | 290.8 | 0.0375 | 29-May-19 | 171.55 | -0.0216 | 288.1 | -0.0028 |
| 12-April- | 157.6 | -0.0063 | 300 | 0.0311 | 30-May-19 | 169.4 | -0.0126 | 288.65 | 0.0019 |
| 15-April- | 156.45 | -0.0073 | 299.76 | -0.0008 | 31-May-19 | 171.95 | 0.0149 | 278.55 | -0.0356 |
| Correlation coefficient of ITC AND ONGC: 0.0546 | | | | | | | | | |

2. Reference Data of Table 3, Correlation Matrix

| Date | Ongc | Itc | Yes Bank | Ntpc | Ndtv |
|---|---|---|---|---|---|
| 2/5/2019 | 169.35 | 304.65 | 173.8 | 133.13 | 34.45 |
| 3/5/2019 | 170.1 | 303.65 | 173.6 | 135.55 | 34.8 |
| 6/5/2019 | 170.2 | 307 | 166.3 | 134.95 | 34.9 |
| 7/5/2019 | 171.45 | 302.35 | 164.55 | 133.95 | 34.5 |
| 8/5/2019 | 168.9 | 300.75 | 160.75 | 131 | 34.45 |
| 9/5/2019 | 169.3 | 299.8 | 170.3 | 127.95 | 34.7 |
| 10/5/2019 | 166.35 | 297.7 | 164 | 127.15 | 34.85 |
| 13/5/2019 | 164.1 | 289.85 | 154.85 | 123.65 | 34.6 |
| 14/5/2019 | 163.95 | 294 | 156.15 | 125.5 | 34.7 |
| 15/5/2019 | 162.65 | 297.1 | 143.65 | 123.85 | 35.7 |
| 16/5/2019 | 165.9 | 294.7 | 137.8 | 125.85 | 37.6 |
| 17/5/2019 | 167.15 | 301.4 | 134.55 | 125.8 | 38.1 |
| 20/5/2019 | 176.05 | 307 | 143.6 | 129.15 | 36.85 |
| 21/5/2019 | 174.3 | 305.3 | 141.66 | 128.45 | 39.4 |
| 22/5/2019 | 176.55 | 299.55 | 137.7 | 129.6 | 39.95 |
| 23/5/2019 | 174.05 | 288.5 | 139.8 | 129.9 | 37.1 |
| 24/5/2019 | 174.4 | 290.15 | 141.3 | 129.2 | 36.15 |
| 27/5/2019 | 173.7 | 290.4 | 146.65 | 133.3 | 35.8 |
| 28/5/2019 | 175.1 | 289 | 152.6 | 132.75 | 35 |
| 29/5/2019 | 171.55 | 288.35 | 151.7 | 130.85 | 34.6 |
| 30/5/2019 | 169.65 | 289.1 | 154.55 | 135.35 | 34.75 |
| 31/5/2019 | 171.85 | 278.65 | 147.95 | 133.2 | 34.85 |
| 3/6/2019 | 172.3 | 278.55 | 149.35 | 133.05 | 34.8 |
| 4/6/2019 | 170.55 | 279.65 | 152.75 | 135 | 34.95 |
| 6/6/2019 | 169.05 | 276.1 | 143.35 | 136 | 34.8 |
| 7/6/2019 | 167.55 | 275.9 | 139.95 | 134.9 | 35 |
| 10/6/2019 | 164.75 | 279.6 | 135.9 | 134.95 | 34.65 |

| | | | | | |
|---|---|---|---|---|---|
| 11/6/2019 | 169 | 280 | 139.3 | 135.25 | 34.85 |
| 12/6/2019 | 170.45 | 280 | 134.65 | 134.3 | 34.9 |
| 13/6/2019 | 168.95 | 279.85 | 117.2 | 134.65 | 34.8 |
| 14/6/2019 | 168.9 | 277.95 | 115.35 | 132.8 | 35.35 |
| 17/6/2019 | 164.65 | 275.3 | 116.2 | 132.2 | 34.8 |
| 18/6/2019 | 166.1 | 275.6 | 109.3 | 132.5 | 34.8 |
| 19/6/2019 | 167.35 | 277.35 | 103.25 | 134.6 | 34.9 |
| 20/6/2019 | 171.85 | 277.15 | 114.55 | 134.55 | 34.5 |
| 21/6/2019 | 171.2 | 274.25 | 109.55 | 134.55 | 34.9 |
| 24/6/2019 | 165.35 | 276.3 | 111.95 | 135.5 | 35 |
| 25/6/2019 | 166.3 | 278.25 | 110.65 | 138.9 | 34.95 |
| 26/6/2019 | 167.45 | 277.35 | 113.1 | 139.95 | 34.65 |
| 27/6/2019 | 170.55 | 273.55 | 112.4 | 140.3 | 34.55 |
| 28/6/2019 | 167.75 | 273.95 | 108.7 | 141.35 | 35.25 |