

Analysis of Portfolio Rebalancing and Technical Indicators

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Abstract— Stock Market is a scenario where investments can yield high rewards. However, each investment in any kind of financial market comes with a significant amount of risk for a period of time, a lot of interest has been diverted towards reducing risk associated in the investment and maintaining the risk to reward ratio as high as possible. In this article, we represent strategies and factors for rebalancing portfolio's that can accommodate changes as per the changes in the financial market environment to reduce the risk. Rebalancing is the process of buying and selling portions of your portfolio in order to set the weight of each asset class back to its original state. It is a weighting method of an asset that includes purchasing and selling assets in a portfolio regularly in a specific period of time to preserve an initial or desired amount of asset allocation or risk.

Index Terms— CAGR, Indicators, Investment, Maximum Drawdown, Portfolio, Rebalancing, Risk to Reward, Sharpe ratio, Stock Market.

1 INTRODUCTION

Each layer of the portfolio addresses a particular investment goal, independent of the other investment goals. Investors target low-risk investments like cash and money market funds to preserve wealth, they target bonds and dividend-paying stocks to provide income, and they target risky investments like emerging market stocks and IPOs to have a chance to get rich. Opportunities to reduce risk by combining assets with low correlations may be neglected and inefficient investing may result from offsetting positions in the various layers.

Portfolio rebalancing is a powerful risk-control strategy. Over time, as a portfolio's different investments produce different returns, the portfolio drifts from its target asset allocation, acquiring risk and return characteristics that may be inconsistent with an investor's goals and preferences. A rebalancing strategy addresses this risk by formalizing guidelines about how frequently the portfolio should be monitored, how far an asset allocation can deviate from its target before it is rebalanced, and whether periodic rebalancing should restore a portfolio to its target or to some intermediate allocation.

This paper establishes a framework for developing a portfolio-rebalancing strategy. We start by exploring various rebalancing decisions and a portfolio's risk and return characteristics. Investors select a rebalancing strategy that balances their willingness to assume risk against returns net of the cost of rebalancing. We also explore a second important determinant of the appropriate rebalancing strategy: the characteristics of the portfolio's assets. For example, high correlation among the returns of a portfolio's various assets reduces the risk that the portfolio will drift from its target allocation, thus limiting the

need to rebalance.

2 PORTFOLIO REBALANCING AND IMPORTANCE

Portfolio management (PM), to be brief, the management of a basket of stocks and (or) bonds, is the art of selecting the right investment policy for the investor in terms of maximum return at a given risk level. Financial theory suggests a wide range of motives for portfolio rebalancing: one of the widely reported rationales is the fact that an investor is passively exposed to greater market risk when realized returns on financial assets result in mechanical variations in portfolio allocation. This risk is managed by actively rebalancing his/her portfolio when asset returns change over time. The periodical resetting of weights of asset classes - stocks and bonds - in the portfolio is one of the controversial aspects of portfolio management. Rebalancing of a portfolio often involves taking profit from outperforming assets (so as to avoid overweighting) and buying underperforming assets. Portfolio rebalancing helps investors achieve their investment goals and avoid the common investment mistakes. There are two major benefits of portfolio rebalancing: the first benefit is risk control which maintains the asset allocation as its original target. The second benefit is the potential return which can be achieved by buy-low/sell-high opportunities.

Portfolio rebalancing is like a tune-up for your car: it allows individuals to keep their risk level in check and minimize risk. Thus, rebalancing is the process of buying and selling portions of your portfolio in order to set the weight of each asset class back to its original state. In addition, if an investor's investment strategy or tolerance for risk has changed, he or she can use rebalancing to readjust the weightings of each security or asset class in the portfolio to fulfill a newly devised asset allocation.

3 MATHEMATICAL RATIOS AND KPI'S

In this section, some risk management ratios and KPI's (Key Performance Indicators) will be discussed which will be used for calculations of portfolio rebalancing. For rebalancing your portfolio, the goal is to align your portfolio with the desired asset

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allocation. As we invest over time its desired that our asset allocation will change. As our goal shifts our time horizon may change and so as our risk tolerance. Hence by using this ratios and KPI's we can calculate our risk for a specific asset.

3.1 CAGR(Compound Annual Growth Rate)

Compound annual growth rate (CAGR) is the rate of return 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 year of the investment's lifespan.

$$CAGR = (EV / BV)^{1/n} - 1 \tag{1}$$

Where:

EV= Ending Value

BV= Beginning Value

n= Number of years

CAGR can be used in portfolio rebalancing, as it is the most accurate way to calculate and determine returns of anything that can rise or fall in a value of time. We can use CARG of two alternative assets in order to check which stock performed well against the other in the markets.

This formula is continuous compounding which means that all the profits are being reinvested continuously. CAGR provides ease of comparison between different trading strategies. It does not reflect investment risk and therefore should always be used in conjunction with a volatility measure.

3.2 Annualized Volatility(AV)

Volatility of a strategy is represented by a standard deviation of the returns. This captures the variability of the returns from the mean return. Measuring the volatility of trading strategy we look at the daily return or monthly returns (or whichever time frame you prefer working with), then we try to see how variable were the returns compared to mean return. If your CAGR is high and volatility is also high that means your returns is compensated by the risk you are taking.(higher the volatility riskier the security). If you are working with daily data, to calculate volatility you will calculate the daily returns and you will find sd (standard deviation) of those returns, it will give you volatility. Annualization is achieved by multiplying the volatility with square root of the annualization factor.

1. To annualize daily volatility multiply by sqrt (252) – as there are 252 trading days in a year.
2. To annualize weekly volatility multiply by sqrt (52) – as there are 52 trading weeks in a year.
3. To annualize monthly volatility multiply by sqrt (12) – as there are 12 trading months in a year.
4. It does not capture the tail risk.

Annualized Volatility is represented as:

$$Annualized\ Volatility\ Formula = \sqrt{252} * \sqrt{Variance} \tag{2}$$

Where:

$$Variance = \sum (P_{av} - P_i)^2 / n$$

P_{av} = Mean Price

P_i = Daily Stock Price on ith day

Hence the annualize volatility can also be written as:

$$Annualized\ volatility = \sqrt{252} * \sqrt{(\sum (P_{av} - P_i)^2 / n)} \tag{3}$$

3.3 Sharpe / Sortino ratio

Sharpe ratio is the measure of risk-adjusted return of a financial portfolio. A portfolio with a higher Sharpe ratio is considered superior relative to its peers. The ratio is the average return earned in excess of the risk-free rate per unit of volatility or total risk. Sharpe ratio is a measure of excess portfolio return over the risk-free rate relative to its standard deviation.

It gives information about both risk and return simultaneously. Sharpe has become industrial standard for measuring the performance or measuring the suitability of particular fund or strategy.

$$Sharpe\ Ratio = (R_p - R_f) / Av \tag{4}$$

Where:

R_p = Return of portfolio

R_f = Risk free rate

Av = Standard deviation of portfolio's excess return

A good sharpe ratio is considered as the below following table:

Table 1 Sharpe Ratio Parameters

Sharpe Ratio	Risk Rate	Verdict
Less than 1.00	Very Low	Poor
1.00 - 1.99	High	Good
2.00 - 2.99	High	Great
3.00 or Above	High	Excellent

3.4 Maximum Drawdown

A maximum drawdown (MDD) is the maximum observed loss from a peak to a trough of a portfolio, before a new peak is attained. Maximum drawdown is an indicator of downside risk over a specified time period.

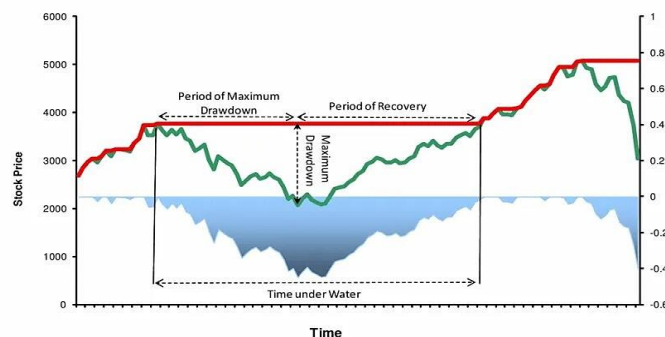


Figure 1 Maximum Drawdown

Largest percentage drop over a specified time period i.e. distance between peak and trough in the line curve of the asset. Investment with longer back testing period will likely have larger max drawdown and therefore caution must be applied in comparing across strategies. The formula for maximum drawdown is:

$$\text{MDD} = (\text{Trough Value} - \text{Peak Value}) / \text{Peak Value} \quad (5)$$

- Maximum drawdown (MDD) measures the maximum fall in the value of the investment, as given by the difference between the value of the lowest trough and that of the highest peak before the trough.
- By measuring the difference between the highest peak and the lowest trough values of an investment, MDD shows the volatility of its value in the past, which provides an almost accurate way of predicting future price movements.
- In addition to associated risk, maximum drawdown also acts as an indicator for market performance.

3.5 Calmar Ratio

The Calmar ratio is a formula that measures the performance of an investment fund compared to its risk. It is commonly used as a risk-adjusted measure in the selection of investments. The Calmar ratio is determined by taking the investment annual rate of return and dividing it by its maximum drawdown. The formula for calmar ratio is:

$$\text{Calmar Ratio} = \text{Rp} - \text{Ri} / \text{Maximum Drawdown} \quad (6)$$

Where:

R_p = Portfolio return

R_i = Risk-free rate

$R_p - R_i$ = Annual rate of return

- The Calmar ratio measures the performance of an investment fund – such as a hedge fund – compared to its risk.
- It aims to demonstrate the amount of risk required to obtain a return. It will help investors to balance their risk appetite with their investment decisions.
- The ratio cannot be adjusted to various time horizons; hence, portfolios must have the same period of backtesting.

The higher the calmar ratio the better it is. The calmar ratio of 3.0 to 5.0 is often recommended as very good.

4 REBALANCING METHODS

4.1 Rebalancing Approach Buy and Hold

Rebalancing is often thought of as a return enhancer. However, it can also be thought of as a risk reducer, particularly for those investors who employ a buy-and-hold approach. The objective of buy-and-hold is to buy the initial allocation mix and then hold it indefinitely, regardless of performance.

Under this strategy, the asset allocation of the portfolio drifts randomly along with the market movements and the market will rebalance the asset allocation. There are a variety of ways to find buy-and-hold stocks. The asset allocation is allowed to vary significantly from the starting allocation as risky assets, such as stocks, increase or decrease. The portfolio becomes more aggressive as stocks rise and you let the profits ride, no matter how high the stock value gets. This strategy also presents benefits like with lower costs like no taxes, trading or brokerage fees and commission.

For example below, we have chosen a monthly rebalancing option (periodic rebalancing) with the intention of allowing only minor deviation from the investment strategy in order to create a version of rebalancing that shows as much distinction from a buy-and-hold approach as possible. However, most of the strategies tend to more closely resemble a buy-and-hold approach in terms of how they work.

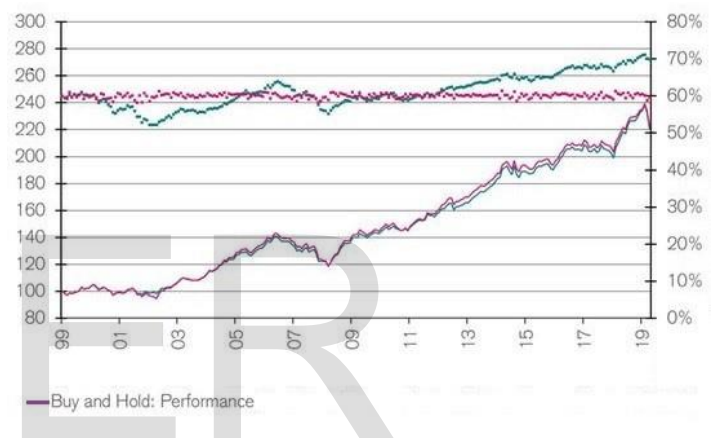


Figure 2 Buy and Hold Performance

The buy and hold approach gives more returns over a period of time. The volatility of buy and hold approach is less as compared to the other rebalancing strategies. The maximum potential loss of other strategies is also higher due to high volatility as compared to the buy and hold strategy. Based on the risk metrics, the buy-and-hold strategy would have required the investor to have lower risk ability compared to the rebalancing approach. It may also be astonishing that both approaches were similar even though the buy-and-hold approach drifted significantly from the neutral allocation multiple times. Hence the buy and hold has an edge over the other strategies due to less volatility and keeping the portfolio more stable with minimum risk and more returns.

4.2 Buy and Hold Rebalancing Strategy

The rebalancing in buy and hold strategy will be done on the basis of the output values calculated of a specific stock using the risk management ratios and KPI's (Key Performance Indicators) mentioned above. If a stock is performing good by taking into consideration of the KPI's value then that stock will be picked or replaced with the worse performing stock in the portfolio.

Choose a particular set of stocks from the universe of stocks

(Large cap, mid cap, small cap, industry specific, factor specific, etc.) and stick to the group of stocks as the source for your portfolio for entire duration of back testing. This particular set of stocks will be fixed and the portfolio will be rebalanced among them based on their performance. Investor has to build/set a fixed individual position size for long positions only by picking 'M' number of stocks based on monthly returns which will be given by KPI's. As the position sizing is fixed every single position for the 'M' number of stocks will be same. For consideration if the number of stocks 'M' is 5 and the total portfolio value is 5 lakh rs then each individual position will of 1 lakh rs respectively. The portfolio will now drift according to the market conditions for a period of 1 month. After a period of a month based on the performance of the M stocks the portfolio will be rebalanced. The worst performing N number stocks will be replaced with the top performing N number of stocks from the set with keeping the total M number of stocks in the portfolio constant with respect to maintaining the position size of each individual stock same.

If a particular stock X is performing well and giving good returns then that stock can be selected again. For consideration if N stocks are removed from the portfolio and (M-N) are replaced with them then that stock X will be selected again in (M-N) number of stocks. Hence, the investor will have 2 positions of a single particular stock X with other 3 stocks in the portfolio having same position sizing.

The following are the results by comparing DJI (Dow Jones Index) with Buy and Hold portfolio rebalancing strategy:

Three KPI's and risk management ratios CAGR, Sharpe ratio and Maximum Drawdown are calculated for a period of time for comparing the results.

Table 2 DJI and Buy and Hold KPI values

KPI's	DJI Index	Buy and Hold
CAGR	0.09600805607302076	0.1509145317339049
Sharpe ratio	0.5230631004342344	0.9391471795190502
Maximum drawdown	0.23201266165063417	0.21909479843264232

The numbers and results clearly reflect that CAGR, Sharpe ratio and Maximum Drawdown of the Buy and Hold portfolio rebalancing strategy is giving more returns than the DJI.



Figure 3 Index vs Strategy Return

By plotting the returns on a line chart it clearly shows that the strategy is having a consistent and higher rate of return than the DJI index. As the chart shows the strategy is moving in a similar kind with the DJI index but with a higher rate of return which clearly states that the Buy and Hold rebalancing strategy is having an edge over the market in terms of the rate of return for the portfolio.

5 RESULT AND DISCUSSION

We had backtested the rebalancing strategy and applied it on different time period to check whether this strategy performs well in each time period and gives consistent return on investment with minimum risk. A set of stocks from NSE (National Stock Exchange) has been taken. All the stocks are of different sector and industries. The Buy and Hold rebalancing strategy will be backtested on the following set of stocks only by including and excluding them in the portfolio for rebalancing purpose.

The following is the set of stocks picked up from NSE:

RELIANCE.NS, TCS.NS, HDFCBANK.NS, INFY.NS, HINDUNILVR.NS, HDFC.NS, ICICIBANK.NS, KOTAKBANK.NS, BHARTIARTL.NS, BAJFINANCE.NS, HCLTECH.NS, SBIN.NS, ASIANPAINT.NS, WIPRO.NS, MARUTI.NS, AXISBANK.NS, LT.NS, DMART.NS, ADANIGREEN.NS, ULTRACEMCO.NS, BAJAJFINSV.NS, HDFCLIFE.NS, SUNPHARMA.NS, TITAN.NS, ONGC.NS, ADANIPTS.NS, BAJAJ_AUTO.NS, TATAMOTORS.NS, POWERGRID.NS, M.M.NS

By using, the rebalancing strategy on the above mentioned set of stocks the following results were obtained by rebalancing the portfolio in a daily, weekly and monthly period of time and were compared with the NSE index:

5.1 Daily Rebalancing

Table 3 Daily Rebalancing Results

KPI's	NSE	Buy and Hold
CAGR	0.10201720025384242	0.29425929108596716
Sharpe ratio	0.4368995297207292	1.1976658902411004
Maximum drawdown	0.38439852452742096	0.31306135498726045

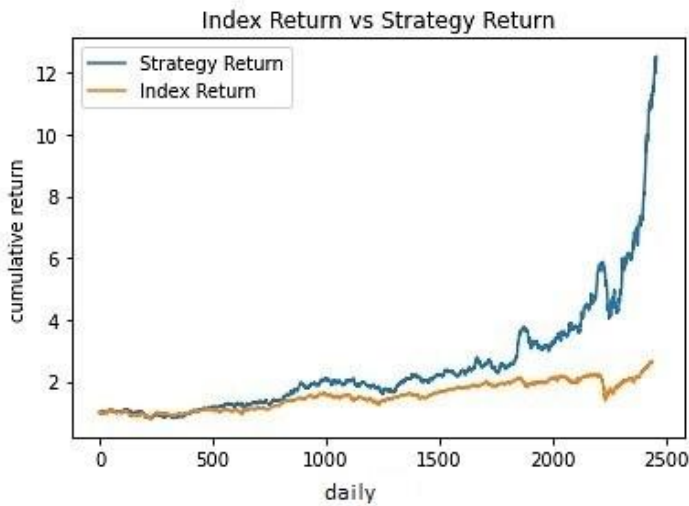


Figure 4 Daily Rebalancing

As we can clearly see the strategy return in daily period of time is way more than the index return in terms of the output of the ratios and as well as by plotting it on a chart. The value of CAGR, Sharpe and Maximum drawdown is greater for the Buy and Hold strategy than that for the index which in term provides more returns as it can also be seen in the chart above. For a period of time the strategy and index returns were increasing gradually and similarly but after a period of time there was as sudden increase in the returns for the strategy which kept increasing over a period of time.

5.2 Weekly Rebalancing

Table 4 Weekly Rebalancing Results

KPI's	NSE	Buy and Hold
CAGR	0.10862715878537887	0.15949819352122896
Sharpe ratio	0.46035582939571723	0.5668309093389577
Maximum drawdown	0.38276335141558027	0.4310338136458011



Figure 5 Weekly Rebalancing

In weekly rebalancing the CAGR, Sharpe and Maximum drawdown were greater for the Buy and Hold strategy than that of the index and the chart also supports as we can see the returns at the end of the strategy were greater than the index. The performance of the strategy at the starting was less but after a certain period of time there was a sudden increase in the performance of the strategy which kept on increasing gradually.

5.3 Monthly Rebalancing

Table 5 Monthly Rebalancing Results

KPI's	NSE	Buy and Hold
CAGR	0.1033071233009284	0.15203910106129115
Sharpe ratio	0.44217301280352506	0.2461639066694335
Maximum drawdown	0.29352043977792835	0.7088679457336193



Figure 6 Monthly Rebalancing

In monthly period of rebalancing, the sharpe ratio for strategy was less than that of the index but the CAGR and Maximum drawdown for the strategy were greater than the index and in terms of the final returns, the strategy performed well than the index after a certain period of time.

It is evident form the above results that the Buy and Hold rebalancing strategy produces highest returns as compared to the index. In all daily, weekly and monthly periods of rebalancing the strategy has given more returns than the index and there by validating form the above results and charts came to the conclusion that the Buy and Hold rebalancing strategy produces highest returns in each period of time.

6 CONCLUSION

Benjamin Graham wrote in the Intelligent Investors than, "The essence of Investment Management is the management of risks, not the management of returns. Well-managed Portfolios start with this precept." The portfolio can drift away from the optimal target weights as the asset price changes over a period of time. Thus, a profitable portfolio rebalancing strategy is sig-

nificant in this case, because it affects the returns and risks associated with the portfolio. The portfolio performance can be optimized by using technical analysis or proposed rebalancing strategies.

First, although the return of buy-and-hold strategy is higher than some of the Index returns. Second, the rebalancing strategies results is lower risk than the Index and gives more percentage of returns. Thirdly, the strategy has a greater risk reward than the index. Fourthly, the return of this buy and hold strategy in each period and timeframe is greater than the index return. In trending market, this strategy always performs and yields more returns than the index.

The strategy performs consistently in all periods for rebalancing the portfolio. Having an edge of different risk management ratios and KPI's for rebalancing purpose the strategy outperform in each and every investors portfolio.

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