# Risk Management
# & Trading Psychology

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# CHAPTER 1

## Orientation Note



## 1.1 – A unique opportunity

I'm excited about this brand new module on Varsity, wherein we will be discussing two important and closely related market topics – 'Risk Management and Trading Psychology'. While risk management may seem straightforward, 'psychology' may sound boring. Trust me; both these topics can potentially open up new realms of trading. Risk management, for instance, is not what you are thinking – it goes beyond the usual topics of position sizing, stop loss and leverage. While trading psychology is a reflection of your actions in the markets – helps you introspect and find answers to why and how you made a profit or a loss in a particular trade or investment.

Given the exhaustive nature of these topics, I tried looking for ideas on how best I can structure this module, and what chapters to include, and to my surprise, there are no contents related to these topics. Of course, you can find tonnes of content online, but they are all fragmented and lack continuity. This gives us both the opportunity and the responsibility to develop some dependable content around these topics, centered on the

Indian context. We will have to work as a team here – we will take up the responsibility to post the content and you will have to take up the responsibility to enrich it by posting queries and comments.

1.2 – What to expect?

At this stage, I can give you a brief orientation on what to expect, however as we proceed, if necessary I'll take the liberty to alter the learning methodology, although not too drastically.

So there are 2 main topics we are dealing with here –

1. Risk Management
2. Trading psychology

Risk management techniques vary based on how you are positioned in the market. For example, if you have a single position in the market, then your approach to risk management is very different compared to the risk management techniques of multiple positions, which is again completely different compared to the risk management techniques of a portfolio.

Given this, we will look at risk management from multiple angles –

1. Risk Management from a single trading position
2. Risk management from multiple trading positions
3. Risk management for a portfolio

In my attempt to explain the above, I will cover the following topics –

1. Risk and its many forms
2. Position sizing – guess this one is mandatory to cover
3. Single position risk
4. Multiple position risk and hedging
5. Hedging with options
6. Portfolio attributes and risk estimation
7. Value at Risk
8. Asset allocation and its impact on risk (and returns)
9. Insights from the portfolio equity curve

I'm guessing these topics will give you a completely different perspective on risk and how one can manage risk.

Further, we would be discussing trading psychology both from a trader and an investor's perspective. The discussion would largely involve cognitive biases, mental models, common

pitfalls, and the thought process which leads you these pitfalls. Here are some of the topics we would be discussing in this section –

1. Anchoring bias
2. Regency bias
3. Confirmation bias
4. Bandwagon effect
5. Loss aversion
6. Illusion of control
7. Hindsight bias

Of course, we will build upon this as we proceed. This is going to be an exciting discussing these topics.

Stay tuned.

# Risk (Part 1)

## 2.1. Warming up to risk

For every rupee of profit made by a trader, there must be a trader losing that rupee. As an extension of this, if there is a group of traders consistently making money, then there must be another group of traders consistently losing money. Usually, this group making money consistently is small, as opposed to the group of traders who lose money consistently.

The difference between these two groups is their understanding of Risk and their techniques of money management. Mark Douglas, in his book 'The Disciplined Trader', says successful trading is 80% money management and 20% strategy. I could not agree more.

Money management and associated topics largely involve assessment of risk. So in this sense, understanding risk and its many forms become essential at this point. For this reason, let us break down risk to its elementary form to get a better understanding of risk.

The usual layman definition of risk in the context of the stock market is the 'probability of losing money'. When you transact in the markets, you are exposed to risk, which means you can (possibly) lose money. For example, when you buy the stock of a company, whether you like it or not, you are exposed to risk. Further, at a very high level, risk can be broken down into two types – Systematic Risk and Unsystematic Risk. You are automatically exposed to both these categories of risks when you own a stock.

Think about it, why do you stand to lose money? Or in other words, what can drag the stock price down? Many reasons as you can imagine, but let me list down a few –

1. Deteriorating business prospects
2. Declining business margins
3. Management misconduct
4. Competition eating margins

All these represent a form of risk. In fact, there could be many other similar reasons and this list can go on. However, if you notice, there is one thing common to all these risks – they are all risks specific to the company. For example, imagine you have an investable capital of Rs.1,00,000/-. You decide to invest this money in HCL Technologies Limited. A few months

later HCL declares that their revenues have declined. Quite obviously HCL stock price will also decline. Which means you will lose money on your investment. However, this news will not impact HCL's competitor's stock price (Mindtree or Wipro). Likewise, if HCL's management is guilty of any misconduct, then HCL's stock price will go down and not its competitors. Clearly, these risks are specific to this one company alone and not its peers.

Let me elaborate on this – I'm not sure how many of you were trading the markets when the 'Satyam scam' broke out on the morning of 7th January 2009. I certainly was, and I remember the day very well. Satyam Computers Limited had been cooking its books, inflating numbers, mishandling funds, and misleading its investors for many years. The numbers shown were way above the actual, myriads of internal party transactions; all these resulting in inflated stock prices.  The bubble finally burst, when the then Chairman, Mr.Ramalinga Raju made a bold confession of this heinous financial crime via a letter addressed to the investors, stakeholders, clients, employees, and exchanges. You have to give him credit for taking such a huge step; I guess it takes a massive amount of courage to own up to such a crime, especially when you are fully aware of the ensuing consequences.

Anyway, I remember watching this in utter disbelief –  Udayan Mukherjee read out this super explosive letter, live on TV, as the stock price dropped like a stone would drop off a cliff. This, for me, was one of the most spine-chilling moments in the market, watch the video **here**

I want you to notice few things in the above video –

1. The rate at which the stock price drops (btw, the stock price continued to drop to as low as 8 or 7)
2. If you manage to spot the scrolling ticker, notice how the other stocks are NOT reacting to Satyam's big revelation
3. Notice the drop in the indices (Sensex and Nifty), they do not drop as much as that of Satyam.
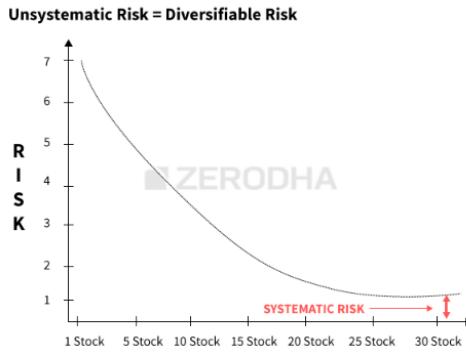
The point here is simple – the drop in stock price can be attributed completely to the events unfolding in the company. Other external factors do not have any influence on the price drop. Rather, a better way of placing this would be – at that given point, the drop in stock price can only be attributable to company specific factors or internal factors. The risk of losing money owing to company specific reasons (or internal reasons) is often termed as "Unsystematic Risk".

Unsystematic risk can be diversified, meaning instead of investing all the money in one company, you can choose to invest in 2-3 different companies (preferably from different sectors). This is called 'diversification'. When you diversify your investments, unsystematic risk drastically reduces. Going back to the above example, imagine instead of buying HCL for the entire capital, you decide to buy HCL for Rs.50,000/- and maybe Karnataka Bank Limited for the other Rs.50,000/-, in such circumstances, even if HCL stock price declines (owing to the unsystematic risk) the damage is only on half of the investment as the other half is invested in a different company. In fact, instead of just two stocks, you can have a 5 or 10 or maybe 20 stock portfolio. The higher the number of stocks in your portfolio, higher the diversification, and therefore lesser the unsystematic risk.

This leads us to a very important question – how many stocks should a good portfolio have so that the unsystematic risk is completely diversified. Research has it that up to 21 stocks in the portfolio will have the required necessary diversification effect and anything beyond 21 stocks may not help much in diversification. I personally own about 15 stocks in my equity portfolio.

The graph below should give you a fair sense of how diversification works –

**Unsystematic Risk = Diversifiable Risk**

As you can notice from the graph above, the unsystematic risk drastically reduces when you diversify and add more stocks. However, after about 20 stocks, the unsystematic risk is not really diversifiable, this is evident as the graph starts to flatten out after 20 stocks. In fact, the risk that remains even after diversification is called the "Systematic Risk".

Systematic risk is the risk that is common to all stocks in the markets. Systematic risk arises out of common market factors such as the macroeconomic landscape, political situation, geographical stability, monetary framework etc. A few specific systematic risks which can drag the stock prices down are: –

1. De-growth in GDP
2. Interest rate tightening
3. Inflation
4. Fiscal deficit
5. Geopolitical risk

The list, as usual, can go on but I suppose you get a fair idea of what constitutes a systematic risk. Systematic risk affects all stocks. Assuming, you have a well diversified 20 stocks portfolio, a de-growth in GDP will indiscriminately affect all the 20 stocks and hence the stock price of stocks across the board will decline. Systematic risk is inherent in the system and it cannot really be diversified. Remember, 'unsystematic risk' can be diversified, but systematic risk cannot be. However, systematic risk can be 'hedged'. Hedging is a craft, a technique one would use to get rid of the systematic risk. Think of hedging as carrying an umbrella with you on a dark cloudy day. The moment, it starts pouring, you snap your umbrella out and you instantly have a cover on your head.

So when we are talking about hedging, do bear in mind that it is not the same as diversification. Many market participants confuse diversification with hedging. They are two different things. Remember, we diversify to minimise unsystematic risk and we hedge to

minimise systematic risk and notice I use the word 'minimise' – this is to emphasise the fact that no investment/trade in the market should be ever considered safe in the markets.

Not mine, not yours.

## 2.2 – Expected Return

We will briefly talk about the concept of 'Expected Return' before we go back to the topic of Risk. It is natural for everyone to expect a return on the investments they make. The expected return on an investment is quite straight forward – the return you would expect from it. If you invest your money in Infosys and expect to generate 20% return in one year, then the expected return is just that – 20%.

Why is this important especially when it sounds like a no-brainer? Well, the 'expected return' plays a crucial role in finance. This is the number we plug in for various calculations – be it portfolio optimisation or a simple estimation of equity curve. So in a sense, expecting a realistic return plays a pivotal role in investment management. Anyway, more on this topic as we proceed. For now, let us stick to basics.

So continuing with the above example – if you invest Rs.50,000/- in Infy (for a year) and you expect 20% return, then the expected return on your investment is 20%. What if instead, you invest Rs.25,000/- in Infy for an expected return of 20% and Rs.25,000/- in Reliance Industries for an expected return of 15%? – What is the overall expected return here? Is it 20% or 15% or something else?

As you may have guessed, the expected return is neither 20% nor 15%. Since we made investments in 2 stocks, we are dealing with a portfolio, hence, in this case, the expected return is that of a portfolio and not the individual asset. The expected return of a portfolio can be calculated with the following formula –

$E(R_P) = W_1 R_1 + W_2 R_2 + W_3 R_3 + ———– + W_n R_n$

Where,

$E(R_P)$ = Expected return of the portfolio

W = Weight of investment

R = Expected return of the individual asset

In the above example, the invested is Rs.25,000/- in each, hence the weight is 50% each. Expected return is 20% and 15% across both the investment. Hence –

E(RP) = 50% * 20% + 50% * 15%

= 10% + 7.5%

= 17.5%

While we have used this across two stocks, you can literally apply this concept across any number of assets and asset classes. This is a fairly simple concept and I hope you've had no problem understanding this. Most importantly, you need to understand that the expected return is not 'guaranteed' return; rather it is just a probabilistic expectation of a return on an investment.

Now that we understand expected returns, we can build on some quantitative concepts like variance and covariance. We will discuss these topics in the next chapter.

**Key takeaways from this chapter**

1. When you buy a stock you are exposed to unsystematic and systematic risk
2. Unsystematic risk with respect to a stock is the risk that exists within the company
3. Unsystematic risk affects only the stock and not its peers
4. Unsystematic risk can be mitigated by simple diversification
5. Systematic risk is the risk prevalent in the system
6. Systematic risk is common across all stock
7. One can hedge to mitigate systematic risk
8. No hedge is perfect – which means there is always an element of risk present while transacting in markets
9. Expected return is the probabilistic expectation of a return
10. Expected return is not a guarantee of return
11. The portfolio's expected return can be calculated as – E(RP) = W1R1 + W2R2 + W3R3 + ———– + WnRn

# Risk (Part 2) – Variance & Covariance



## 3.1. Variance

In the previous chapter, we touched upon the topic of expected return, continuing on it, we will understand the concept of 'Portfolio variance'. Portfolio Variance helps us understand the risk at a portfolio level. I'm hoping you are familiar with 'Standard Deviation' as a measure of risk. We have discussed standard deviation multiple times in the previous modules (refer to Module 5, chapter 15 onwards). I'd suggest you get familiar with it if you are not already. While we can easily measure the risk of a single stock by calculating its standard deviation, calculating the risk of a portfolio is a whole different ball game. When you put a few individual stocks together and create a portfolio, it becomes a different animal altogether. The agenda for this chapter is to help you understand how to estimate risk at a portfolio level.

However, before we proceed, we need to understand the concept of Variance and Covariance. Both Variance and Covariance are statistical measures. Let's deal with the Variance first.

The variance of stock returns is a measure of how much a stock's return varies with respect to its average daily returns. The formula to calculate variance is quite straight forward –

$$\sigma^2 = \sum \frac{(X - \mu)^2}{N}$$

Where,

σ2 = Variance

X = Daily return

μ = Average of daily return

N = Total number of observation

Note, the variance is measured as sigma squared; I will not get into the reasons for this as the explanation is quite complex and we could digress. For now, I'd request you to be aware of the fact that variance is sigma squared. Anyway, calculating variance is quite simple, I'll take a simple example to help us understand this better.

Assume the daily return for a stock for 5 consecutive days is as below –

Day 1 – + 0.75%

Day 2 – + 1.25%

Day 3 – -0.55%

Day 4 – -0.75%

Day 5 – +0.8%.

In this case, the average return is +0.3%. We now need to calculate the dispersion of daily return over its average return, and also square the dispersion.

| Daily Return | Dispersion from average | Dispersion squared |
| --- | --- | --- |
| + 0.75% | 0.75% – 0.3% = + 0.45% | 0.45%^2 = 0.002025% |
| + 1.25% | +1.25% – 0.3% = + 0.95% | 0.95%^2 = 0.009025% |
| -0.55% | -0.55% – 0.3% = -0.85% | -0.85%^2 = 0.007225% |
| -0.75% | -0.75% – 0.3% = -1.05% | -1.05%^2 = 0.011025% |

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| Daily Return | Dispersion from average | Dispersion squared |
|---|---|---|
| +0.80% | +0.8% – 0.3% = +0.5% | 0.50%^2 = 0.002500% |

We now sum up the dispersion squared to get 0.0318000%. We divide this over 5 (N) to get the variance i.e.

0.0318000% / 5

$\sigma^2$ = 0.0063600%.

So what does this number tell us? It gives us a sense of how the daily returns are spread out from the average expected returns. So you as an investor should look into the variance to determine the riskiness of the investment. A large variance indicates that the stock could be quite risky while a small variance can indicate lesser risk. In the above example, I would consider the variance high, since we are looking at just 5 days' worth of data.

Now, here is something you may be interested in knowing. Variance and standard deviation are related to each other by the following simple mathematical relationship –

Square Root of Variance = Standard Deviation

We can apply this to the example above and calculate the 5-day standard deviation of the stock,

%

~ 0.8%

which is the standard deviation a.k.a. the volatility of the stock (over the last 5 days). Anyway, at this point, I want you to be aware of Variance and what it really means. We will eventually plug variance along with covariance into the portfolio variance equation.

## 3.2 – Covariance

Covariance indicates how two (or more) variables move together. It tells us whether the two variables move together (in which case they share a positive covariance) or they move in the opposite direction (negatively covariance). Covariance in the context of stock market measures how the stock prices of two stocks (or more) move together. The two stocks prices are likely to move in the same direction if they have a positive covariance; likewise, a negative covariance indicates that they two stocks move in opposite direction.

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I understand covariance may sound similar to 'correlation', however, the two are different. We will discuss more on this further in the chapter.

I guess calculating the covariance for two stocks will help us get a grip on understanding covariance better. The formula to calculate covariance of two stocks is as follows –

$$\text{Covariance} = \sum \frac{\left((Rt\ S1 - Avg\ Rt\ S1) * (Rt\ S2 - Avg\ Rt\ S2)\right)}{n-1}$$

Where,

Rt S1 = Daily stock return of stock 1

Avg Rt S1 = Average return of stock 1 over n period

Rt S2 = Daily stock return of stock 2

Avg Rt S2 = Average return of stock 2 over n period

n – The total number of days

In other words, you can calculate the covariance between two stocks by taking the sum product of the difference between the daily returns of the stock and its average return across both the stocks.

Sounds confusing? I guess so.

Let us take up an example and see how we can calculate the covariance between two stocks.

For the sake of this illustration, I've selected two stocks – Cipla Limited and Idea Cellular Limited. To calculate the covariance between these two stocks, we need to work around with the above formula. We will resort to good old excel to help us implement the formula.

Before we proceed, if you were to guess the covariance between Cipla and Idea, what do you think it would be? Think about it – two large corporate, similar size, but in two completely unrelated sectors. What do you think would be the covariance? Give it a thought.

Anyway, here are the steps involved in calculating covariance in excel (note, although there is a direct function in excel to calculate covariance, I'll take the slightly longer approach, just to ensure clarity) –

Step 1 – Download the daily stock prices. For the purpose of this illustration, I've downloaded 6 months' data for both the stocks.

| Date | Cipla | Idea |
|------|-------|------|
| 1-Sep-16 | 579.15 | 83.65 |
| 2-Sep-16 | 577.95 | 84.45 |
| 6-Sep-16 | 578.6 | 84.85 |
| 7-Sep-16 | 580.75 | 83.7 |
| 8-Sep-16 | 595.15 | 84.5 |
| 9-Sep-16 | 580.5 | 83.6 |
| 12-Sep-16 | 570.1 | 82.8 |

| Starting Date | 1st Sept 2016 |
|---------------|---------------|
| Ending Date | 7th Mar 2017 |

Step 2 – Calculate the daily returns for both the stocks. Daily returns can be calculated by dividing today's stock price over yesterday's stock price and subtracting 1 from the result of this division

| Date | Cipla | Daily Rt | Idea | Daily Rt |
|------|-------|----------|------|----------|
| 1-Sep-16 | 579.15 | | 83.65 | |
| 2-Sep-16 | 577.95 | =B3/B2-1 | 84.45 | =D3/D2-1 |
| 6-Sep-16 | 578.6 | | 84.85 | |
| 7-Sep-16 | 580.75 | | 83.7 | |
| 8-Sep-16 | 595.15 | | 84.5 | |
| 9-Sep-16 | 580.5 | | 83.6 | |
| 12-Sep-16 | 570.1 | | 82.8 | |

Step 3 – Calculate the average of the daily returns

| A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|
| Date | Cipla | Daily Rt | Idea | Daily Rt | | | |
| 1-Sep-16 | 579.15 | ⇩ | 83.65 | ⇩ | | | |
| 2-Sep-16 | 577.95 | -0.2% | 84.45 | 1.0% | | | |
| 6-Sep-16 | 578.6 | 0.1% | 84.85 | 0.5% | | | |
| 7-Sep-16 | 580.75 | 0.4% | 83.7 | -1.4% | | Starting Date | 1st Sept 2016 |
| 8-Sep-16 | 595.15 | 2.5% | 84.5 | 1.0% | | Ending Date | 7th Mar 2017 |
| 9-Sep-16 | 580.5 | -2.5% | 83.6 | -1.1% | | Cipla Avg Rt | =AVERAGE(C3:C128) |
| 12-Sep-16 | 570.1 | -1.8% | 82.8 | -1.0% | | Idea Avg Rt | =AVERAGE(E3:E128) |

Step 4 – Once the average is calculated, subtract the daily return by its average

| A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|
| Date | Cipla | Daily Rt | Rt - Avg | Idea | Daily Rt | Rt - Avg | | | |
| 1-Sep-16 | 579.15 | | | 83.65 | | | | | |
| 2-Sep-16 | 577.95 | -0.2% | =C3-$J$7 | 84.45 | 1.0% | 0.70% | | | |
| 6-Sep-16 | 578.6 | 0.1% | ⇧ | 84.85 | 0.5% | | | | |
| 7-Sep-16 | 580.75 | 0.4% | | 83.7 | -1.4% | | | Starting Date | 1st Sept 2016 |
| 8-Sep-16 | 595.15 | 2.5% | | 84.5 | 1.0% | | | Ending Date | 7th Mar 2017 |
| 9-Sep-16 | 580.5 | -2.5% | | 83.6 | -1.1% | | | Cipla Avg Rt | 0.02% |
| 12-Sep-16 | 570.1 | -1.8% | | 82.8 | -1.0% | | | Idea Avg Rt | 0.26% |
| 14-Sep-16 | 577.5 | 1.3% | | 83.75 | 1.1% | | | | |

Step 5 – Multiply the two series calculated in the previous step

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| Date | Cipla | Rt1 Daily Rt | Rt - Avg | Idea | Rt2 Daily Rt | Rt - Avg | Rt1*Rt2 |
|------|-------|--------------|----------|------|--------------|----------|---------|
| 1-Sep-16 | 579.15 | | | 83.65 | | | |
| 2-Sep-16 | 577.95 | -0.2% | -0.2% | 84.45 | 1.0% | 0.70% | =D4*G4 |
| 6-Sep-16 | 578.6 | 0.1% | 0.1% | 84.85 | 0.5% | 0.21% | |
| 7-Sep-16 | 580.75 | 0.4% | 0.3% | 83.7 | -1.4% | -1.61% | |
| 8-Sep-16 | 595.15 | 2.5% | 2.5% | 84.5 | 1.0% | 0.70% | |
| 9-Sep-16 | 580.5 | -2.5% | -2.5% | 83.6 | -1.1% | -1.32% | |
| 12-Sep-16 | 570.1 | -1.8% | -1.8% | 82.8 | -1.0% | -1.22% | |

Step 6 – Sum up the calculation made in the previous step. Take a count of the number of data points. You can do this by using the count function in excel and giving any of the fields as the input array. I've used the count on the dates here.

| | |
|---|---|
| Starting Date | 1st Sept 2016 |
| Ending Date | 7th Mar 2017 |
| Cipla Avg Rt | 0.02% |
| Idea Avg Rt | 0.26% |
| Sum | =SUM(H4:H129) |
| Count (n) | =COUNT(A3:A129) |

Step 7 – This is the final step in calculating the covariance. To do so, one needs to divide the sum by count minus 1 i.e. (n-1). The count, in this case, is 127, so count-1 would be 126. Sum calculated in the previous step was 0.006642. Hence, covariance would be

= 0.006642/126

= 0.00005230

| Date | Cipla | Rt1 Daily Rt | Rt - Avg | Idea | Rt2 Daily Rt | Rt - Avg | Rt1*Rt2 |
|------|-------|--------------|----------|------|--------------|----------|---------|
| 1-Sep-16 | 579.15 | | | 83.65 | | | |
| 2-Sep-16 | 577.95 | -0.2% | -0.2% | 84.45 | 1.0% | 0.70% | -0.002% |
| 6-Sep-16 | 578.6 | 0.1% | 0.1% | 84.85 | 0.5% | 0.21% | 0.000% |
| 7-Sep-16 | 580.75 | 0.4% | 0.3% | 83.7 | -1.4% | -1.61% | -0.006% |
| 8-Sep-16 | 595.15 | 2.5% | 2.5% | 84.5 | 1.0% | 0.70% | 0.017% |
| 9-Sep-16 | 580.5 | -2.5% | -2.5% | 83.6 | -1.1% | -1.32% | 0.033% |
| 12-Sep-16 | 570.1 | -1.8% | -1.8% | 82.8 | -1.0% | -1.22% | 0.022% |
| 14-Sep-16 | 577.5 | 1.3% | 1.3% | 83.75 | 1.1% | 0.89% | 0.011% |
| 15-Sep-16 | 585.4 | 1.4% | 1.3% | 84.5 | 0.9% | 0.64% | 0.009% |
| 16-Sep-16 | 593.55 | 1.4% | 1.4% | 85.15 | 0.8% | 0.51% | 0.007% |
| 19-Sep-16 | 597.8 | 0.7% | 0.7% | 84.85 | -0.4% | -0.61% | -0.004% |

| | |
|---|---|
| Starting Date | 1st Sept 2016 |
| Ending Date | 7th Mar 2017 |
| Cipla Avg Rt | 0.02% |
| Idea Avg Rt | 0.26% |
| Sum | 0.006642 |
| Count (n) | 127 |
| Count -1 | 126 |
| Covariance | =L9/L11 |

You can download the excel sheet.

As you can see, the covariance number is quite small. However, that's not the point here. We only look at whether the two stocks share a positive or negative covariance. Clearly, since the two stocks share a positive covariance, it means that the returns of the two stocks move in similar directions. It means that for a given situation in the market, both the stocks are likely

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to move in the same direction. Note – covariance does not tell us the degree to which the two stocks move. The degree or magnitude is captured by correlation. The correlation between Idea and Cipla is 0.106, which indicates that the two stocks are not tightly correlated.

By the way, here is something very interesting fact. The mathematical equation for correlation between two stocks is as follows –

$$Correlation = \frac{Cov\ (x, y)}{\sigma x * \sigma y}$$

Where,

Cov (x,y) is the covariance between the two stocks

σx = Standard deviation of stock x

σy = Standard deviation of stock y

Note, the standard deviation of a stock is simply the square root of the variance of the stock. Here is a task for you – we have calculated the correlation between Idea and Cipla using the direct excel function. Can you confirm the accuracy by implementing the formula?

Anyway, in the case of building a stock portfolio, do you think a positive covariance is good or bad? Or rather do portfolio managers desire stocks (in their portfolio) which share a positive covariance or they don't? Well, portfolio managers strive to select stocks which share a negative covariance. The reason is quite simple – they want stocks in the portfolio which can hold up. Meaning if one stock goes down, they want, at least the other to hold up. This kind of counter balances the portfolio and reduces the overall risk.

Now, think about a regular portfolio – it will certainly contain more than 2 stocks. In fact, a good portfolio will contain at least 12-15 stocks. How would one measure covariance in this case? This is where things start getting complicated. One will have to measure covariance of each stock with all the other stocks in the portfolio. Let me illustrate this with a 4 stocks portfolio. Assume the portfolio is like this –

1. ABB
2. Cipla
3. Idea
4. Wipro

In this case, we need to calculate the covariance across –

1. ABB, Cipla
2. ABB, Idea
3. ABB, Wipro
4. Cipla, Idea
5. Cipla, Wipro
6. Idea, Wipro

Note, the covariance between stock 1 and stock 2 is the same as the covariance between stock 2 and stock 1. So as you can see, 4 stocks require us to compute 6 covariances. You can imagine the complexity when we have 15 or 20 stocks. In fact, when we have more than 2 stocks in the portfolio, the covariance between them is calculated and tabulated using a 'Variance – Covariance Matrix'. I would love to talk about this now, but I guess, I'll will keep it for the next chapter.

Stay tuned for more!

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**Key takeaways from this chapter**

1. Variance measures the dispersion of returns over the expected average returns
2. Higher variance indicates higher risk, lower variance indicates lower risk
3. Square root of variance is standard deviation
4. Covariance between the returns of two stock measures how the returns of the two stocks vary
5. A positive covariance indicates that the returns move positively and a negative covariance indicates that while one stock returns moves up, the other comes down
6. Correlation measures the strength of the movement
7. Covariance between two stocks divided over their individual standard deviations results in a correlation between two stocks.
8. When we have more than 2 stocks in a portfolio, we compute the variance-covariance using a matrix

# Risk (Part 3) – Variance & Covariance Matrix

## 4.1 – A quick recap

Let us begin this chapter with a quick recap of our discussion so far.

We started this module with a discussion on the two kinds of risk a market participant is exposed to, when he or she purchases a stock – namely the systematic risk and the unsystematic risk. Having understood the basic difference between these two types of risk, we proceeded towards understanding **risk from a portfolio perspective**. In our discussion leading to portfolio risk or portfolio variance, we discussed two crucial concepts – variance and co variance. **Variance** is the deviation of a stock's return with its own average returns. **Co variance** on the other hand is the variance of a stock's return with respect to another stock's return. The discussion on variance and co variance was mainly with respect to a two stock portfolio; however, we concluded that a typical equity portfolio contains multiple stocks. In order to estimate the variance co variance and the correlation of a multi stock portfolio, we need the help of **matrix algebra**.

So that's where we are as of now.

In this chapter we will extent this discussion to estimate the 'variance co variance' of multiple stocks; this will introduce us to matrix multiplication and other concepts. However, the 'variance covariance' matrix alone does not convey much information. To make sense of this, we need to develop the correlation matrix. Once we are through with this part, we use the results of the correlation matrix to calculate the **portfolio variance**. Remember, our end goal is to estimate the portfolio variance. Portfolio variance tells us the amount of risk one is exposed to when he or she holds a set of stocks in the portfolio.

At this stage you should realize that we are focusing on risk from the entire portfolio perspective. While we are at it we will also discuss 'asset allocation' and how it impacts portfolio returns and risk. This will also include a quick take on the concept of 'value at risk'.

Of course, we will also take a detailed look at risk from a trader's perspective. How one can identify trading risk and ways to mitigate the same.

## 4.2 – Variance Covariance matrix

Before we proceed any further, I've been talking about 'Variance Covariance matrix'. Just to clear up any confusion – is it 'variance covariance matrix' or is it a variance matrix and a covariance matrix? Or is it just one matrix i.e. the 'Variance Covariance matrix'.

Well, is it just one matrix i.e. the 'Variance Covariance matrix'. Think about it, if there are 5 stocks, then this matrix should convey information on the variance of a stock and it should also convey the covariance of between stock 1 and the other 4 stock. Soon we will take up an example and I guess you will have a lot more clarity on this.

Please do note – it is advisable for you to know some basis on matrix operations. If not, here is a great video from Khan Academy which introduces matrix multiplication –

Anyway, continuing from the previous chapter, let us now try and calculate the Variance Covariance matrix followed by the correlation matrix for a portfolio with multiple stocks. A well-diversified (high conviction) portfolio typically consists of about 10-15 stocks. I'd have loved to take up a portfolio of this size to demonstrate the calculation of the variance covariance matrix, but then, it would be a very cumbersome affair on excel and there is a good a newbie could get intimidated with the sheer size of the matrix, hence for this reason, I just decided to have a 5 stock portfolio.

The following 5 stocks constitutes my portfolio –

1. Cipla
2. Idea
3. Wonderla
4. PVR
5. Alkem

The size of the variance covariance matrix for a 5 stock portfolio will be 5 x 5. In general, if there are 'k' stocks in the portfolio, then the size of the variance covariance matrix will be **k x k** (read this as k by k).

The formula to create a variance covariance matrix is as follows –

$$\Sigma_{k \, x \, k} = \left(\frac{1}{n}\right) X^T X$$

Where,

k = number of stocks in the portfolio

n = number of observations

X = this is the n x k excess return matrix. We will understand this better shortly

$X^T$ = transpose matrix of X

Here is a quick explanation of what is going on in that formula. You may understand this better when we deal with its implementation.

In simple terms, we first calculate the **n x k excess return matrix**; multiply this matrix by its own transpose matrix. This is a matrix multiplication and the resulting matrix will be a **k x k** matrix. We then divide each element of this k x k matrix by n, where n denotes the number of observations. The resulting matrix after this division is a **k x k variance covariance matrix**.

Generating the k x k variance covariance matrix is one step away from our final objective i.e. getting the correlation matrix.

So, let us apply this formula and generate the variance covariance matrix for the 5 stocks listed above. I'm using MS excel for this. I have downloaded the daily closing prices for the 5 stocks for the last 6 months.

**Step 1** – Calculated the daily returns. I guess you are quite familiar with this by now. I'm not going to explain how to calculate the daily returns. Here is the excel snapshot.

### Variance Covariance & Correlation Matrix

| Date | Cipla | Rt | Idea | Rt | Wonderla | Rt | PVR | Rt | Alkem | Rt |
|---|---|---|---|---|---|---|---|---|---|---|
| 1-Sep-16 | 579.15 | | 83.65 | | 410.25 | | 1185.45 | | 1569.85 | |
| 2-Sep-16 | 577.95 | -0.21% | 84.45 | 0.96% | 409.55 | -0.17% | 1273.45 | 7.42% | 1636.5 | =J5/J4-1 |
| 6-Sep-16 | 578.6 | 0.11% | 84.85 | 0.47% | 406.6 | -0.72% | 1261 | -0.98% | 1644.75 | 0.50% |
| 7-Sep-16 | 580.75 | 0.37% | 83.7 | -1.36% | 405.6 | -0.25% | 1241.65 | -1.53% | 1616.9 | -1.69% |
| 8-Sep-16 | 595.15 | 2.48% | 84.5 | 0.96% | 405.6 | 0.00% | 1237.9 | -0.30% | 1635.9 | 1.18% |
| 9-Sep-16 | 580.5 | -2.46% | 83.6 | -1.07% | 404.55 | -0.26% | 1219.75 | -1.47% | 1602.85 | -2.02% |
| 12-Sep-16 | 570.1 | -1.79% | 82.8 | -0.96% | 400.5 | -1.00% | 1179.25 | -3.32% | 1616.35 | 0.84% |
| 14-Sep-16 | 577.5 | 1.30% | 83.75 | 1.15% | 400.25 | -0.06% | 1173.6 | -0.48% | 1624.3 | 0.49% |

As you can see, I've lined up the stock's closing price and next to it I have calculated the daily returns. I have indicated the formula to calculate the daily return.

**Step 2** – Calculate the average daily returns for each stock. You can do this by using the 'average' function in excel.

### Variance Covariance & Correlation Matrix

| Date | Cipla | Rt | Idea | Rt | Wonderla | Rt | PVR | Rt | Alkem | Rt |
|---|---|---|---|---|---|---|---|---|---|---|
| 6-Mar-17 | 590.1 | 0.25% | 109.75 | -0.72% | 380.2 | 0.52% | 1331.9 | 1.67% | 2110.2 | -1.34% |
| 7-Mar-17 | 588.05 | -0.35% | 108.6 | -1.05% | 381.2 | 0.26% | 1344.6 | 0.95% | 2048.6 | -2.92% |
| **Average Daily Rt** | | **0.06%** | | **0.57%** | | **0.06%** | | **0.15%** | | **=AVERAGE(K51:K130)** |

**Step 3** – Set up the excess return matrix.

Excess return matrix is defined as the difference between stock's daily return over its average return. If you recall, we did this in the previous chapter while discussing covariance between two stocks.

I've set up the excess return matrix in the following way –

### Variance Covariance & Correlation Matrix                                    X = Excess Retun matrix

| Date | Cipla | Rt | Idea | Rt | Wonderla | Rt | PVR | Rt | Alkem | Rt | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21-Feb-17 | 593.1 | 0.06% | 108.35 | -0.09% | 374.15 | 0.32% | 1268 | -0.04% | 2000.05 | -1.73% | 0.00% | -0.66% | 0.26% | -0.19% | -2.02% |
| 22-Feb-17 | 589.25 | -0.65% | 112.6 | 3.92% | 374.45 | 0.08% | 1263.35 | -0.37% | 2022.55 | 1.12% | -0.71% | 3.36% | 0.02% | -0.52% | 0.84% |
| 23-Feb-17 | 592.4 | 0.53% | 119.6 | 6.22% | 373.4 | -0.28% | 1260.1 | -0.26% | 2076.85 | 2.68% | 0.47% | 5.65% | -0.34% | -0.41% | 2.40% |
| 27-Feb-17 | 585.25 | -1.21% | 114.55 | -4.22% | 373.85 | 0.12% | 1278.1 | 1.43% | 2154.75 | 3.75% | -1.27% | -4.79% | 0.06% | 1.27% | 3.46% |
| 28-Feb-17 | 583.7 | -0.26% | 115.85 | 1.13% | 372.4 | -0.39% | 1295.55 | 1.37% | 2141.55 | -0.61% | -0.33% | 0.57% | -0.45% | 1.21% | -0.90% |
| 1-Mar-17 | 586.3 | 0.45% | 113.25 | -2.24% | 373.8 | 0.38% | 1296.25 | 0.05% | 2144.15 | 0.12% | 0.38% | -2.81% | 0.32% | -0.10% | -0.17% |
| 2-Mar-17 | 589.25 | 0.50% | 109.6 | -3.22% | 375.3 | 0.40% | 1303.65 | 0.57% | 2142.1 | -0.10% | 0.44% | -3.79% | 0.34% | 0.42% | -0.38% |
| 3-Mar-17 | 588.6 | -0.11% | 110.55 | 0.87% | 378.25 | 0.79% | 1310.05 | 0.49% | 2138.95 | -0.15% | -0.17% | 0.30% | 0.73% | 0.34% | =K128-$K$131 |
| 6-Mar-17 | 590.1 | 0.25% | 109.75 | -0.72% | 380.2 | 0.52% | 1331.9 | 1.67% | 2110.2 | -1.34% | 0.19% | -1.29% | 0.46% | 1.51% | -1.63% |
| 7-Mar-17 | 588.05 | -0.35% | 108.6 | -1.05% | 381.2 | 0.26% | 1344.6 | 0.95% | 2048.6 | -2.92% | -0.41% | -1.61% | 0.21% | 0.80% | -3.21% |
| **Average Daily Rt** | | **0.06%** | | **0.57%** | | **0.06%** | | **0.15%** | | **0.29%** | n = | 127 | | k= | 5 |

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Do note, the resulting matrix is of **n x k** size, where **n** represents the number of observations (127 in this case) and **k** denotes the number of stocks (5 stocks). So in our example the matrix size is 127 x 5. We have denoted this matrix as X.

**Step 4** – Generate the **X$^T$ X** matrix operation to create a k x k matrix

This may sound fancy, but it is not.

X$^T$ is a new matrix, formed by interchanging the rows and columns of the original matrix X. When you interchange the rows and columns of a matrix to form a new one, then it is referred to as a transpose matrix of X and denoted as X$^T$. Our objective now is to multiply the original matrix with its transpose. This is denoted as X$^T$ X.

Note, the resulting matrix from this operation will result in a k x k matrix, where k denotes the number of stocks in the portfolio. In our case this will be 5 x 5.

We can do this in one shot in excel. I will use the following function steps to create the k x k matrix –

List down the stocks in rows and columns –



**X transpose multipled by X**

| | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| **Cipla** | | | | | |
| **Idea** | | | | | |
| **Wonderla** | | | | | |
| **PVR** | | | | | |
| **Alkem** | | | | | |

Apply the function = 'MMULT ((transpose X), X). Remember X is the excess return matrix.



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Do note, while applying this formula, you need to ensure that you highlight the k x k matrix. Once you finish typing the formula, do note – you cannot hit 'enter' directly. You will hit **ctrl+shift+enter**. In fact, for all array functions in excel, use ctrl+shift+enter.

So once you hit ctrl+shift+enter, excel will present you with a beautiful k x k matrix, which in this case looks like this –

**X transpose multipled by X**

|  | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| Cipla | 0.02788 | 0.00679 | 0.00425 | 0.00515 | 0.00804 |
| Idea | 0.00679 | 0.14084 | 0.00497 | 0.00289 | 0.00475 |
| Wonderla | 0.00425 | 0.00497 | 0.03055 | 0.00500 | 0.00351 |
| PVR | 0.00515 | 0.00289 | 0.00500 | 0.05109 | 0.00338 |
| Alkem | 0.00804 | 0.00475 | 0.00351 | 0.00338 | 0.04310 |

**Step 5** – This is the last step in creating the variance covariance matrix. We now have to divide each element of the $X^T X$ matrix by the total number of observations i.e. n. For your clarity, let me post the formula for the variance covariance matrix again –

$$\Sigma_{k \times k} = \left(\frac{1}{n}\right) X^T X$$

Again, we start by creating the layout for k x k matrix –

**Variance Covariance matrix**

|  | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| Cipla |  |  |  |  |  |
| Idea |  |  |  |  |  |
| Wonderla |  |  |  |  |  |
| PVR |  |  |  |  |  |
| Alkem |  |  |  |  |  |

Once the layout is set, without deselecting the cells, select the entire $X^T X$ matrix and divide it by n i.e. 127. Do note, this is still an array function; hence you need to hit **ctrl+shift+enter** and not just enter.

## X transpose multipled by X

|  | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| **Cipla** | 0.02788 | 0.00679 | 0.00425 | 0.00515 | 0.00804 |
| **Idea** | 0.00679 | 0.14084 | 0.00497 | 0.00289 | 0.00475 |
| **Wonderla** | 0.00425 | 0.00497 | 0.03055 | 0.00500 | 0.00351 |
| **PVR** | 0.00515 | 0.00289 | 0.00500 | 0.05109 | 0.00338 |
| **Alkem** | 0.00804 | 0.00475 | 0.00351 | 0.00338 | 0.04310 |

**n**         127

## Variance Covariance matrix

|  | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| **Cipla** | =S8:W12/S14 |  |  |  |  |
| **Idea** |  |  |  |  |  |
| **Wonderla** |  |  |  |  |  |
| **PVR** |  |  |  |  |  |
| **Alkem** |  |  |  |  |  |

Once you hit control shift enter, you will get the 'Variance – Covariance' matrix. Do note, the numbers in the matrix will be very small, do not worry about this. Here is the variance co variance matrix –

## X transpose multipled by X

|  | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| **Cipla** | 0.02788 | 0.00679 | 0.00425 | 0.00515 | 0.00804 |
| **Idea** | 0.00679 | 0.14084 | 0.00497 | 0.00289 | 0.00475 |
| **Wonderla** | 0.00425 | 0.00497 | 0.03055 | 0.00500 | 0.00351 |
| **PVR** | 0.00515 | 0.00289 | 0.00500 | 0.05109 | 0.00338 |
| **Alkem** | 0.00804 | 0.00475 | 0.00351 | 0.00338 | 0.04310 |

**n**         127

## Variance Covariance matrix

|  | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| **Cipla** | 0.0002195 | 0.0000535 | 0.0000335 | 0.0000405 | 0.0000633 |
| **Idea** | 0.0000535 | 0.0011090 | 0.0000391 | 0.0000227 | 0.0000374 |
| **Wonderla** | 0.0000335 | 0.0000391 | 0.0002405 | 0.0000394 | 0.0000277 |
| **PVR** | 0.0000405 | 0.0000227 | 0.0000394 | 0.0004022 | 0.0000266 |
| **Alkem** | 0.0000633 | 0.0000374 | 0.0000277 | 0.0000266 | 0.0003393 |

Let us spend some time to understand the 'Variance – Covariance' matrix better. Suppose I want to know the covariance between any two stocks, let's say Wonderla and PVR, then I simply have to look for Wonderla on the left hand side and in the same row, look for the value which coincides with PVR. This would be the covariance between the two stocks. I've highlighted the same in yellow –

**Variance Covariance matrix**

|          | Cipla     | Idea      | Wonderla  | PVR       | Alkem     |
|----------|-----------|-----------|-----------|-----------|-----------|
| Cipla    | 0.0002195 | 0.0000535 | 0.0000335 | 0.0000405 | 0.0000633 |
| Idea     | 0.0000535 | 0.0011090 | 0.0000391 | 0.0000227 | 0.0000374 |
| Wonderla | 0.0000335 | 0.0000391 | 0.0002405 | 0.0000394 | 0.0000277 |
| PVR      | 0.0000405 | 0.0000227 | 0.0000394 | 0.0004022 | 0.0000266 |
| Alkem    | 0.0000633 | 0.0000374 | 0.0000277 | 0.0000266 | 0.0003393 |

So the matrix suggests that the covariance between Wonderla and PVR is 0.000034. Do note, this is the same as the covariance between PVR and Wonderla.

Further, notice the number highlighted in blue. This value corresponds to Cipla and Cipla. What do you this represents? This represents the covariance between Cipla and Cipla, and if you realize, covariance of a stock with itself, is nothing but variance!

This is exactly why this matrix is called '**Variance – Covariance Matrix**', because it gives us both the values.

Now, here is the bitter pill – the variance and covariance matrix on its own is quite useless. These are extremely small numbers and it is hard to derive any meaning out of it. What we really need is the 'Correlation Matrix'.

In the next chapter, let us deal with generating the correlation matrix, and also work towards estimating the portfolio variance, which is our end objective. However, before we close this chapter, here are few tasks for you –

1. Download the last 1-year data for 5 or more stocks.
2. Calculate the Variance – Covariance matrix for the same
3. For a given stock, identify the variance value. Apply the = 'Var()' function on excel on the returns of the same stock and evaluate if both are matching.

You can **download** the excel sheet used in this chapter.

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**Key Takeaways from this chapter**

1. X is defined as an excess return matrix
2. Excess return matrix is simply the time series difference daily return versus the average daily return
3. $X^T$ is defined as the transpose of X
4. Variable **n** is defined as the number of observations in the data set. For example, if you have 6 months' data, n is 127, for 1-year data n would be 252
5. Excess return matrix is of the size n x k, where k is the number of stocks
6. When you divide the matrix product of $X^T X$ by n, we get the variance covariance matrix
7. The variance covariance matrix is of the size k x k
8. The covariance of stock 1 with itself is the variance of stock 1
9. The variance covariance matrix will lead us to the correlation matrix.

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# CHAPTER 5

# Risk (Part 4) – Correlation Matrix & Portfolio Variance



## 5.1 – Correlation Matrix

In the previous chapter, we successfully calculated the variance co variance matrix. As we discussed, these numbers are too small for us to make any sense. Hence, as a practice, it always makes sense to calculate the correlation matrix when we calculate the variance covariance matrix.

So let us go ahead and do this.

How is the correlation between two stocks calculated? Well, hopefully from the previous chapter, you will recall the formula for correlation –

$$Correlation = \frac{Cov\ (x, y)}{\sigma x * \sigma y}$$

Where,

Cov (x,y) is the covariance between the two stocks

$\sigma_x$ = Standard deviation of stock x

$\sigma_y$ = Standard deviation of stock y

This works fine if we have 2 stocks in the portfolio, but since we have 5 stocks in the portfolio, we need to resort to matrix operation to find correlations. So, when we have multiple stocks in the portfolio, the correlations between stocks are all stacked up in a **n x n** (read it as n by n) matrix. For example, if it is a 5 stock portfolio (5 being the n here), then we need to create a 5 x 5 matrix.

The formula for calculating the correlation remains the same. Recall, from the previous chapter, we have the variance-covariance matrix. For the sake of convenience, I'll paste the image again here –

### Variance Covariance matrix

|          | Cipla     | Idea      | Wonderla  | PVR       | Alkem     |
|----------|-----------|-----------|-----------|-----------|-----------|
| Cipla    | 0.0002195 | 0.0000535 | 0.0000335 | 0.0000405 | 0.0000633 |
| Idea     | 0.0000535 | 0.0011090 | 0.0000391 | 0.0000227 | 0.0000374 |
| Wonderla | 0.0000335 | 0.0000391 | 0.0002405 | 0.0000394 | 0.0000277 |
| PVR      | 0.0000405 | 0.0000227 | 0.0000394 | 0.0004022 | 0.0000266 |
| Alkem    | 0.0000633 | 0.0000374 | 0.0000277 | 0.0000266 | 0.0003393 |

This takes care of the numerator part of the formula. We need to now calculate the denominator, which is simply the product of the standard deviation of stock A with the standard deviation of stock B. If the portfolio has 5 stock, then we need the product of the standard deviation of all possible combination between the stocks in the portfolio.

Let's go ahead and set this up.

We first need to calculate the standard deviations of each of the stocks in the portfolio. I'm assuming you are familiar how to do this. You just need to use the '=Stdev()' function on the daily returns array to get the standard deviations.

I've calculated the same on excel used in the previous chapter. Here is the image –

### Standard Deviations

| Cipla    | =STDEV(C5:C130) |
|----------|-----------------|
| Idea     | 3.34%           |
| Wonderla | 1.56%           |
| PVR      | 2.02%           |
| Alkem    | 1.86%           |

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Given that we have the stock specific standard deviations; we now need to get the product of the standard deviation of all possible portfolio combination. We resort to matrix multiplication for this. This can be easily achieved by multiply the standard deviation array with the transpose of itself.

We first create the matrix skeleton and keep all the cells highlighted –

**Product of SDs**

|  | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| Cipla |  |  |  |  |  |
| Idea |  |  |  |  |  |
| Wonderla |  |  |  |  |  |
| PVR |  |  |  |  |  |
| Alkem |  |  |  |  |  |

Now, without deselecting the cells, we apply the matrix multiplication function. Note, we are multiplying the standard deviation array with the transpose of itself. The image below should give you an idea, do look at the formula used –

**Standard Deviations**

| Cipla | 1.49% |
|---|---|
| Idea | 3.34% |
| Wonderla | 1.56% |
| PVR | 2.02% |
| Alkem | 1.86% |

**Product of SDs**

|  | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| Cipla | =MMULT(S25:S29,TRANSPOSE(S25:S29)) |  |  | 0.000301746 | 0.000277040 |
| Idea | 0.000498988 | 0.001117270 | 0.000521368 | 0.000675631 | 0.000620312 |
| Wonderla | 0.000232850 | 0.000521368 | 0.000243293 | 0.000315280 | 0.000289465 |
| PVR | 0.000301746 | 0.000675631 | 0.000315280 | 0.000408565 | 0.000375112 |
| Alkem | 0.000277040 | 0.000620312 | 0.000289465 | 0.000375112 | 0.000344399 |

As I mentioned in the previous chapter, whenever you use matrix or array function in excel, always hold the 'ctrl+shit+enter' combo. The resulting matrix looks like this –

## Product of SDs

| | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| Cipla | 0.0002229 | 0.0004990 | 0.0002328 | 0.0003017 | 0.0002770 |
| Idea | 0.0004990 | 0.0011173 | 0.0005214 | 0.0006756 | 0.0006203 |
| Wonderla | 0.0002328 | 0.0005214 | 0.0002433 | 0.0003153 | 0.0002895 |
| PVR | 0.0003017 | 0.0006756 | 0.0003153 | 0.0004086 | 0.0003751 |
| Alkem | 0.0002770 | 0.0006203 | 0.0002895 | 0.0003751 | 0.0003444 |

At this point let me paste the formula for the correlation again –

$$Correlation = \frac{Cov\ (x, y)}{\sigma x * \sigma y}$$

The numerator is the variance covariance matrix as seen below, and the denominator is the product of the standard deviations which we have just calculated above –

## Variance Covariance matrix

| | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| Cipla | 0.0002195 | 0.0000535 | 0.0000335 | 0.0000405 | 0.0000633 |
| Idea | 0.0000535 | 0.0011090 | 0.0000391 | 0.0000227 | 0.0000374 |
| Wonderla | 0.0000335 | 0.0000391 | 0.0002405 | 0.0000394 | 0.0000277 |
| PVR | 0.0000405 | 0.0000227 | 0.0000394 | 0.0004022 | 0.0000266 |
| Alkem | 0.0000633 | 0.0000374 | 0.0000277 | 0.0000266 | 0.0003393 |

Dividing the variance co-variance matrix by the product of the standard deviations should result in the correlation matrix. Do note, this is an element by element division, which is still and array function, so the use of 'ctrl+shit+enter' is necessary.

## Product of SDs

|  | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| Cipla | 0.0002229 | 0.0004990 | 0.0002328 | 0.0003017 | 0.0002770 |
| Idea | 0.0004990 | 0.0011173 | 0.0005214 | 0.0006756 | 0.0006203 |
| Wonderla | 0.0002328 | 0.0005214 | 0.0002433 | 0.0003153 | 0.0002895 |
| PVR | 0.0003017 | 0.0006756 | 0.0003153 | 0.0004086 | 0.0003751 |
| Alkem | 0.0002770 | 0.0006203 | 0.0002895 | 0.0003751 | 0.0003444 |

## Correlation Matrix

|  | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| Cipla | =S18:W22/S33:W37 |  |  |  |  |
| Idea |  |  |  |  |  |
| Wonderla |  |  |  |  |  |
| PVR |  |  |  |  |  |
| Alkem |  |  |  |  |  |

The resulting correlation matrix looks like this –

## Correlation Matrix

|  | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| Cipla | 1.0 | 0.10715052 | 0.14368425 | 0.13434778 | 0.22858556 |
| Idea | 0.10715052 | 1.0 | 0.07499042 | 0.03363225 | 0.06024903 |
| Wonderla | 0.14368425 | 0.07499042 | 1.0 | 0.12484625 | 0.09557120 |
| PVR | 0.13434778 | 0.03363225 | 0.12484625 | 1.0 | 0.07085759 |
| Alkem | 0.22858556 | 0.06024903 | 0.09557120 | 0.07085759 | 1.0 |

The correlation matrix gives us the correlation between any two stocks. For example, if I have to know the correlation between Cipla and Alkem, I simply have to look under the intersecting cell between Cipla and Alkem. There are two ways you can do this –

1. Look at the row belonging to Cipla and scroll till the Alkem column
2. Look at the row belonging to Alkem and scroll till the Cipla column

Both these should reflect the same result i.e. 0.2285. This is quite obvious since correlation between stock A with Stock B is similar to the correlation of Stock B with Stock A. For this reason, the matrix displays symmetrically similar values above and below the diagonal. Check this image below, I have highlighted the correlation between Cipla and Alkem and Alkem and Cipla –

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## Correlation Matrix

| | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| **Cipla** | 1.0 | 0.10715052 | 0.14368425 | 0.13434778 | 0.22858556 |
| **Idea** | 0.10715052 | 1.0 | 0.07499042 | 0.03363225 | 0.06024903 |
| **Wonderla** | 0.14368425 | 0.07499042 | 1.0 | 0.12484625 | 0.09557120 |
| **PVR** | 0.13434778 | 0.03363225 | 0.12484625 | 1.0 | 0.07085759 |
| **Alkem** | 0.22858556 | 0.06024903 | 0.09557120 | 0.07085759 | 1.0 |

The correlations along the diagonal represents the correlation of certain stock with itself. Do note, the correlation numbers above the diagonal is symmetrically similar to the correlation numbers below the diagonal.

Needless to say, correlation of Stock A with Stock A is always 1, which is what we have got in the diagonal and the same is highlighted in yellow boxes.

## 5.2 – Portfolio Variance

We are just few steps away from calculating the Portfolio Variance. As I have discussed earlier, we need the portfolio variance to identify the extent of risk my portfolio is exposed to. With this information, I'm no longer driving blind. In fact, one can develop many other insights based on this. Of course, we will talk about this going forward.

The first step in calculating portfolio variance is to assign weights to the stocks. Weights are simply the amount of cash we decide to invest in each stock. For example, if I have Rs.100, and I decide to invest all of that money in Stock A, then the weight in stock A is 100%. Likewise, if I decide to invest Rs.50 in A, Rs.20 in B, and Rs.30 in C, the weights in A, B, and C would be 50%, 20%, and 30% respectively.

I have arbitrarily assigned weights to the 5 stocks in the portfolio –

o Cipla @ 7%

o Idea @ 16%

o Wonderla @ 25%

o PVR @ 30%

o Alkem @ 22%

Clearly, there is no science to assigning weights at this stage. However, at a later point in the module I will discuss more about this part.

The next step is to calculate the weighted standard deviation. The Weighted standard deviation is simply the weight of a stock multiplied by its respective standard deviation. For example, Cipla's standard deviation is 1.49%, hence its weighted standard deviation would be **7% * 1.49% = 0.10%**

Here are the weights and the weighted standard deviation of 5 stocks in the portfolio –

**Weights & weight SD**

| Stock | Weight | Wt.SD |
|---|---|---|
| Cipla | 7.00% | 0.104% |
| Idea | 16.00% | 0.535% |
| Wonderla | 25.00% | 0.390% |
| PVR | 30.00% | 0.606% |
| Alkem | 22.00% | 0.408% |
| **Total Weight** | 100.00% | |

Do note, the total weight should add up to 100% i.e. the sum of the individual weights in stocks should add up to 100%.

At this stage, we have all the individual components needed to calculate the 'Portfolio Variance'. The formula to calculate the Portfolio Variance is as shown below –

Portfolio Variance = Sqrt (Transpose (Wt.SD) * Correlation Matrix * Wt. SD)

Where,

Wt.SD is the weights standard deviation array.

We will implement the above formula in 3 steps –

1. Calculate the product of Transpose of Wt.SD with correlation matrix. This will result in a row matrix with 5 elements

2. Multiply the result obtained above (row matrix) with the weighted standard deviation array. This will result in a single number

3. Take the square root of the result obtained above to get the portfolio variance

   So, let's jump straight ahead and solve for portfolio variance in the same order –

   I will create row matrix called 'M1' with 5 elements. This will contain the product of the Transpose of Wt.SD with correlation matrix.

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## Correlation Matrix

|  | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| **Cipla** | 1.0 | 0.10715052 | 0.14368425 | 0.13434778 | 0.22858556 |
| **Idea** | 0.10715052 | 1.0 | 0.07499042 | 0.03363225 | 0.06024903 |
| **Wonderla** | 0.14368425 | 0.07499042 | 1.0 | 0.12484625 | 0.09557120 |
| **PVR** | 0.13434778 | 0.03363225 | 0.12484625 | 1.0 | 0.07085759 |
| **Alkem** | 0.22858556 | 0.06024903 | 0.09557120 | 0.07085759 | 1.0 |

## Weights & weight SD

| Stock | Weight | Wt.SD |
|---|---|---|
| Cipla | 7.00% | 0.104% |
| Idea | 16.00% | 0.535% |
| Wonderla | 25.00% | 0.390% |
| PVR | 30.00% | 0.606% |
| Alkem | 22.00% | 0.408% |
| **Total Weight** | **100.00%** | |

## M1

| Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|
| =MMULT(TRANSPOSE(T49:T53),S41:W45) | | | 0.007066495 | 0.005386129 |

Do note, you will have to select the empty array space and hold down the ctrl+shift+enter keys simultaneously.

We now create another value called 'M2', which contains the product of M1 and weighted standard deviation –

## Weights & weight SD

| Stock | Weight | Wt.SD |
|---|---|---|
| Cipla | 7.00% | 0.104% |
| Idea | 16.00% | 0.535% |
| Wonderla | 25.00% | 0.390% |
| PVR | 30.00% | 0.606% |
| Alkem | 22.00% | 0.408% |
| **Total Weight** | **100.00%** | |

5R x 1C

## M1

| Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|
| 0.003910484 | 0.006162738 | 0.00555355 | 0.007066495 | 0.005386129 |

## M2

=MMULT(R59:V59,T49:T53)

We obtain the value of M2 as 0.000123542, the square root of this value is the portfolio variance.



The result for the above operation yields a value of **1.11%,** which is the portfolio variance of the 5 stocks portfolio.

Phew!!

I need a break at this. Let's figure out the next steps in the next chapter J

**Download** the excel sheet used in this chapter.

**Key takeaways from this chapter –**

1.  Correlation matrix gives out the correlation between any two stocks in a portfolio
2.  Correlation between stock A with stock B is the same as the correlation between stock B with stock A
3.  Correlation of a stock with itself is always 1
4.  The diagonals of a correlation matrix should represent the correlation of stock A with itself
5.  The correlation matrix contains symmetrical values above and below the diagonals
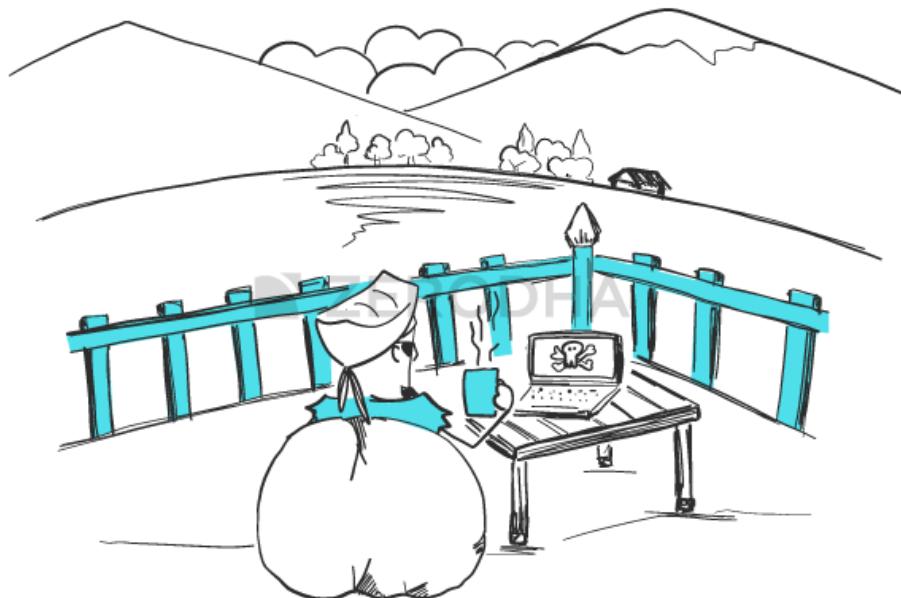
# CHAPTER 6

# Equity Curve

## 6.1 – Overview

This is off topic – but a little digression hurts no one, I guess. Of all the chapters I have written in Varsity, I guess this one will be a very special one for me. Not because of the topic that I will be discussing. It is because of the place where I'm sitting right now and writing this for you all. Its 6:15 AM – surrounding me 360 degrees are misty mountains; the landscape I guess cannot get any better. There is only one shack here with a little music player, playing Bob

Marley's Redemption Song. Can it get any better? At least not for me I guess



Anyway, back to school

We discussed Portfolio Variance in the previous chapter. It would be pointless to crunch all the numbers to extract the variance of the portfolio, unless we put that to good use. This is exactly what we will achieve over the next 2 chapters.

Over the next 2 chapters, we will try and do the following –

1. Discuss Equity curve and an alternate method to calculate portfolio variance
2. Estimate the portfolio's expected returns over 1 year
3. Optimize the portfolio for maximum returns and minimum variance

Note, this chapter is a continuation of the discussion panned out in the previous chapters. You need to know the context here. If you are reading this chapter without knowing what happened over the last few chapters, then I'd suggest you go back and read those chapters first.

## 6.2 – Equity Curve

We will use this opportunity to develop an equity curve for the 5 stock portfolio that we have. In a very lose sense, a typical equity curve helps you visualize the performance of the portfolio on a normalized scale of 100. In other words, it will help you understand how Rs.100/- invested in this portfolio would have performed over the given period. You can further use this to benchmark the portfolio's performance against its benchmark – say Nifty 50 or BSE Sensex.

There are certain attributes which can be extracted out of the equity curve to develop deeper insights on the portfolio. More on that later.

Let us proceed to build an equity curve for the 5 stock portfolio. Remember, we had the following stocks and we also assigned random weights to these stock to form our portfolio. Here are the stock names along with the weightages –

| Stock Name | Investment weight |
|---|---|
| Cipla | 7% |
| Idea Cellular Ltd | 16% |
| Wonderla | 25% |
| PVR | 30% |
| Alkem | 22% |

So what does 'Investment weight' means? – It represents the percentage of your corpus invested in the stock. For example, out of Rs.100,000/-, Rs.7,000/- has been invested in Cipla and Rs.22,000/- has been invested in Alkem Lab. So on and so forth.

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While developing an equity curve, the usual practice is to normalize the portfolio for Rs.100. This helps us understand how an investment of Rs.100/- in this portfolio behaved during the period of investment. I have incorporated this in the excel sheet (please note, the excel used here is a continuation of the excel used in the previous chapter)

Have a look at the image below –

| Eq Curve & Optimization | | | | | | | | | | | | | | Starting Value | Total Wt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Cipla | Rt | Wt | Idea | Rt | Wt | Wonderla | Rt | Wt | PVR | Rt | Wt | Alkem | Rt | Wt | 100 | 100% |
| 1-Sep-16 | 579.15 | | 7% | 83.65 | | 16% | 410.25 | | 25% | 1185.45 | | 30% | 1569.85 | | 22% | | |
| 2-Sep-16 | 577.95 | -0.21% | 6.9855 | 84.45 | 0.96% | | 409.55 | -0.17% | | 1273.45 | 7.42% | | 1636.5 | 4.25% | | |

I have introduced a new column next to the daily return column and included the weight of the respective stock. At the end, you will find two new column being introduced – starting value pegged at 100 and total weight at 100%.

Starting value – this is basically the amount of money we are starting with. I have set this to Rs.100/-. This means, out of the 100 Rupees in total corpus, Rupees 7 is being invested in Cipla, Rupees 16 in Idea, Rupee 25 in Wonderla so on and so forth.

Now, if I add up the individual weights, then they should all add up to 100%, indicating that 100% of Rs.100 is being invested.

We now have to see how the investment in each stock has performed. To help you understand this better, let's take up the case of Cipla for now. The weight assigned to Cipla is 7%, which means out of Rs.100, Rs.7 is invested in Cipla. Based on the daily price movement of Cipla, our money i.e. Rs.7/- either increases or decreases. It is important to note that, if on day 1, if Rs.7 becomes, Rs.7.5/- then the following day, our starting price is Rs.7.5 and not Rs.7/-. I've done this on excel for Cipla, and this is how the calculation looks.

# Eq Curve & Optimization

| Date | Cipla | Rt | Wt |
|---|---|---|---|
| 1-Sep-16 | 579.15 | | 7% |
| 2-Sep-16 | 577.95 | -0.21% | 6.99 |
| 6-Sep-16 | 578.6 | 0.11% | =D5*(1+C6) |
| 7-Sep-16 | 580.75 | 0.37% | 7.02 |
| 8-Sep-16 | 595.15 | 2.48% | 7.19 |

On 1st Sept, Cipla was trading at 579.15, this is the day we decided to invest Rs.7 in the stock. I understand that this is technically not possible, but for the sake of this example, let us just assume this is possible and proceed. So on day one i.e. 1st Sept, 7 is invested, on 2nd Sept

Cipla closed at 577.95, down -0.21% from the previous day. This also means we lose -0.21% on our investment of Rs.7/- making it Rs.6.985. On 6th Sept Cipla shot up by 0.11% to 578.6, hence we gain 0.11% on 6.985 to make it 6.993. So on and so forth the rest of the data points.

I've done this math for all the stocks in portfolio and here is how the table looks –

**Eq Curve & Optimization**

| Date | Cipla | Rt | Wt | Idea | Rt | Wt | Wonderla | Rt | Wt | PVR | Rt | Wt | Alkem | Rt | Wt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-Sep-16 | 579.15 | | 7% | 83.65 | | 16% | 410.25 | | 25% | 1185.45 | | 30% | 1569.85 | | 22% |
| 2-Sep-16 | 577.95 | -0.21% | 6.985 | 84.45 | 0.96% | 16.153 | 409.55 | -0.17% | 24.957 | 1273.45 | 7.42% | 32.227 | 1636.5 | 4.25% | 22.934 |
| 6-Sep-16 | 578.6 | 0.11% | 6.993 | 84.85 | 0.47% | 16.230 | 406.6 | -0.72% | 24.778 | 1261 | -0.98% | 31.912 | 1644.75 | 0.50% | 23.050 |
| 7-Sep-16 | 580.75 | 0.37% | 7.019 | 83.7 | -1.36% | 16.010 | 405.6 | -0.25% | 24.717 | 1241.65 | -1.53% | 31.422 | 1616.9 | -1.69% | 22.659 |
| 8-Sep-16 | 595.15 | 2.48% | 7.193 | 84.5 | 0.96% | 16.163 | 405.6 | 0.00% | 24.717 | 1237.9 | -0.30% | 31.327 | 1635.9 | 1.18% | 22.926 |
| 9-Sep-16 | 580.5 | -2.46% | 7.016 | 83.6 | -1.07% | 15.990 | 404.55 | -0.26% | 24.653 | 1219.75 | -1.47% | 30.868 | 1602.85 | -2.02% | 22.462 |
| 12-Sep-16 | 570.1 | -1.79% | 6.891 | 82.8 | -0.96% | 15.837 | 400.5 | -1.00% | 24.406 | 1179.25 | -3.32% | 29.843 | 1616.35 | 0.84% | 22.652 |
| 14-Sep-16 | 577.5 | 1.30% | 6.980 | 83.75 | 1.15% | 16.019 | 400.25 | -0.06% | 24.391 | 1173.6 | -0.48% | 29.700 | 1624.3 | 0.49% | 22.763 |
| 15-Sep-16 | 585.4 | 1.37% | 7.076 | 84.5 | 0.90% | 16.163 | 399.65 | -0.15% | 24.354 | 1158.65 | -1.27% | 29.322 | 1622.35 | -0.12% | 22.736 |
| 16-Sep-16 | 593.55 | 1.39% | 7.174 | 85.15 | 0.77% | 16.287 | 394.75 | -1.23% | 24.055 | 1185 | 2.27% | 29.989 | 1682.1 | 3.68% | 23.573 |

I've calculated the daily fluctuation in the invested price across all stocks and I've highlighted the same in blue.

Now, think about what is happening here – I've basically split Rs.100/- across 5 stocks and invested in different proportions. If I sum up the daily variation in each stock, I should be able to get the overall daily fluctuation of Rs.100, right? Doing this gives me the overall perspective on how my portfolio is moving. Let me add these up and see how Rs.100 invested across 5 stocks moves on a daily basis –
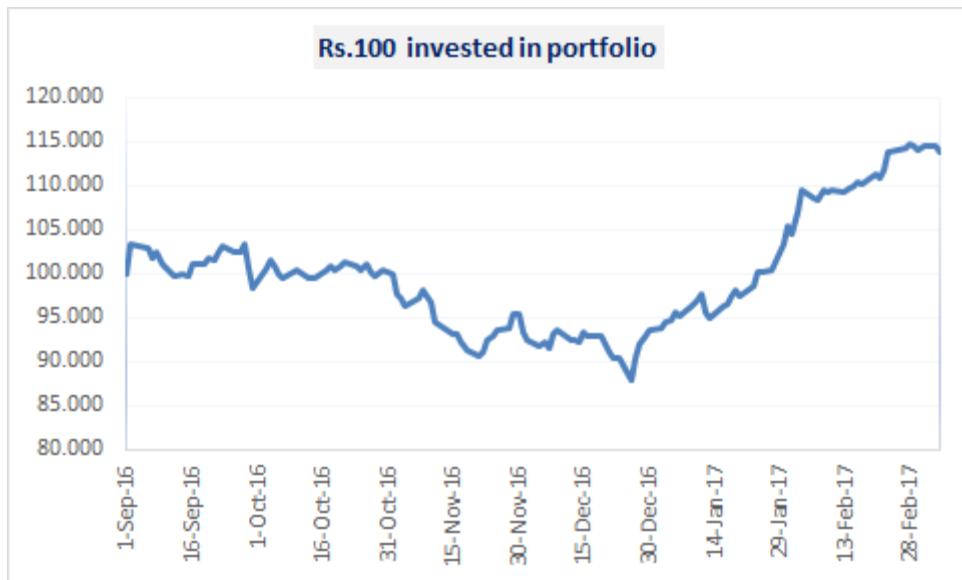
**Eq Curve & Optimization** | **Starting Value**

| Date | Cipla | Rt | Wt | Idea | Rt | Wt | Wonderla | Rt | Wt | PVR | Rt | Wt | Alkem | Rt | Wt | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-Sep-16 | 579.15 | | 7% | 83.65 | | 16% | 410.25 | | 25% | 1185.45 | | 30% | 1569.85 | | 22% | |
| 2-Sep-16 | 577.95 | -0.21% | 6.985 | 84.45 | 0.96% | 16.153 | 409.55 | -0.17% | 24.957 | 1273.45 | 7.42% | 32.227 | 1636.5 | 4.25% | 22.934 | =D5+G5+J5+M5+P5 |
| 6-Sep-16 | 578.6 | 0.11% | 6.993 | 84.85 | 0.47% | 16.230 | 406.6 | -0.72% | 24.778 | 1261 | -0.98% | 31.912 | 1644.75 | 0.50% | 23.050 | |
| 7-Sep-16 | 580.75 | 0.37% | 7.019 | 83.7 | -1.36% | 16.010 | 405.6 | -0.25% | 24.717 | 1241.65 | -1.53% | 31.422 | 1616.9 | -1.69% | 22.659 | |
| 8-Sep-16 | 595.15 | 2.48% | 7.193 | 84.5 | 0.96% | 16.163 | 405.6 | 0.00% | 24.717 | 1237.9 | -0.30% | 31.327 | 1635.9 | 1.18% | 22.926 | |
| 9-Sep-16 | 580.5 | -2.46% | 7.016 | 83.6 | -1.07% | 15.990 | 404.55 | -0.26% | 24.653 | 1219.75 | -1.47% | 30.868 | 1602.85 | -2.02% | 22.462 | |
| 12-Sep-16 | 570.1 | -1.79% | 6.891 | 82.8 | -0.96% | 15.837 | 400.5 | -1.00% | 24.406 | 1179.25 | -3.32% | 29.843 | 1616.35 | 0.84% | 22.652 | |
| 14-Sep-16 | 577.5 | 1.30% | 6.980 | 83.75 | 1.15% | 16.019 | 400.25 | -0.06% | 24.391 | 1173.6 | -0.48% | 29.700 | 1624.3 | 0.49% | 22.763 | |

Adding up the values on a daily basis gives me the time series of the daily fluctuation of the portfolio.

**Eq Curve & Optimization** | **Starting Value**

| Date | Cipla | Rt | Wt | Idea | Rt | Wt | Wonderla | Rt | Wt | PVR | Rt | Wt | Alkem | Rt | Wt | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-Sep-16 | 579.15 | | 7% | 83.65 | | 16% | 410.25 | | 25% | 1185.45 | | 30% | 1569.85 | | 22% | |
| 2-Sep-16 | 577.95 | -0.21% | 6.985 | 84.45 | 0.96% | 16.153 | 409.55 | -0.17% | 24.957 | 1273.45 | 7.42% | 32.227 | 1636.5 | 4.25% | 22.934 | 103.257 |
| 6-Sep-16 | 578.6 | 0.11% | 6.993 | 84.85 | 0.47% | 16.230 | 406.6 | -0.72% | 24.778 | 1261 | -0.98% | 31.912 | 1644.75 | 0.50% | 23.050 | 102.962 |
| 7-Sep-16 | 580.75 | 0.37% | 7.019 | 83.7 | -1.36% | 16.010 | 405.6 | -0.25% | 24.717 | 1241.65 | -1.53% | 31.422 | 1616.9 | -1.69% | 22.659 | 101.827 |
| 8-Sep-16 | 595.15 | 2.48% | 7.193 | 84.5 | 0.96% | 16.163 | 405.6 | 0.00% | 24.717 | 1237.9 | -0.30% | 31.327 | 1635.9 | 1.18% | 22.926 | 102.326 |
| 9-Sep-16 | 580.5 | -2.46% | 7.016 | 83.6 | -1.07% | 15.990 | 404.55 | -0.26% | 24.653 | 1219.75 | -1.47% | 30.868 | 1602.85 | -2.02% | 22.462 | 100.990 |
| 12-Sep-16 | 570.1 | -1.79% | 6.891 | 82.8 | -0.96% | 15.837 | 400.5 | -1.00% | 24.406 | 1179.25 | -3.32% | 29.843 | 1616.35 | 0.84% | 22.652 | 99.629 |

An 'Equity Curve' (EQ curve) can be developed if you plot the chart of this – i.e. the time series data of the daily normalized portfolio value. I say normalized because I've scaled down the investment to Rs.100/-.

So, here is the EQ curve for the portfolio that we have –



As easy as that. Eq curve is a very popular way of visualizing the portfolio performance. It gives a quick estimate of the returns generated by the portfolio. In this case, we started with and investment of Rs.100/- and at the end of 6 months the portfolio was valued at 113.84. Have a look at the image below –

| Date | Cipla | Rt | Wt | Idea | Rt | Wt | Wonderla | Rt | Wt | PVR | Rt | Wt | Alkem | Rt | Wt | 100 |
|------|-------|-----|-----|------|-----|-----|----------|-----|-----|------|-----|-----|-------|-----|-----|-----|
| 2-Mar-17 | 589.25 | 0.50% | 7.122 | 109.6 | -3.22% | 20.964 | 375.3 | 0.40% | 22.870 | 1303.65 | 0.57% | 32.991 | 2142.1 | -0.10% | 30.020 | 113.967 |
| 3-Mar-17 | 588.6 | -0.11% | 7.114 | 110.55 | 0.87% | 21.145 | 378.25 | 0.79% | 23.050 | 1310.05 | 0.49% | 33.153 | 2138.95 | -0.15% | 29.975 | 114.438 |
| 6-Mar-17 | 590.1 | 0.25% | 7.132 | 109.75 | -0.72% | 20.992 | 380.2 | 0.52% | 23.169 | 1331.9 | 1.67% | 33.706 | 2110.2 | -1.34% | 29.573 | 114.572 |
| 7-Mar-17 | 588.05 | -0.35% | 7.108 | 108.6 | -1.05% | 20.772 | 381.2 | 0.26% | 23.230 | 1344.6 | 0.95% | 34.028 | 2048.6 | -2.92% | 28.709 | 113.846 |

So without much thinking, I know the portfolio has done close to 13.8% during the given period.

## 6.3 – Portfolio as a whole

Now, here is something I'd like you to think about. In the previous chapter, we calculated the portfolio variance. While doing so, one of the key things we had to calculate was the standard deviation of each stock. Standard deviation as you may know, represents the volatility of the stock which is nothing but the risk associated with the stock.

To calculate the standard deviation, we used the inbuilt excel function '=STDEV()' applied on the daily return of the stock. Now, think about this – we anyway have the daily value of the portfolio (although normalized to Rs.100).

Now imagine the portfolio itself in its entirety, as a whole, as a single stock, and calculate its daily returns. Just like how we calculated the daily returns of the stocks in the previous

chapter. Further, what if I apply the '=STDEV()' function on the portfolio's daily return? The resulting value should be the standard deviation of the portfolio which in other words should represents risk also called as Variance of the portfolio.

Are you able to sense where we are heading? Yes, we are talking about calculating portfolio variance using a different approach all together

To help you comprehend this better, let me paste the portfolio variance value we calculated in the previous chapter–

**Portfolio Variance**
1.11%
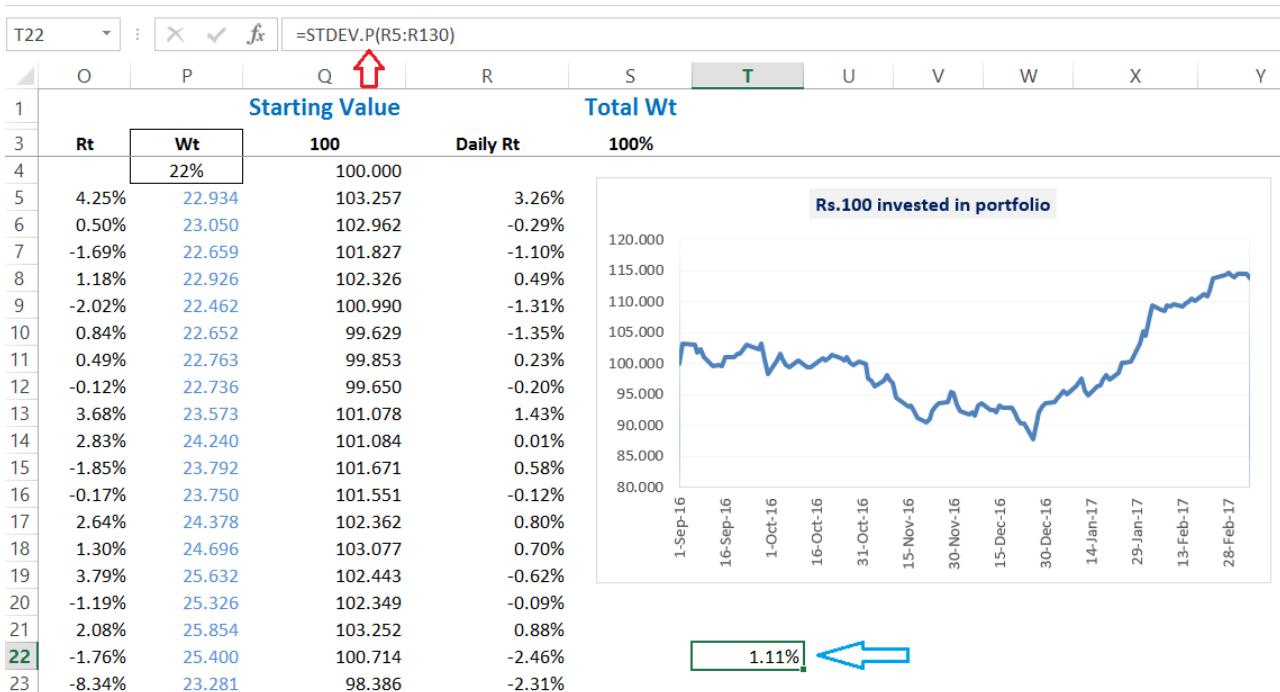
We calculated the above value using the matrix multiplication and the correlation matrix technique.

We will now look at the portfolio as a whole and calculate the daily returns of the normalized portfolio value. The standard deviation of the portfolio's daily returns should yield us a value equal to or somewhere near the portfolio variance calculated previously.

I've included a new column next to the daily normalized portfolio value and calculated the Portfolio's daily returns –

| O | P | Q | R |
|---|---|---|---|
| | | **Starting Value** | |
| **Rt** | **Wt** | **100** | **Daily Rt** |
| | 22% | 100.000 | |
| 4.25% | 22.934 | 103.257 =Q5/Q4-1 | |
| 0.50% | 23.050 | 102.962 | -0.29% |
| -1.69% | 22.659 | 101.827 | -1.10% |

Once I have the returns in place, I will apply the standard deviation function on the time series data, this should yield a value close to the portfolio variance value we previously calculated.

| | O | P | Q | R | S | T | U | V | W | X | Y |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | **Starting Value** | | **Total Wt** | | | | | | |
| 3 | **Rt** | **Wt** | **100** | **Daily Rt** | **100%** | | | | | | |
| 4 | | 22% | 100.000 | | | | | | | | |
| 5 | 4.25% | 22.934 | 103.257 | 3.26% | | | | | | | |
| 6 | 0.50% | 23.050 | 102.962 | -0.29% | | | | | | | |
| 7 | -1.69% | 22.659 | 101.827 | -1.10% | | | | | | | |
| 8 | 1.18% | 22.926 | 102.326 | 0.49% | | | | | | | |
| 9 | -2.02% | 22.462 | 100.990 | -1.31% | | | | | | | |
| 10 | 0.84% | 22.652 | 99.629 | -1.35% | | | | | | | |
| 11 | 0.49% | 22.763 | 99.853 | 0.23% | | | | | | | |
| 12 | -0.12% | 22.736 | 99.650 | -0.20% | | | | | | | |
| 13 | 3.68% | 23.573 | 101.078 | 1.43% | | | | | | | |
| 14 | 2.83% | 24.240 | 101.084 | 0.01% | | | | | | | |
| 15 | -1.85% | 23.792 | 101.671 | 0.58% | | | | | | | |
| 16 | -0.17% | 23.750 | 101.551 | -0.12% | | | | | | | |
| 17 | 2.64% | 24.378 | 102.362 | 0.80% | | | | | | | |
| 18 | 1.30% | 24.696 | 103.077 | 0.70% | | | | | | | |
| 19 | 3.79% | 25.632 | 102.443 | -0.62% | | | | | | | |
| 20 | -1.19% | 25.326 | 102.349 | -0.09% | | | | | | | |
| 21 | 2.08% | 25.854 | 103.252 | 0.88% | | | | | | | |
| 22 | -1.76% | 25.400 | 100.714 | -2.46% | 1.11% | | | | | | |
| 23 | -8.34% | 23.281 | 98.386 | -2.31% | | | | | | | |

Formula bar: T22 =STDEV.P(R5:R130)

Chart: Rs.100 invested in portfolio (values 80.000 to 120.000; dates 1-Sep-16 to 28-Feb-17)

So there you go, the STDEV function gives us the exact same value!

You can **download** the excel sheet used in this chapter. In the next chapter, we will use the portfolio variance to estimate the expected returns along with optimization.

Quick Task – I'd like to leave you with a quick task here. We have assigned random weights to the stocks. Go ahead and change the weights of the stocks and see the impact on the overall returns. Do share your observation in the comment box below.

**Key takeaways from this chapter**

1. An equity curve is a standard way to visualize the performance of a portfolio
2. A standard industry wide practice is to normalize the portfolio to a starting investment value of Rs.100/-
3. We assign weights and the respective investment to each stock
4. We need to calculate the daily change in investment value in each stock
5. The sum total of all the variation in each stock adds up to the variation of the entire portfolio
6. The graph of the change in daily prices of the portfolio yields the equity curve
7. We can look at the portfolio as a whole, as a single stock and calculate its SD
8. The SD of portfolio also yields the portfolio variance

# CHAPTER 7

# Expected Returns

## 7.1 – Expected returns



The next two chapter will be very insightful, especially for people who have never been familiar with portfolio techniques. We will venture into the realms of expected return framework and portfolio optimization. Portfolio optimization in particular (which we will discuss in the next chapter) is like a magic wand, it helps you decide how much to invest in a particular stock (within a portfolio) so that you achieve the best possible results in terms of risk and return. These are topics which the high priests of finance prefer to keep for themselves, but today we will discuss them here and truly work towards democratizing quality financial knowledge.

But please note, to best understand the discussion here, you need to have a sense of all the things we have discussed over the previous couple of chapters. If you have not read them yet, please, I'd urge you to read them first. This is good quality information and you would be a better market participant if you simply spent few hours reading them. The excel sheet used here is a continuation of the one used in the previous chapters.

So assuming you are all set, let us get started.

It is time we put the portfolio variance to good use. To begin with let us take a good look at the portfolio variance number calculated in the previous chapters –

**Portfolio Variance**
**1.11%**

What does this number tell you?

The number gives you a sense of the degree of the risk associated with the portfolio. Remember, we worked on the daily data, hence the Portfolio Variance of 1.11% represents risk on a daily basis.

**Risk or variance or volatility** is like a coin with two faces. Any price movement below our entry price is called risk while at the same time, the same price movement above our entry price is called return. We will soon use the variance data to establish the expected range within which the portfolio is likely to move over the year. If you've read the Options module you will probably know where we are headed.

However, before doing that, we need to figure out the expected return of the portfolio. The expected return of the portfolio is simply, the grand sum of the average return of each stock, multiplied by its weight and further multiplied by 252 (number of trading days). In simple terms, we are scaling the daily returns to its annual return, and then scaling it according to the investment we have made.

Let us calculate the expected return for the portfolio that we have, I'm sure you will understand this better. To begin with, I've lined up the data as follows –

### Expected Stock Returns

| Stock | Weight | Daily Avg | Expected yr rt |
|-------|--------|-----------|----------------|
| Cipla | 7.00% | 0.06% | 15.49% |
| Idea | 16.00% | 0.57% | 142.42% |
| Wonderla | 25.00% | 0.06% | 14.45% |
| PVR | 30.00% | 0.15% | 38.86% |
| Alkem | 22.00% | 0.29% | 72.73% |

The first 3 columns are fairly easy to understand I suppose. The last column is simply the multiplication of the daily average return by 252 – this is a step to annualize the return of the stock.

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For example, (Cipla) – 0.06% * 252 = 15.49%.

What does this mean? For a moment assume, I have invested all the money in just Cipla and no other stocks, then the weight of Cipla would be 100% and I can expect a return of 15.49%. However, since I've invested only 7% of my capital in Cipla, the expected return from Cipla would be –

Weight * Expected Return

= 7% * 15.49%

=1.08%

We can generalize this at the portfolio level to get the expected return of the portfolio –

**Expected Stock Returns**

| Stock | Weight | Daily Avg | Expected yr rt |
|-------|--------|-----------|----------------|
| Cipla | 7.00% | 0.06% | 15.49% |
| Idea | 16.00% | 0.57% | 142.42% |
| Wonderla | 25.00% | 0.06% | 14.45% |
| PVR | 30.00% | 0.15% | 38.86% |
| Alkem | 22.00% | 0.29% | 72.73% |

Where,

Wt = Weight of each stock

Rt = Expected annual return of the stock

I've applied the same formula for the 5 stock portfolio that we've got, and here is what we have –

=S69*U69+S70*U70+S71*U71+S72*U72+S73*U73

## X = Excess Retun matrix

| | Rt | Alkem | Rt | Cipla | Idea | Wonderla | PVR | Alkem | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.5 | -0.99% | 1692.15 | 0.03% | 0.91% | 2.35% | -0.29% | -1.14% | -0.26% | **M2** | | | |
| 11.1 | 0.94% | 1712.1 | 1.18% | -0.31% | 3.99% | 1.98% | 0.78% | 0.89% | 0.000124 | | | |
| 0.25 | 0.71% | 1699.85 | -0.72% | -0.51% | -2.84% | 1.41% | 0.56% | -1.00% | | | | |
| 2.55 | -1.45% | 1679.1 | -1.22% | 0.22% | -6.57% | -1.63% | -1.61% | -1.51% | **Portfolio Variance** | | | |
| 09.8 | -2.89% | 1679.7 | 0.04% | 0.47% | 0.33% | -1.67% | -3.05% | -0.25% | **1.11%** | | | |
| 59.1 | -2.79% | 1702.95 | 1.38% | 0.25% | -1.65% | 0.16% | -2.95% | 1.10% | | | | |
| 35.2 | 1.51% | 1690.8 | -0.71% | 0.26% | 1.84% | -1.48% | 1.35% | -1.00% | **Expected Stock Returns** | | | |
| 0.65 | -0.42% | 1675.25 | -0.92% | -0.76% | 0.85% | -1.98% | -0.57% | -1.21% | Stock | Weight | Daily Avg | Expected yr rt |
| 01.5 | 1.93% | 1680.45 | 0.31% | 2.02% | 1.03% | 3.08% | 1.78% | 0.02% | Cipla | 7.00% | 0.06% | 15.49% |
| 07.3 | 0.53% | 1675.35 | -0.30% | -0.72% | -0.37% | 1.40% | 0.37% | -0.59% | Idea | 16.00% | 0.57% | 142.42% |
| 08.9 | -0.76% | 1623.95 | -3.07% | -0.77% | -2.13% | 0.51% | -0.91% | -3.36% | Wonderla | 25.00% | 0.06% | 14.45% |
| 07.5 | -0.13% | 1639.75 | 0.97% | 0.64% | 1.35% | -2.65% | -0.28% | 0.68% | PVR | 30.00% | 0.15% | 38.86% |
| 2.75 | -0.43% | 1609.35 | -1.85% | -1.94% | -0.44% | 1.82% | -0.59% | -2.14% | Alkem | 22.00% | 0.29% | 72.73% |
| 02.4 | -0.03% | 1632.6 | 1.44% | -0.92% | -0.82% | 4.61% | -0.19% | 1.16% | | | | |
| 0.85 | -1.15% | 1601.95 | -1.88% | 0.48% | -1.54% | 1.88% | -1.30% | -2.17% | | | | |
| 0.65 | 0.07% | 1632.8 | 1.93% | 0.46% | -0.30% | -2.55% | -0.08% | 1.64% | **Expected Portfolio Return** | | | |
| 76.6 | -0.37% | 1632 | -0.05% | -1.12% | -4.69% | -0.46% | -0.53% | -0.34% | =S69*U69- | | | |
| 51.9 | -2.29% | 1639.85 | 0.48% | -0.11% | -1.25% | -1.51% | -2.45% | 0.19% | **55.14%** | | | |
| 3.45 | -0.33% | 1607.6 | -1.97% | -0.31% | -2.28% | 0.60% | -0.48% | -2.26% | | | | |

At this stage, we have arrived at two extremely important portfolio parameters. They are the expected portfolio return which is **55.14%** and the portfolio variance which is 1.11%.

In fact, we can scale the portfolio variance to represent the annual variance, to do this we simply have to multiply the daily variance by Square root of 252.

Annual variance =

= 1.11% * Sqrt (252)

= **17.64%.**

We will keep both these important numbers aside.

It is now time to recall our discussion on normal distribution from the **options module.**

I'd suggest you quickly read through the 'Dalton board experiment' and understand normal distribution and how one can use this to develop an opinion on future outcome. Understanding normal distribution and its characteristics is quite crucial at this point. I'd encourage you to read through it before proceeding.

Portfolio returns are normally distributed, I'll skip plotting the distribution here, but maybe you can do this as an exercise. Anyway, if you do plot the distribution of a portfolio, you are likely to get a normally distributed portfolio. If the portfolio is normally distributed, then **we can estimate the likely return of this portfolio over the next 1 year with certain degree of confidence.**

To estimate the return with certain degree of confidence we simply have to add and subtract the portfolio variance from the expected annualized return. By doing so we will know how much the portfolio will generate or lose for the given year.

In other words, based on normal distribution, we can predict (although I hate using the word predict in markets) the range within which the portfolio is likely to fluctuate. The accuracy of this predication varies across three levels.

- Level 1 – one standard deviation away, 68% confidence
- Level 2 – Two standard deviation away, 95% confidence
- Level 3 – Three standard deviation away,99% confidence

Remember, variance is measured in terms of standard deviation. So it is important to note that the annualized portfolio variance of 17.64% is also the 1 standard deviation.

So, 17.64% represents 1 standard deviation. Therefore, two standard deviations are 17.64% * 2 = 35.28% and 3 standard deviation would be 17.64% * 3 = 52.92%.

If you are reading this for the first time, then yes, I'd agree it would not be making any sense. Hence it is important to understand normal distribution and its characteristics. I've explained the same in the options chapter (link provided earlier).

**7.2 – Estimating the portfolio range**

Given the annualized variance (17.64%) and expected annual return (55.14%), we can now go ahead and estimate the likely range within which the portfolio returns are likely to vary over the next year. Remember when we are talking about a range, we are taking about a lower and upper bound number.

To calculate the upper bound number, we simply had to add the annualized portfolio variance to the expected annual return i.e. 17.64% + 55.15% = 72.79%. To calculate the lower bound range we simply have to deduct the annualized portfolio variance from the expected annual return i.e. 55.15% – 17.64% = 37.51%.

So, if you were to ask me – how are the returns likely to be if I decide to hold the 5 stock portfolio over the next year, then my answer would be that the returns are likely to fluctuate between **+37.51% and +72.79%**.

Three quick question may crop up at this stage –

1. The range suggests that the portfolio does not lose money at all, how is this even possible? In fact, the worst case scenario is still a whopping +37.51%, which in reality is fantastic.
    1. True, I agree it sounds weird. But the fact is, the range calculation is statistics based. Remember we are in a bull market (April – May 2017, as I write this), and the stocks that we have selected have trended well. So quite obviously, the numbers we have got here is positively biased. To get a true sense of the range, we should have taken at least last 1 year or more data points. However, this is beside the point here – remember our end objective is to learn the craft and not debate over stock selection.
2. Alright, I may have convinced you on the range calculation, but what is the guarantee that the portfolio returns would vary between 37.15% and 72.79%?
    1. As I mentioned earlier, since we are dealing with level 1 (1 standard deviation), the confidence is just about 68%.
3. What if I want a higher degree of confidence?
    1. Well, in this case you will have to shift gears to higher standard deviations.

Let us do that now.

To calculate the range with 95% confidence, we have to shift gears and move to the $2^{nd}$ standard deviation. Which means we have to multiply the 1 standard deviation number by 2. We have done this math before, so we know the $2^{nd}$ SD is 35.28%.

Given this, the range of the portfolio's return over the next 1 year, with 95% confidence would be –

Lower bound = 55.15% – 35.28% = **19.87%**

Upper bound = 55.15% + 35.28% = **90.43%**

We can further increase the confidence level to 99% and check the return's range for 3 standard deviation, recall at 3 SD, the variance is 52.92% –

Lower bound = 55.15% – 52.92%% = **2.23%**

Upper bound = 55.15% + 52.92% = **108.07%**

As you may notice, the higher the confidence level, the larger the range. I'll end this chapter here with a set of tasks for you –

1. Plot the frequency distribution for this 5 stock portfolio – observe the distribution, check if you see a bell curve
2. We are dealing with the range for a year, what if you were to estimate the range for 3 months, or maybe 3 weeks? How would you do it?

It will be great if you can attempt these tasks, please do leave your thoughts in the comment box below.

You can **download** the excel sheet used in this chapter.

**Key takeaways from this chapter**

1. The returns of the portfolio are dependent on the weights of the individual stocks in the portfolio
2. The calculate the effect of an individual stock on the overall portfolio's return, one has to multiply the average return of the stock by its weight
3. The overall expected return of the portfolio is grand sum of the individual stock's returns (which is scaled by its weight)
4. The daily variance can be converted to annualized variance by multiplying it by square root of 252
5. The variance of the portfolio which we calculate is by default the $1^{st}$ standard deviation value
6. To get the $2^{nd}$ and $3^{rd}$ SD, we simply have to multiply it by 2 and 3
7. The expected return of the portfolio can be calculated as a range
8. To get the range, we simply have to add and subtract the variance from the portfolio's expected return
9. Each standard deviation comes with a certain confidence level. For higher confidence level, one has to look at moving higher standard deviation

# Portfolio Optimization (Part 1)



## 8.1 – A tale of 2 stocks

We have spent a great deal of time and efforts towards understanding risk associated with a portfolio. Our discussion has brought us to a very important stage – it's time we discuss portfolio optimization. Perhaps, a good start to this discussion would be to understand what portfolio optimization is all about and why it makes sense to optimize a given portfolio.

Before we proceed, let me ask you a question – what do you think is the overall portfolio return, considering a portfolio consists investment in Infosys and Biocon (equally weighted). Assume the expected return of Infosys is 22% and Biocon is 15%.

I know it sounds like a typical MBA class question, but this is an important question and you should know how to answer this question at this stage J

Since the portfolio is equally weighted across two stocks, it implies we invest 50% in Infosys and 50% in Biocon. Given this, the expected portfolio return would be –

= Weight of investment in Infosys **\*** Expected return of Infosys **+** Weight of investment in Biocon **\*** Expected return of Biocon

Do recall, in the previous chapter we did discuss "Expected Return of a stock" in detail. Anyway, let us work out the answer –

50% * 22% + 50% * 15%

=11% + 7.5%

= **18.5%**

So, the portfolio is expected to yield a return of 18.5% annually.

Great, now what if we change the weights? What if invest 30% in Infosys and 70% in Biocon? Or let us say 70% in Infosys and 30% in Biocon?

Let's figure this out, Case 1 –

30% * 22% + 70% * 15%

= 6.6% + 10.5%

**17.1%**

Case 2 –

70% * 22% + 30% * 15%

=15.4% + 4.5%

=**19.9%**

Needless to say, we can do this for multiple combinations of weights. In fact, here is the table with few of the other combinations possible –

| Infosys @ 22% | Biocon @ 18% | Portfolio Return |
|---|---|---|
| 10.0% | 90.0% | 15.7% |
| 20.0% | 80.0% | 16.4% |
| 30.0% | 70.0% | 17.1% |
| 40.0% | 60.0% | 17.8% |
| 50.0% | 50.0% | 18.5% |
| 60.0% | 40.0% | 19.2% |
| 70.0% | 30.0% | 19.9% |
| 80.0% | 20.0% | 20.6% |
| 90.0% | 10.0% | 21.3% |

As you can notice, as the investment weight varies, the returns also vary. For example, if I had decided to invest just 40% in Infy and 60% in Biocon, I'd have enjoyed a return of 17.8%. However, if I had reversed it by investing 60% in Infy and 40% in Biocon, I'd have enjoyed a return of 19.2%, which is an additional 2% return.

This leads us to a super important conclusion – **as the investment weights vary, the returns vary**. In fact, each return has an associated risk profile, so it is prudent to state – as the weights vary, both the risk and return characteristics vary.

Now imagine this – for a given portfolio with 'n' number of stocks, wouldn't it be awesome if you were to look at the past data and intelligently identify how much to invest in each stock, so that the portfolio yields the best possible returns?

This is exactly what happens when you optimize your portfolio. Generally speaking, you can adjust the weights (or optimize your portfolio) such that, for the given set of stocks –

o   You identify the investment weights to achieve the best possible return or
o   You identify the investment weights to achieve the least possible risk
    Sounds confusing? Fear not, just read ahead!

## 8.2 – Caution! Jargons ahead

Hopefully by now, you fully appreciate the reason why one should optimize the portfolio. So,

I won't spend more time convincing you

Let us go ahead and optimize the portfolio we have been working with. However, there are few important terms I want you to be familiar with at this stage –

**Minimum variance portfolio** – Assume you have a portfolio of 10 stocks. It must be quite obvious by now that you can play around with the weights of each stock to achieve different results. When I say results, I'm talking about the risk and return characteristics.  Each unique set of weights represents a unique portfolio. For example, an equally weighted portfolio (10 stocks, 10% weight in each) is a unique portfolio. A portfolio where you invest 30% in stock 1 and 7.8% each across the remaining 9 stocks is another unique portfolio. The number of combination possible are many and each combination of weights results in a unique risk and return characteristics.

Given this, there should be that one set of combination of stock weights possible, such that the risk for the portfolio is the least possible. More technically, there should be combination of weights possible such that the variance of the portfolio is minimum. This particular portfolio is also referred to as the "Minimum Variance Portfolio". The minimum variance portfolio represents the least amount of risk you can take. So if you are a highly risk averse investor, you should aim to create a minimum variance portfolio.
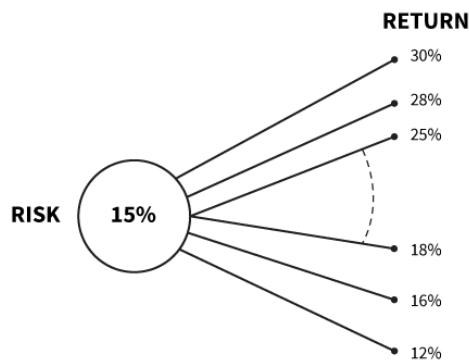
**Maximum Return portfolio** – This is somewhat the opposite of a minimum variance portfolio. Just like a minimum variance portfolio, there should be a combination of weights such that we can achieve a portfolio with maximum return possible. This also means that for a maximum return portfolio, the risk too will be on the higher side.

**Fixed variance, multiple portfolios –** This is not really a jargon, but a concept that you need to be aware of at this stage. It may come across as a little confusing at this point, but I'm certain, later on in this chapter (or maybe next) you will understand this much better, especially when we perform portfolio optimization.

For a given level of risk or variance of a portfolio, you can create **at least two** unique portfolios. One of such portfolio will yield the highest possible return and the other portfolio will yield the lowest return for the same given level of risk.

Here is an example on a completely arbitrary basis – let us say the risk or variance of a portfolio is 15%, given this, there will be a portfolio which can yield 30% return (highest possible return) and another portfolio which can yield 12% return (lowest possible return). Do note, for both these portfolios, the risk is fixed to 15% but the returns vary.

Between these two portfolios there could be multiple other (unique) portfolios with varying return profile. In super simple terms – for a fixed amount of risk, there could be multiple portfolio combinations, and within these possible combinations, there will be a portfolio with maximum return and another with minimum return.

We will revisit this concept a little later in the chapter, but for now, just keep this thought at the back of your mind.

## 8.3 – Portfolio optimization (steps)

Let us recall the portfolio that we have – the stock names and the associated weights are as follows. Do note, this is a continuation of the portfolio we have been working with over the previous few chapters.

| Stock | Weight |
|---|---|
| Cipla | 7.00% |
| Idea | 16.00% |
| Wonderla | 25.00% |
| PVR | 30.00% |
| Alkem | 22.00% |
| **Total Weight** | 100.00% |

Do remember, the weights assigned are all random, there was no thought process to it. For this portfolio with these combination of weights, the annual portfolio variance was estimated at **17.64%** and expected return as **55.14%.**

Our objective now is to optimize this portfolio to achieve a desired outcome. To optimize a portfolio in excel, we need the 'Solver Tool' in excel. You will find the solver tool under the

Many of you may not find the 'solver' tool under the data ribbon. This is because you've not added it from the excel add ins. To add solver, follow these simple steps –

1. Click on Files on the opened excel sheet

2. Select Options

3. Select Add-ins (last but one option)

4. Click on 'Solver Add Ins'

5. Click on "Go"

6. Check on "Solved Add ins" once again

7. Click Ok and close

8. Close the excel sheet, if required restart your system

9. Check under data ribbon – you should be able to find the solver tool

To begin with, let us optimize the portfolio to get the "Minimum Variance portfolio". Here are few simple steps that you can follow to achieve this.

**Step 1** – Organize your data. This is the key to using solver. Your cells should be linked; data should be neatly organized. No hard coding of data. Here is how the data on excel sheet looks at this stage.

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## Weights & weight SD

| Stock | Weight | Wt.SD |
|---|---|---|
| Cipla | 7.00% | 0.104% |
| Idea | 16.00% | 0.535% |
| Wonderla | 25.00% | 0.390% |
| PVR | 30.00% | 0.606% |
| Alkem | 22.00% | 0.408% |
| **Total Weight** | **100.00%** | |

## M1

| Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|
| 0.003910484 | 0.00616274 | 0.00555355 | 0.007066495 | 0.005386129 |

## M2

0.000123542

## Portfolio Variance
1.11%

## Expected Stock Returns

| Stock | Weight | Daily Avg | Expected yr rt |
|---|---|---|---|
| Cipla | 7.00% | 0.06% | 15.49% |
| Idea | 16.00% | 0.57% | 142.42% |
| Wonderla | 25.00% | 0.06% | 14.45% |
| PVR | 30.00% | 0.15% | 38.86% |
| Alkem | 22.00% | 0.29% | 72.73% |

| Expected Port Return | 55.14% |
|---|---|
| Annual Port Varience | 17.64% |
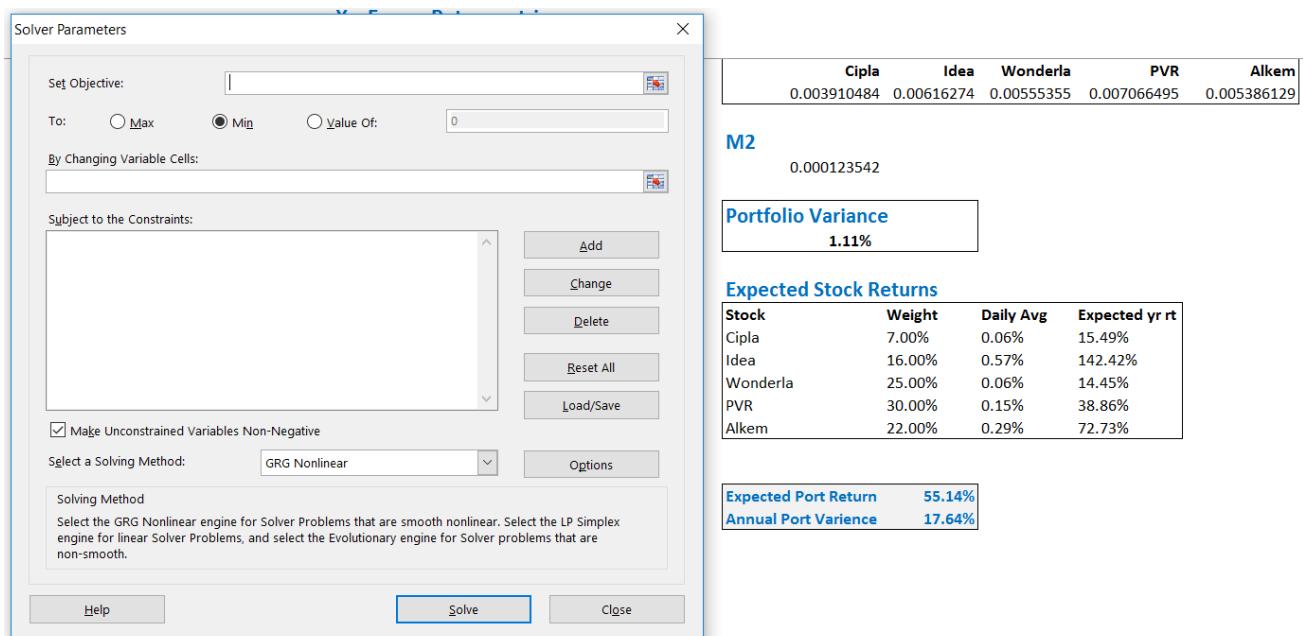
I've highlight two important parts, which we will use for optimizing. The top most part has the weights assigned to each stock. Needless to say, this will change once the portfolio is optimized. The 2$^{nd}$ part has the expected return and annual portfolio variance calculation, which will also change when we optimize the portfolio.

**Step 2** – Use the solver tool in excel to optimize the weights. I'm assuming you may be new to solver, hence will give you a quick overview of this tool. You can use solver to work with something called as an 'objective'. An objective, according to solver is essentially a data point, derived by set of formulas. You can minimize the objective's value or maximize the objective's value or set the value of an objective to a certain desired value. You can do this while changing certain variables. The variables, according to solver are the elements of the formulas used in deriving the objective. For example, I can choose to minimize the variance

of the portfolio by changing the weights of each stock. Here, the variance is the objective and the weights are the variable.

When we command the solver to minimize the objective (variance in this case), then in the background, excel's solver will quickly check the formulas used and works around it in such a way that the objective's value is least minimum.

Look at the image below, I'm invoking the solver tool and will soon ask it to minimize the variance.



When you click on the data ribbon and click on solver, you will see the solver tool open up, as seen above. We need to set the objective here. Objective as I mentioned earlier, is the annual portfolio variance. Remember, we are working towards finding the minimum variance portfolio here.

Check the image below –

Objective is set to 'Annual portfolio variance' – you can notice the cell address is highlighted in the 'set objective' field. The cell containing the annual portfolio variance itself is highlighted below, you will find another red arrow here. We are minimizing the objective here, the same is highlighted by the green arrow.

Once this is set, the next step is to inform the solver tool that we need minimize the objective by changing the variables. In this case, the variable happens to be the weights assigned to each stock.



As you can see, in the "By changing variable cells" field, I've highlighted the weights assigned to each stocks.

You can also find "subject to constraints", field. This essentially means, that solver will minimize the variance, by change the weights of each stock, and at this stage, it is also asking us if there are any constraints it needs to keep in mind while solving to minimize the variance.
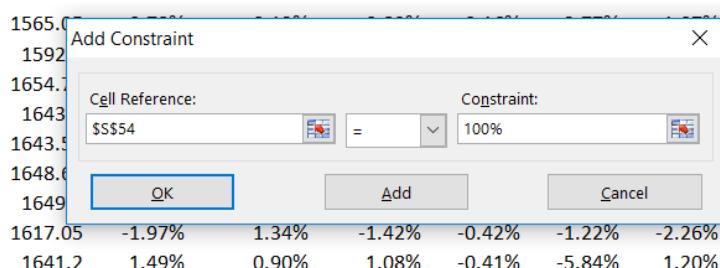
One constraint that I can think of at this stage is that the total weight of all stocks put together should be 100%. This essentially means that my capital is 100% deployed across all the 5 stocks. If I do not specific this, then there is a chance that solver may suggest to skip investments across few stock altogether. Remember, solver is an excel tool, and it does not appreciate stock picking

To add a constraint, click on 'add'. When you do so the following window opens up –



Under Cell reference, I will give the sum of weights of stocks – which needs to be equal to 100%. Next to this, you can see a drop down menu with multiple options, I'd pick '=' here. Finally, the constraint itself will be 100%. Note, I've typed out 100% here.

In simple words, I'm asking solver to optimize for minimum variance, keeping the weight of all stock to 100%. The window now looks like this –



| Weights & weight SD | | |
|---|---|---|
| Stock | Weight | Wt.SD |
| Cipla | 7.00% | 0.104% |
| Idea | 16.00% | 0.535% |
| Wonderla | 25.00% | 0.390% |
| PVR | 30.00% | 0.606% |
| Alkem | 22.00% | 0.408% |
| Total Weight | 100.00% | |

The solver is completely set up now. The final screen before pressing "Solve" looks like this –

**X = Excess Retun matrix**

|  | Cipla | Idea |
|---|---|---|
| Cipla | 1.0 | 0.10715052 |
| Idea | 0.10715052 | 1.0 |
| Wonderla | 0.14368425 | 0.07499042 |
| PVR | 0.13434778 | 0.03363225 |
| Alkem | 0.22858556 | 0.06024903 |

**Weights & weight SD**

| Stock | Weight | Wt.SD |
|---|---|---|
| Cipla | 7.00% | 0.104% |
| Idea | 16.00% | 0.535% |
| Wonderla | 25.00% | 0.390% |
| PVR | 30.00% | 0.606% |
| Alkem | 22.00% | 0.408% |
| **Total Weight** | **100.00%** | |

**M1**

| Cipla | Idea | Wonderla |
|---|---|---|
| 0.003910484 | 0.00616274 | 0.00555355 |

**M2**

0.000123542

**Portfolio Variance**

**1.11%**

I've highlighted the weights of each stock for reference. Remember, these are pre optimized weights that we randomly assigned at the beginning of this discussion. Post optimizing, the weights will be changed such that the variance is least possible for these set of stocks. Let us go ahead and press 'solve' and check what solver has for us.

And here you go –

**Expected Stock Returns**

| Stock | Weight | Daily Avg | Expected yr rt |
|---|---|---|---|
| Cipla | 29.58% | 0.06% | 15.49% |
| Idea | 5.22% | 0.57% | 142.42% |
| Wonderla | 30.22% | 0.06% | 14.45% |
| PVR | 16.47% | 0.15% | 38.86% |
| Alkem | 18.51% | 0.29% | 72.73% |

| Expected Port Return | 36.25% |
|---|---|
| Annual Port Varience | 15.57% |

Solver has solved for the 'minimum variance' portfolio and accordingly it has worked out the weights for each stock.

For example, it wants us to increase the weight in Cipla from current 7% to 29.58%, while it wants us to reduce the weight in Idea to 5.22% from 16%. So on and so forth. Further, it is also telling us that the least possible variance with this portfolio is **15.57%** (remember, the

variance was earlier at 17.64%).  Along with this, the portfolio's expected return too seem to have dropped to **36.25%** from the earlier 55.14%.

So, no matter what you do, the variance cannot be lowered below 15.57%. In other words, if these are the 5 stocks that you want to invest in, then the least amount of risk you will be exposed to is 15.57% and absolutely nothing below that!

I'll leave you at this. In the next chapter, we will optimize the same portfolio for few more scenarios and work towards building something called as an 'Efficient Frontier'.

You can **download** the excel sheet used in this chapter. Do note, the excel contains the optimized weights for the minimum variance portfolio.

**Key takeaways from this chapter**

1.  The returns of the portfolio are dependent on the weights assigned to each stock
2.  Minimum variance portfolio is that portfolio where the variance or risk is least possible for the given set of stocks
3.  Maximum return portfolio is that portfolio where the expected portfolio returns are maximized for the given set of stocks
4.  When we fix the variance of a portfolio we can achieve at least two portfolios where the expected portfolio returns can be maximum or least
5.  One can optimize a given portfolio with 'n' number of stocks on excel, by using the solver tool
6.  One of the most important points to remember while using solver is to ensure the data is well organized. One can do this by linking all the relevant cells and avoiding hard coding of values
7.  You can optimize the portfolio by subjecting the variable to constrains

# Portfolio Optimization (Part 2)



## 9.1 – Working with the weights

In the previous chapter we introduced the concept of portfolio optimization using excel's solver tool. We will build on the same concept in this chapter and proceed to understand an important portfolio concept, often referred to as the 'Efficient Frontier'.

Recall in the previous chapter, we discussed how a portfolio can produce multiple return series for a fixed portfolio variance. We will now go ahead and see how this works. This concept will eventually lead us to understanding portfolio optimization better.

In the previous chapter, we optimized the portfolio to produce the minimum variance portfolio. The results, in terms of weights of individual stocks were as follows –

| SI No | Stock name | Pre optimized weight | Optimized for minimum variance |
|-------|------------|---------------------|-------------------------------|
| 01 | Cipla | 7% | 29.58% |
| 02 | Idea | 16% | 5.22% |
| 03 | Wonderla | 25% | 30.22% |
| 04 | PVR | 30% | 16.47% |
| 05 | Alkem | 22% | 18.51% |

And the expected portfolio returns and the portfolio variance is as follows –

| | Pre optimized | Optimized for minimum variance |
|--|--------------|-------------------------------|
| Expected Portfolio return | 55.14% | 36.35% |
| Portfolio Variance | 17.64% | 15.57% |

Here is where things start to get a little interesting. So far what we have achieved in terms of portfolio optimization is merely a minimum variance portfolio. Like we discussed in the previous chapter, for every fixed risk level, there could be multiple unique portfolio with varying return characteristics. We will now go ahead and explore this in greater detail.

We know at 15.57% portfolio variance, the return expected is 36.35%. We will now go ahead and increase the risk maybe to 17%, and calculate the highest and lowest possible returns for this. In other words, we are essentially trying to identify the highest and lowest possible return for a fixed portfolio variance of 17%. Also, do pay attention here – when I say increase the risk, we are essentially fixing the risk to certain desired level. 17% for now.
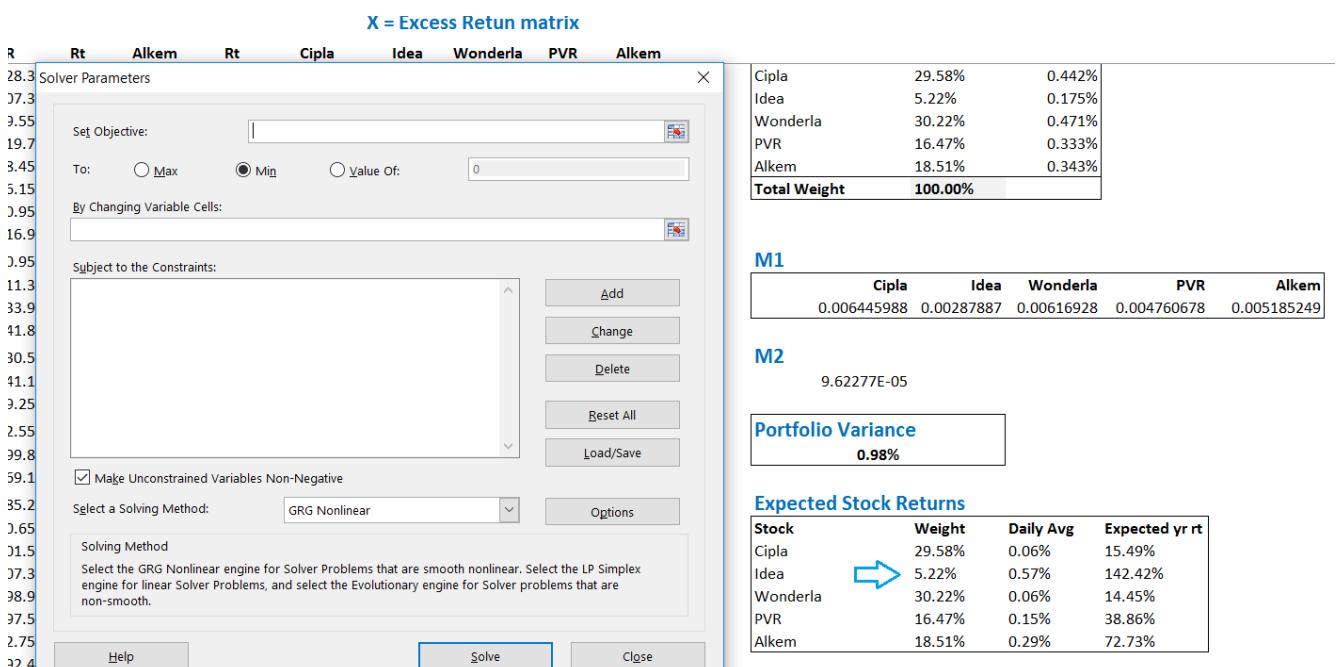
## 9.2 – More optimization

The general direction we are headed is this – we know the minimum risk possible for this portfolio is 15.57%. We have also noted the return achievable at this level of risk i.e – 36.35%. Like I mentioned earlier, we will now increase the risk a notch higher and note down the maximum and minimum return for this risk. Along with the return, we will also note the investment weights. We will then increase the risk another notch higher and again note the max and min return along with the weights. We will do few such iterations and note down all the observation.

Eventually, I would like to plot a scatter plot of fixed risk along with its respective max return and min return data points and study this scatter plot in greater detail. This scatter plot will help us understand portfolio optimization.

So let us get started by fixing the risk at 17%. Please note, I've opted 17% just like that, it could very well have been 16% or 18%.
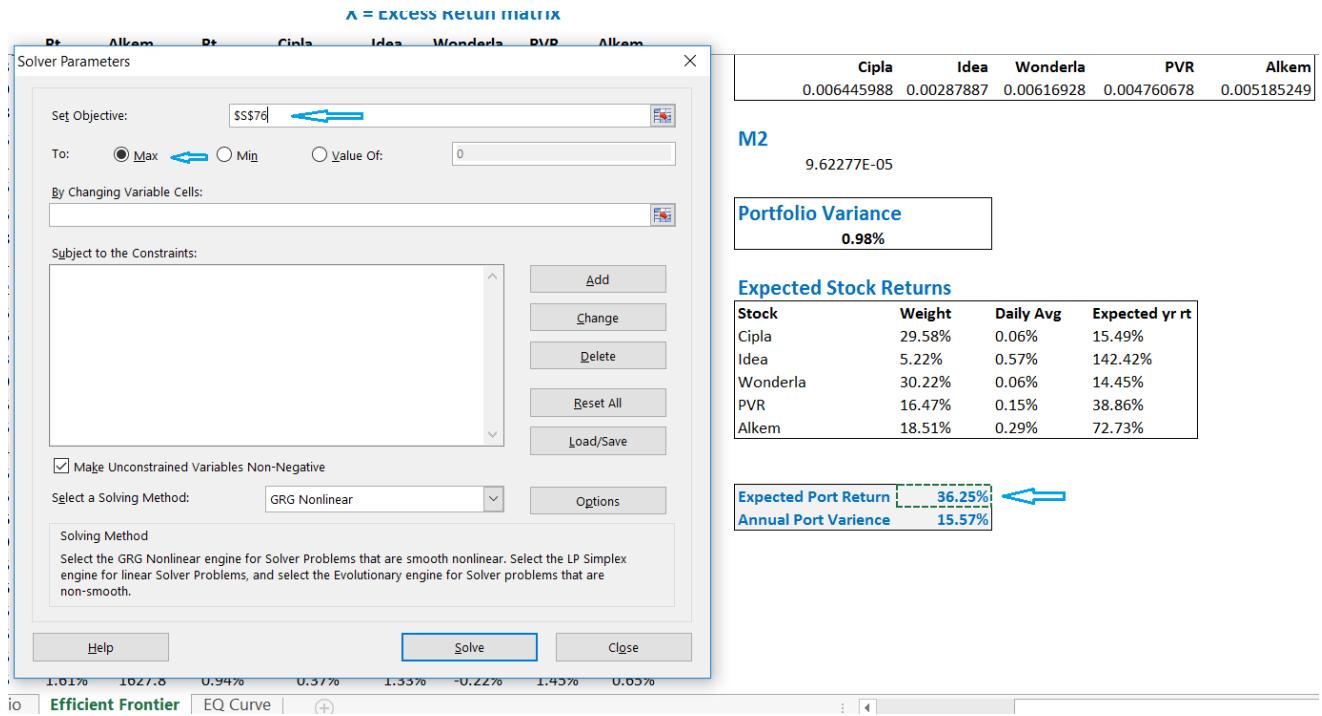
**Step 1 – Invoke the solver**



As I explained in the previous chapter, I've invoked the solver calculator by clicking on the data ribbon. I've highlighted the optimized weights for the minimum variance portfolio, this is just for your reference.
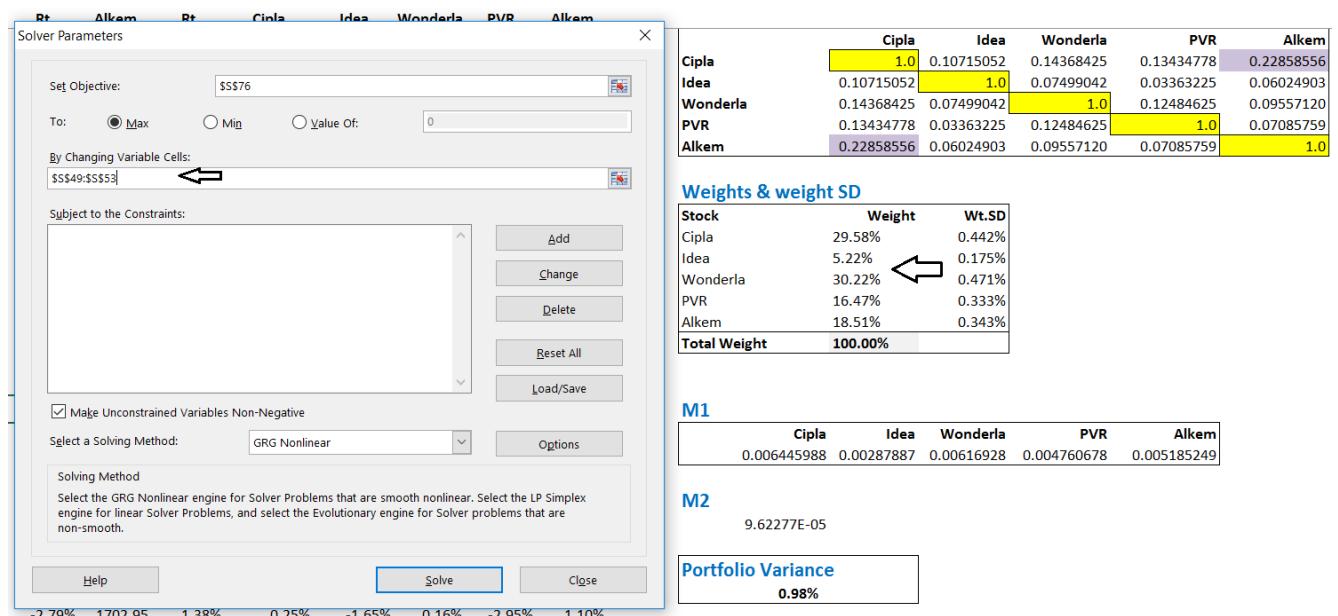
**Step 2 – Set the parameters**

To begin with let us find out the maximum return one can achieve for a fixed 17% risk. For this, we need to set the objective to **maximize** the 'expected portfolio return'. The same is highlighted as shown below –

X = Excess Return matrix

| | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| | 0.006445988 | 0.00287887 | 0.00616928 | 0.004760678 | 0.005185249 |

M2
9.62277E-05

**Portfolio Variance**
0.98%

**Expected Stock Returns**

| Stock | Weight | Daily Avg | Expected yr rt |
|---|---|---|---|
| Cipla | 29.58% | 0.06% | 15.49% |
| Idea | 5.22% | 0.57% | 142.42% |
| Wonderla | 30.22% | 0.06% | 14.45% |
| PVR | 16.47% | 0.15% | 38.86% |
| Alkem | 18.51% | 0.29% | 72.73% |

Expected Port Return 36.25%
Annual Port Varience 15.57%

## Step 3 – Select the weights

The next step is to ensure that we tell the solver tool that we want to optimize the portfolio for maximum return by varying the weights. This is very similar to what we did in the previous chapter.



| | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| Cipla | 1.0 | 0.10715052 | 0.14368425 | 0.13434778 | 0.22858556 |
| Idea | 0.10715052 | 1.0 | 0.07499042 | 0.03363225 | 0.06024903 |
| Wonderla | 0.14368425 | 0.07499042 | 1.0 | 0.12484625 | 0.09557120 |
| PVR | 0.13434778 | 0.03363225 | 0.12484625 | 1.0 | 0.07085759 |
| Alkem | 0.22858556 | 0.06024903 | 0.09557120 | 0.07085759 | 1.0 |

**Weights & weight SD**

| Stock | Weight | Wt.SD |
|---|---|---|
| Cipla | 29.58% | 0.442% |
| Idea | 5.22% | 0.175% |
| Wonderla | 30.22% | 0.471% |
| PVR | 16.47% | 0.333% |
| Alkem | 18.51% | 0.343% |
| Total Weight | 100.00% | |

M1

| | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|
| | 0.006445988 | 0.00287887 | 0.00616928 | 0.004760678 | 0.005185249 |

M2
9.62277E-05

**Portfolio Variance**
0.98%

Do note, the weights here are the variable cells.

**Step 4 – Set the constraints**

Now, here is the important part of the optimization where we set the constraints. We now tell solver that we need to maximize the returns @ 17% risk, by varying the investment weights. We do these while keeping the following two constraints –

1. The total weights add up to 100%
2. The Portfolio risk is fixed to 17%

The constraints section now looks like this –



With these constraints loaded and rest of the parameters specified, we can go ahead and click on 'solve' to figure out the maximum return possible @ 17%, along with the respective weights.

The result upon optimization is as follows –

**Expected Stock Returns**

| Stock | Weight | Daily Avg | Expected yr rt |
|-------|--------|-----------|----------------|
| Cipla | 16.04% | 0.06% | 15.49% |
| Idea | 14.78% | 0.57% | 142.42% |
| Wonderla | 20.35% | 0.06% | 14.45% |
| PVR | 18.05% | 0.15% | 38.86% |
| Alkem | 30.77% | 0.29% | 72.73% |

| | |
|---|---|
| Expected Port Return | 55.87% |
| Annual Port Varience | 17.00% |
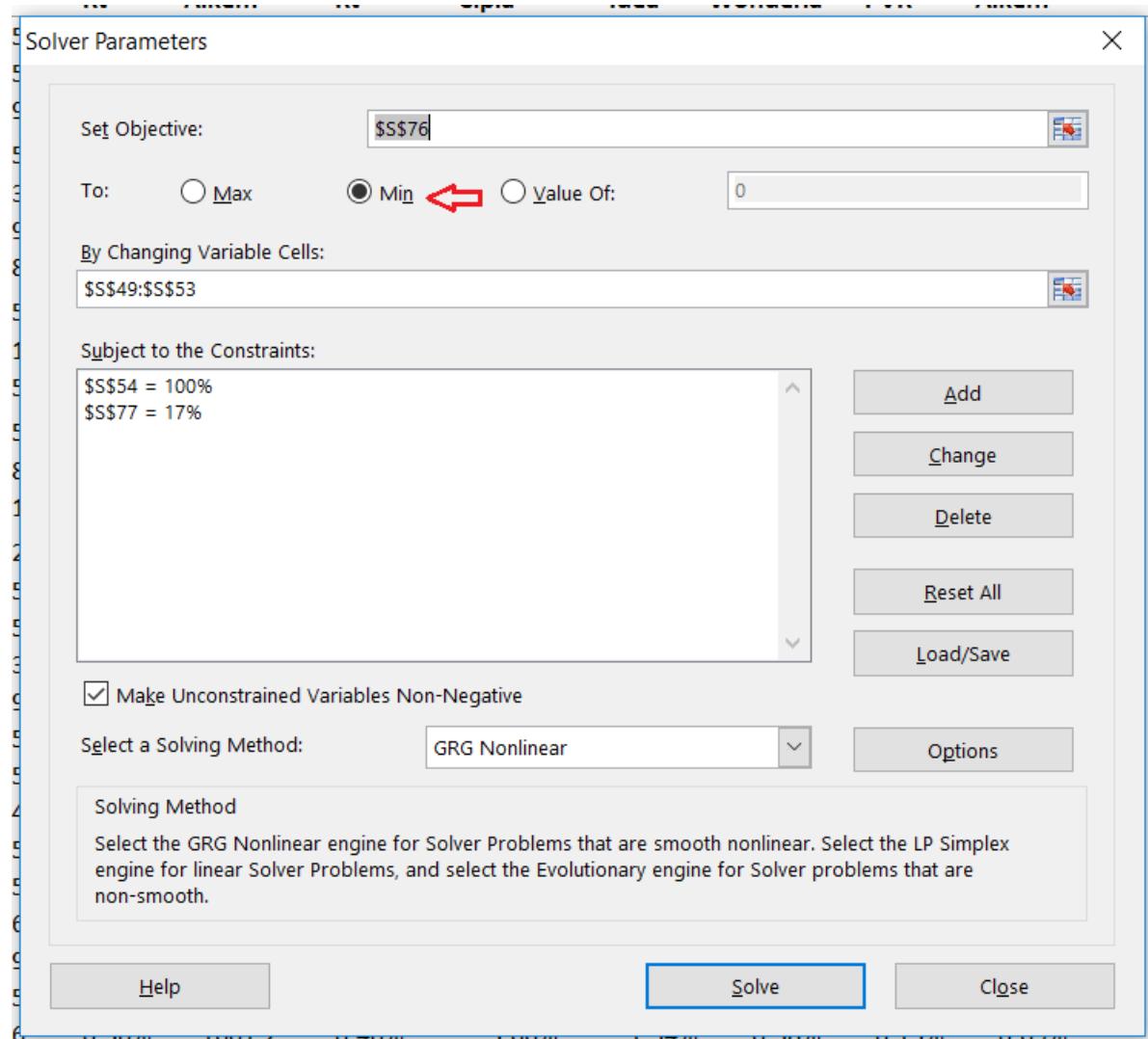
The maximum possible returns @17% portfolio variance happens to be 55.87%. However, to achieve this, the weights are as show above. Notice how the weights for this portfolio has changes when compared to the minimum variance portfolio.

We will now proceed to figure out the minimum return possible for the same fixed amount of risk, which is 17% in our case. Before we proceed, here is a table that I'm compiling of all the various portfolios that we are building, along with its respective weights and risk return characteristics.

| Portfolio | Risk | Return | Cipla | Idea | Wonderl | PVR | Alkem |
|-----------|------|--------|-------|------|---------|-----|-------|
| P1 - Min Var | 15.57% | 36.25% | 29.58% | 5.22% | 30.22% | 16.47% | 18.51% |
| P2 - max risk @ 17% | 17% | 55.87% | 16.04% | 14.78% | 20.35% | 18.05% | 30.77% |
| P3 - Min risk @ 17% | 17.00% | | | | | | |

We are now working on portfolio 3 (P3), which is the minimum risk possible for a fixed risk of 17%. Here is the solver tool, fully loaded and ready to be optimized.

Solver Parameters dialog box

- Set Objective: $S$76
- To: ○ Max  ● Min  ← ○ Value Of: 0
- By Changing Variable Cells: $S$49:$S$53
- Subject to the Constraints:
  - $S$54 = 100%
  - $S$77 = 17%
- ☑ Make Unconstrained Variables Non-Negative
- Select a Solving Method: GRG Nonlinear

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Notice, while other variables remain the same, the objective is shifted to minimize from maximize. Upon optimization, the return is now minimized to 18.35%. Clearly, for the same given risk, we have now established two unique portfolios with different possible return characteristics, all these while just changing the investment weights in the stocks.

Here are the three unique portfolios that we have generated so far –

| Portfolio | Risk | Return | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|---|---|
| P1 - Min Var | 16% | 36% | 30% | 5% | 30% | 16% | 19% |
| P2 - max risk @ 17% | 17% | 56% | 16% | 15% | 20% | 18% | 31% |
| P3 - Min risk @ 17% | 17% | 18% | 45% | 0% | 41% | 13% | 0% |

Just to recall – P1 is the minimum variance portfolio, P2 max risk @17%, and P3 is min risk at 17%.

## 9.3 – Efficient Frontier
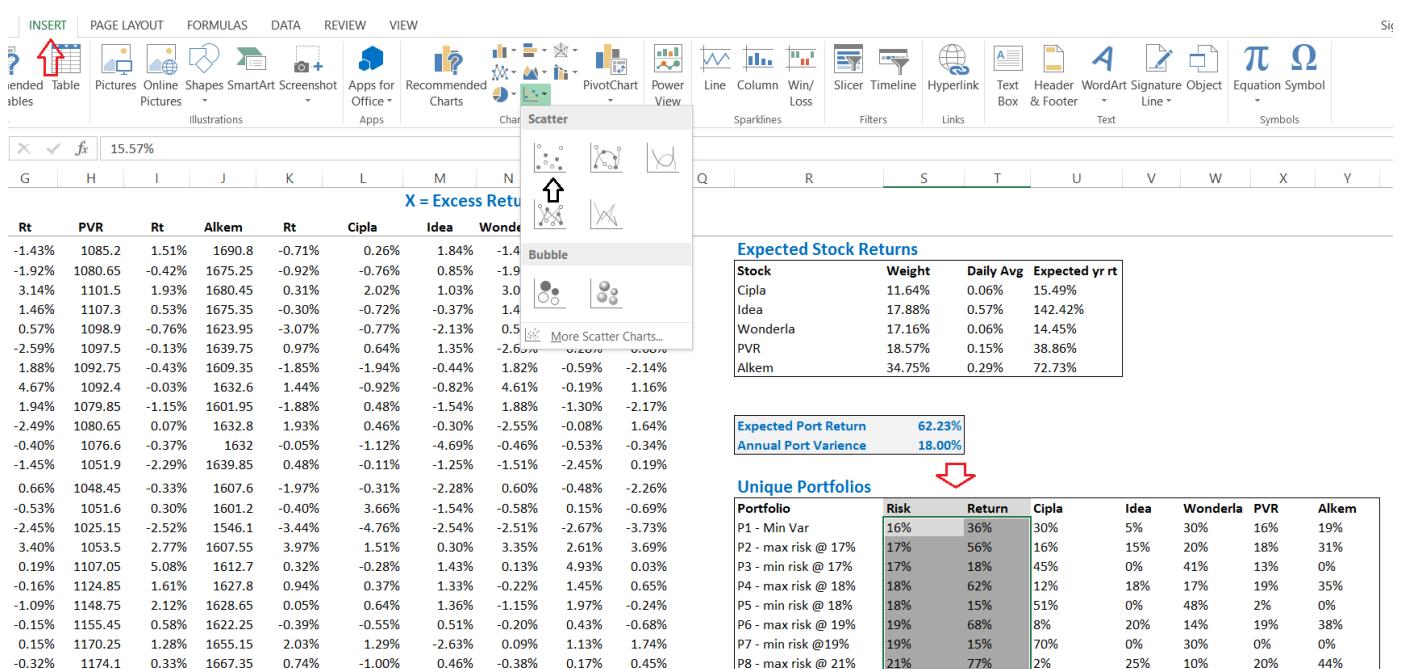
As discussed earlier, we can now increase the risk a notch higher to maybe 18%, 19%, and 21% and identify the maximum and minimum risk at both these risk levels. Remember, our end objective is attain a scatter plot of the risk and return profile and study its characteristics. I've gone ahead and optimized the portfolios for all the risk points, and at each point, I've identified the maximum and minimum return possible. Please note, I've rounded off the decimal values here, just so that the table looks pretty

### Unique Portfolios
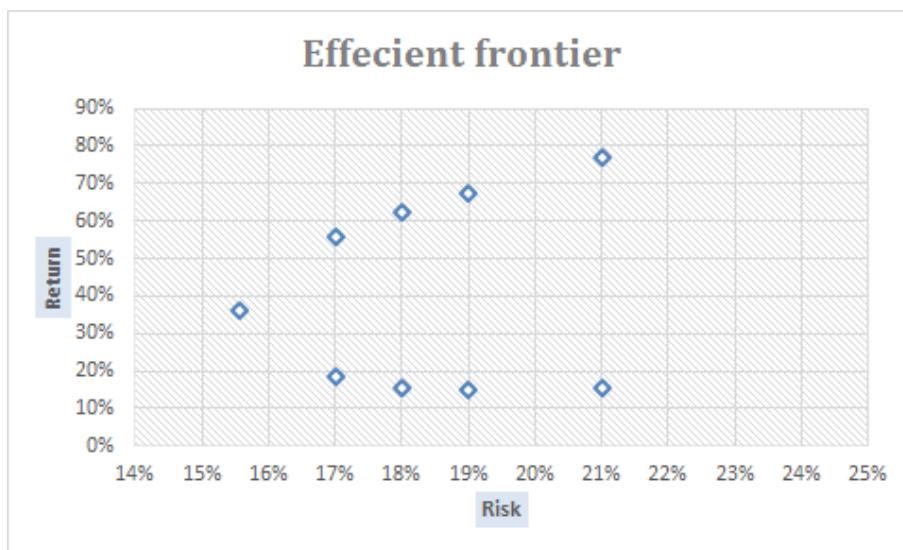
| Portfolio | Risk | Return | Cipla | Idea | Wonderla | PVR | Alkem |
|---|---|---|---|---|---|---|---|
| P1 - Min Var | 16% | 36% | 30% | 5% | 30% | 16% | 19% |
| P2 - max risk @ 17% | 17% | 56% | 16% | 15% | 20% | 18% | 31% |
| P3 - min risk @ 17% | 17% | 18% | 45% | 0% | 41% | 13% | 0% |
| P4 - max risk @ 18% | 18% | 62% | 12% | 18% | 17% | 19% | 35% |
| P5 - min risk @ 18% | 18% | 15% | 51% | 0% | 48% | 2% | 0% |
| P6 - max risk @ 19% | 19% | 68% | 8% | 20% | 14% | 19% | 38% |
| P7 - min risk @19% | 19% | 15% | 70% | 0% | 30% | 0% | 0% |
| P8 - max risk @ 21% | 21% | 77% | 2% | 25% | 10% | 20% | 44% |
| P9 - min risk @ 21% | 21% | 15% | 86% | 0% | 14% | 0% | 0% |

If you notice, I've highlighted the risk and return values of each portfolios. I'll now go ahead and plot a scatter plot of these data points and see, what I can see.

To plot a scatter plot, simply select the data points and opt for the scatter plot under the insert ribbon. This is how it looks –
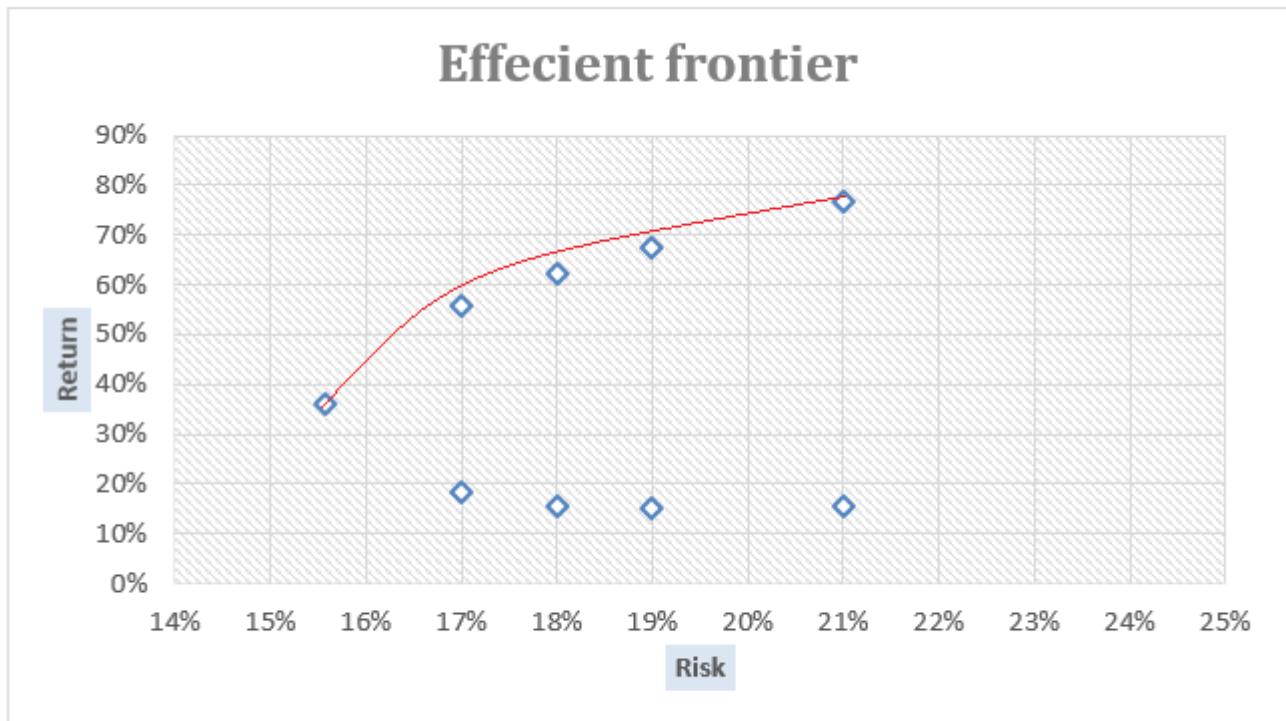
Once you click on the scatter plot, you will be able to see the how the plot appears. Here is how it looks, of course, I've tried to format the graph to make it look more presentable.



This curve that you see above my friend, is called the 'efficient frontier' of this portfolio. So what do we understand from this curve and why is it so important? Well, quite a few things, lets deal with it one by one –

1. As you can see, the X-axis represents risk and the Y-axis represents returns
2. Starting from the left most point, the one which seems to be a little isolated from the rest, represents the minimum variance portfolio. We know this portfolio has a risk of 15.57% with a return of 36.25%.
3. We now move focus to 17% risk (notice the x axis), you can find two plots, one at 18.35% and another at 55.87% – what does this tell you?
   1. It tells us that at 17% risk (or when we are particular about fixing the risk at 17%), the best possible portfolio can achieve a return of 55.87%
   2. The worst possible portfolio (in terms of return) is 18.35%
   3. In simple terms, when you fix a level of risk you are comfortable, you should aim to maximize the return
   4. There are multiple other portfolios that are possible between 18.35% and 55.87% (when we fix risk at 17%) these would be represented as plots between the minimum and maximum return. All these portfolios are considered inefficient, the minimum return portfolio being the worst amongst the rest
   5. So as an investor, your aim should be to maximum the return, especially when you have some clarity on how much risk you are willing to bear
4. You can notice the same behavior for risks at 18%, 19%m and 21%

5.  The best possible portfolios, or in other words, the efficient portfolio will always lie on the line above the minimum variance portfolio. This line is highlighted below



So, you as an investor, should always aim to create a portfolio, which lies on the efficient frontier, and as you may realize, creating this portfolio is merely a function of rearranging weights as per the results obtained in portfolio optimization.

Think about it – when you risk your money, you obviously want the best possible return, right? This is exactly what the curve above is trying to convey to us. Its prompting us to create portfolios more efficiently.

In the next chapter, we will take a quick look at a concept called "Value at risk" and then proceed to understanding risk from a trader's perspective.

You can **download** the excel sheet used in this chapter.

**Key takeaways from this chapter**

1. A portfolio with certain weights to each stock is considered unique
2. When we fix the desired level of risk, we can optimize the portfolio to yield the minimum return and maximum return portfolios
3. Between the min and max return portfolio (for a given fixed level of risk), we can have multiple unique portfolios
4. The scatter plot of risk and return gives us the efficient frontier
5. For a given level of risk, the best possible portfolio one can construct would lie on the efficient frontier, all other portfolios are deemed inefficient

# Value at Risk

## 10.1 – Black Monday

Let's start this chapter with a flashback. For many of us, when we think of the 70's, we can mostly relate to all the great rock and roll music being produced from across the globe. However, the economists and bankers saw the 70's very differently.
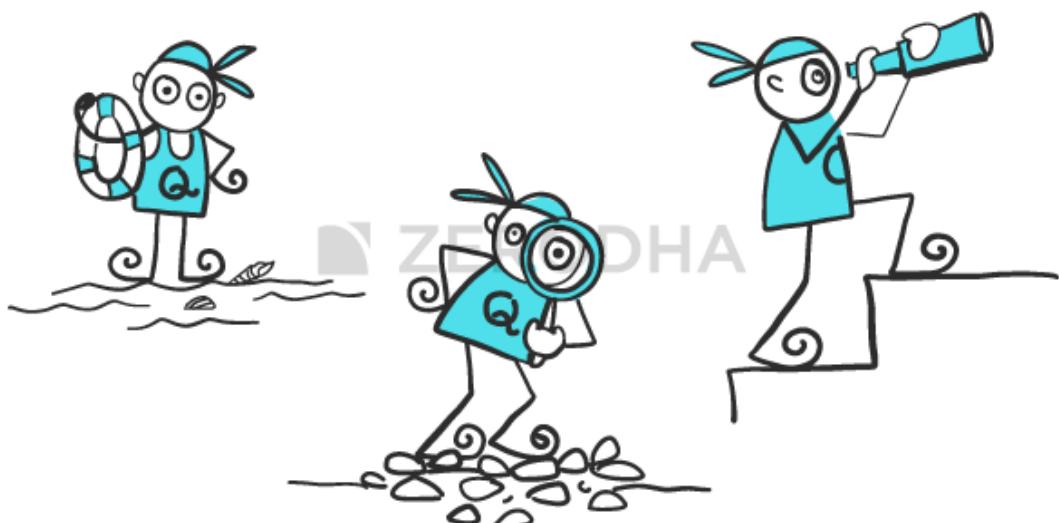
The global energy crisis of 70's had drawn the United States of America into an economic depression of sorts. This lead to a high inflationary environment in the United States followed by elevated levels of unemployment (perhaps why many took to music and produced great music). It was only towards the late 70's that things started to improve again and the economy started to look up. The Unites States did the right things and took the right steps to ease the economy, and as a result starting late seventies / early eighties the economy of United States was back on track. Naturally, as the economy flourished, so did the stock markets.

Markets rallied continuously starting from the early 1980s all the way to mid-1987. Traders describe this as one of the dream bull runs in the United Sates. Dow made an all-time high of 2,722 during August 1987. This was roughly a 44% return over 1986.  However, around the same time, there were again signs of a stagnating economy. In economic parlance, this is referred to as 'soft landing' of the economy, where the economy kind of takes a breather. Post-August 1987's peak, the market started to take a breather. The months of Aug, Sept, Oct 1987, saw an unprecedented amount of mixed emotions. At every small correction, new leveraged long positions were taken. At the same time, there was a great deal of unwinding of positions as well. Naturally, the markets neither rallied nor corrected.

While this was panning on the domestic front, trouble was brewing offshore with Iran bombing American super tankers stationed near Kuwait's oil port. The month of October 1987, was one of its kind in the history of financial markets. I find the sequence of events which occurred during the 2nd week of October 1987 extremely intriguing, there were way too much drama and horror panning out across the globe –

- 14<sup>th</sup> Oct 1987 (Wednesday) – Dow dropped nearly 4%, this was a record drop during that period

- 15<sup>th</sup> Oct 1987 (Thursday) – Dow dropped another 2.5%. Dow was nearly 12% down from the August 1987's high. On the other side of the globe, Iran attacked an American super tanker stationed outside Kuwait's oil port, with a Silkworm missile

- With these two events, there were enough fear and panic spread across the global financial markets

- 16<sup>th</sup> Oct 1987 (Friday) – London was engulfed by an unexpected giant storm, winds blowing at 175 KMPH caused blackouts in London (especially the southern part, which is the financial hub). London markets were officially closed. Dow opened weak, and crashed nearly 5%, creating a global concern. Treasury Secretary was recorded stating economic concerns. Naturally, this would add more panic

- 19<sup>th</sup> Oct 1987 (**Black Monday**) – Starting from the Hong Kong, markets shaved off points like melting cheese. Panic spread to London, and then finally to the US. Dow recorded the highest ever fall with close 508 or 22.61% getting knocked off on a single day, quite naturally attracting the Black Monday tile.

The financial world had not witnessed such dramatic turn of events. This was perhaps the very first few 'Black Swan' events to hit word hard. When the dust settled, a new breed of traders occupied Wall Street, they called themselves, "The Quants".

## 10.2 – The rise of quants

The dramatic chain of events of October 1987 had multiple repercussion across the financial markets. Financial regulators were even more concerned about system wide shocks and firm's capability to assess risk. Financial firms were evaluating the probability of a 'firm-wide survival' if things of such catastrophic magnitude were to shake up the financial system once again. After all, the theory suggested that 'October 1987' had a very slim chance to occur, but it did.

It is very typical for financial firms to take up speculative trading positions across geographies, across varied counterparties, across varied assets and structured assets. Naturally, assessing risk at such level gets nothing short of a nightmarish task. However, this was exactly what the business required. They needed to know how much they would stand to lose, if October 1987 were to repeat. The new breed of traders and risk mangers calling themselves 'Quants', developed highly sophisticated mathematical models to monitor positions and evaluate risk level on a real-time basis. These folks came in with doctorates from different backgrounds – statisticians, physicist, mathematicians, and of course traditional finance. Firms officially recognized 'Risk management' as an important layer in the system, and risk management teams were inducted in the 'middle office' segment, across the banks and trading firms on Wall Street. They were all working towards the common cause of assessing risk.

Then CEO of JP Morgan Mr.Dennis Weatherstone, commissioned the famous '4:15 PM' report. A one-page report which gave him a good sense of the combined risk at the firm-wide level. This report was expected at his desk every day 4:15 PM, just 15 minutes past market close. The report became so popular (and essential) that JP Morgan published the methodology and started providing the necessary underlying parameters to other banks. Eventually, JP Morgan, spun off this team and created an independent company, which goes by the name 'The Risk Metrics Group', which was later acquired by the MSCI group.

The report essentially contained what is called as the 'Value at Risk' (VaR), a metric which gives you a sense of the worst case loss, if the most unimaginable were to occur tomorrow morning.

The focus of this chapter is just that. We will discuss Value at Risk, for your portfolio.

## 10.3 – Normal Distribution

At the core of Value at Risk (VaR) approach, lies the concept of normal distribution. We have touched upon this topic several times across multiple modules in Varsity. For this reason, I will not get into explaining normal distribution at this stage. I'll just assume you know what we are talking about. The Value at Risk concept that we are about to discuss is a 'quick and dirty' approach to estimating the portfolio VaR. I've been using this for a few years now, and trust me it just works fine for a simple 'buy and hold' equity portfolio.

In simple words, Portfolio VaR helps us answer the following questions –

1. If a black swan event were to occur tomorrow morning, then what is the worst case portfolio loss?
2. What is the probability associated with the worst case loss?

Portfolio VaR helps us identify this. The steps involved in calculating portfolio VaR are very simple, and is as stated below –

1. Identify the distribution of the portfolio returns
2. Map the distribution – idea here to check if the portfolio returns are 'Normally distributed'
3. Arrange portfolio returns from ascending to descending order
4. Observe out the last 95% observation
5. The least value within the last 95% is the portfolio VaR
6. Average of the last 5% is the cumulative VaR or CVar
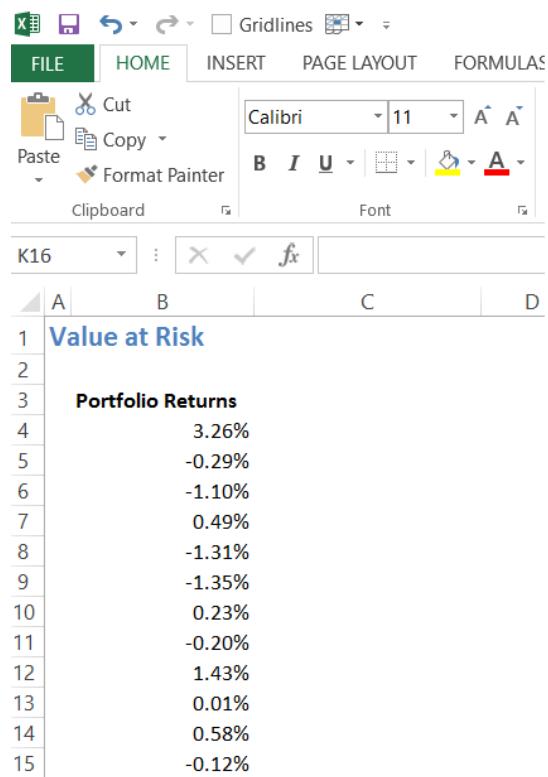
Of course, for better understanding, let us apply this to the portfolio we have been dealing with so far and calculate its Value at Risk.

## 10.4 – Distribution of portfolio returns

In this section, we will concentrate on the first two steps (as listed above) involved in calculating the portfolio VaR. The first two steps involve us to identify the distribution of the portfolio returns. For this, we need to deal with either the normalized returns or the direct portfolio returns. Do recall, we have already calculated the normalized returns when we discussed the 'equity curve'. I'm just using the same here –

| Q | R |
|---|---|
| **Starting Value** | ⬇ |
| **100** | **Daily Rt** |
| 100.000 | |
| 103.257 | 3.26% |
| 102.962 | -0.29% |
| 101.827 | -1.10% |
| 102.326 | 0.49% |
| 100.990 | -1.31% |
| 99.629 | -1.35% |
| 99.853 | 0.23% |
| 99.650 | -0.20% |
| 101.078 | 1.43% |
| 101.084 | 0.01% |
| 101.671 | 0.58% |

You can find these returns in the sheet titled 'EQ Curve'. I've copied these portfolio returns onto a separate sheet to calculate the Value at Risk for the portfolio. At this stage, the new sheet looks like this –



Remember, our agenda at this stage is to find out what kind of distribution the portfolio returns fall under. To do this, we do the following –

**Step 1** – From the given time series (of portfolio returns) calculate the maximum and minimum return. To do this, we can use the '=Max()' and '=Min()' function on excel.

## Value at Risk

**Portfolio Returns**

| | | |
|---|---|---|
| 3.26% | | |
| -0.29% | Max | 3.26% |
| -1.10% | Min | -2.82% |
| 0.49% | | |
| -1.31% | | |
| -1.35% | | |
| 0.23% | | |
| -0.20% | | |
| 1.43% | | |

**Step 2** – Estimate the number of data points. The number of data points is quite straight forward. We can use the '=count ()' function for this.

## Value at Risk

**Portfolio Returns**

| | | |
|---|---|---|
| 3.26% | | |
| -0.29% | Max | 3.26% |
| -1.10% | Min | -2.82% |
| 0.49% | Count | 126 |
| -1.31% | | |
| -1.35% | | |

There are 126 data points, please do remember we are dealing with just last six months data for now. Ideally speaking, you should be running this exercise on at least 1 year of data. But as of now, the idea is just to push the concept across.

**Step 3** – **Bin width**

We now have to create 'bin array' under which we can place the frequency of returns. The frequency of returns helps up understand the number of occurrence of a particular return. In simple terms, it helps us answer 'how many times a return of say 0.5% has occurred over the last 126 day?'. To do this, we first calculate the bin width as follows –

Bin width = (Difference between max and min return) / 25

I've selected 25 based on the number of observations we have.

= (3.26% – (-2.82%))/25

=0.002431

**Step 4** – **Build the bin array**

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This is quite simple – we start form the lowest return and increment this with the bin width. For example, lowest return is -2.82, so the next cell would contain

= -2.82 + 0.002431

= – 2.58

We keep incrementing this until we hit the maximum return of 3.26%. Here is how the table looks at this stage –



And here is the full list –

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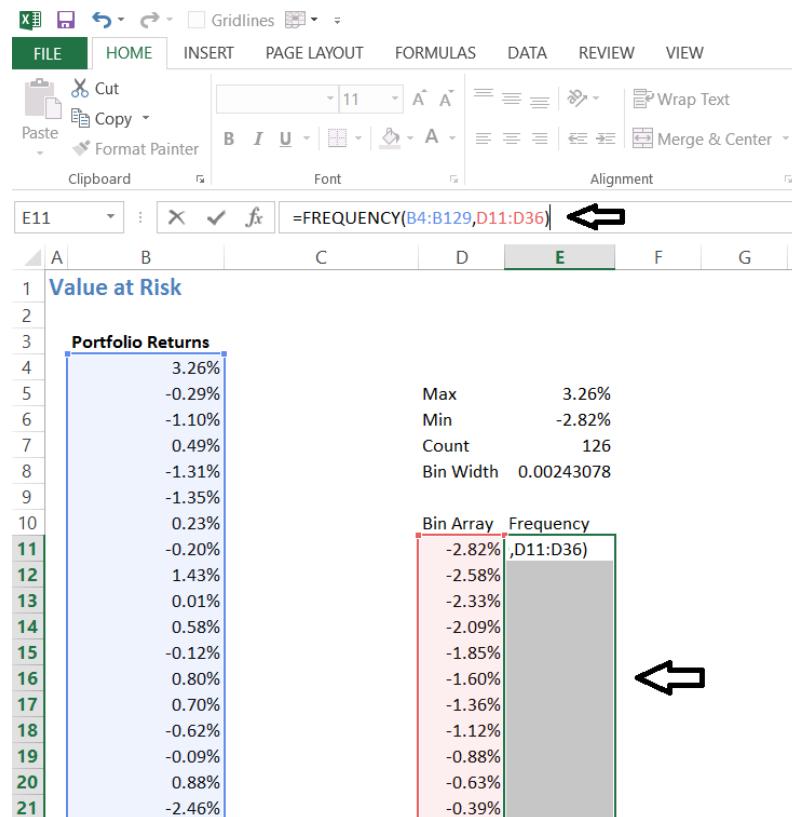
| Bin Array |
|-----------|
| -2.82% |
| -2.58% |
| -2.33% |
| -2.09% |
| -1.85% |
| -1.60% |
| -1.36% |
| -1.12% |
| -0.88% |
| -0.63% |
| -0.39% |
| -0.15% |
| 0.10% |
| 0.34% |
| 0.58% |
| 0.83% |
| 1.07% |
| 1.31% |
| 1.56% |
| 1.80% |
| 2.04% |
| 2.28% |
| 2.53% |
| 2.77% |
| 3.01% |
| 3.26% |

We now have to calculate the frequency of these return occurring within the bin array. Let me just present the data first and then explain what is going on –

| Bin Array | Frequency |
|-----------|-----------|
| -2.82% | 1 |
| -2.58% | 0 |
| -2.33% | 2 |
| -2.09% | 2 |
| -1.85% | 2 |
| -1.60% | 0 |
| -1.36% | 1 |
| -1.12% | 4 |
| -0.88% | 8 |
| -0.63% | 10 |
| -0.39% | 11 |
| -0.15% | 12 |
| 0.10% | 9 |
| 0.34% | 11 |
| 0.58% | 13 |
| 0.83% | 10 |
| 1.07% | 11 |
| 1.31% | 4 |
| 1.56% | 2 |
| 1.80% | 5 |
| 2.04% | 2 |
| 2.28% | 1 |
| 2.53% | 2 |
| 2.77% | 0 |
| 3.01% | 2 |
| 3.26% | 0 |

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I've used the '=frequency ()', function on excel to calculate the frequency. The first row, suggests that out of the 126 return observation, there was only 1 observation where the return was -2.82%. There were 0 observations between -2.82% and 2.58%. Similarly, there were 13 observations 0.34% and 0.58%. So on and so forth.

To calculate the frequency, we simply have to select all the cells next to Bin array, without deselecting, type =frequency in the formula bar and give the necessary inputs. Here is the image of how this part appears –
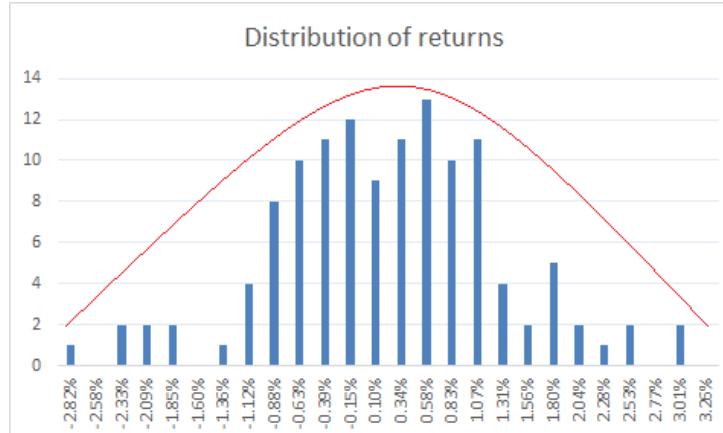


Do remember to hit 'Ctrl + shift + enter' simultaneously and not just enter. Upon doing this, you will generate the frequency of the returns.

**Step 5** – **Plot the distribution**

This is fairly simple. We have the bin array which is where all our returns lie and next to that we have the frequency, which is the number of times a certain return has occurred. We just need to plot the graph of the frequency, and we get the frequency distribution. Our job now is to visually estimate if the distribution looks like a bell curve (normal distribution) or not.

To plot the distribution, I simply have to select the all the frequency data and opt for a bar chart. Here is how it looks –

Distribution of returns

Clearly what we see above is a bell-shaped curve, hence it is quite reasonable to assume that the portfolio returns are normally distributed.

## 10.5 – Value at Risk

Now that we have established that the returns are normally distributed, we proceed to calculate the Value at Risk. From here on, the process is quite straightforward. To do this, we have to reorganize the portfolio returns from the ascending to descending order.



I've used excels sort function to do this. At this stage, I will go ahead and calculate Portfolio VaR and Portfolio CVaR. I will shortly explain, the logic behind this calculation.

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Portfolio VaR – is defined as the least value within 95% of the observation. We have 126 observations, so 95% of this is 120 observations. Portfolio VaR is essential, the least most value within the 120 observations. This works out to be **-1.48%.**

I take the average of the remaining 5% of the observation, i.e the average of the last 6 observations, and that is the Cumulative VaR of CVaR.

The CVaR works out to **-2.39%.**

You may have many questions at this stage, let me list them down here along with the answers –

1. Why did we plot the frequency distribution of the portfolio?
   1. To establish the fact that the portfolio returns are normally distributed
2. Why should we check for normal distribution?
   1. If the data we are studying is normally distributed, then we can characteristics of normal distribution is applicable to the data set
3. What are the characteristics of normally distributed data?
   1. There are quite a few, but you should specifically know that 68% of the data lies within 1 SD, 95% of the data within $2^{nd}$, and 99.7% of the data lies within the $3^{rd}$ I'd suggest you read **this chapter** to know more about the normal distribution.
4. Why did we sort the data?
   1. We have established that the data set is normally distributed. Do remember, we are only interested in the worst case scenario. Given this, when we sort it from highest to lowest, we are essentially in a position to look at the returns in a more systematic way.
5. Why did bother to take only 95% observation?
   1. Remember, according to the normal distribution theory, 95% of the data lies within the $2^{nd}$ standard deviation. This means on any random day, the return on the portfolio is likely to be any value within the 95% of the observations. Therefore, quite naturally the least most value within the 95% observation should represent the worst case loss or the Value at Risk.
6. What does the VaR of -1.48% indicate?
   1. It tells that the worst case loss for the given portfolio is -1.49% and we can conclude this with a confidence of 95%
7. Can't the loss not exceed -1.48%?
   1. Yes, it certainly can and this is where CVaR comes into play. In the case of an extreme event, there is a 5% chance that the portfolio could experience a loss of -2.39%.
8. Can't the loss exceed beyond -2.89%?

1. Yes, it can but the probability of this occurring is quite very low.

I hope the above discussion makes sense, do apply this on your equity portfolio and I'm sure you will gain a greater insight into how your portfolio is positioned.

We have discussed quite a few things with respect to the portfolio and the risk associated with it. We will now proceed to understand risk with respect to trading positions.

**Download** the Excel workbook used in this chapter.

**Key takeaways from this chapter**

1. Events which have a very low probability of occurrence is called 'Black Swan 'events
2. When a black swan event occurs, a portfolio can experience higher levels of losses
3. Value at Risk is one approach to estimate the worst case loss if a black swan event were to occur
4. We can estimate the portfolio VaR by studying the distribution of the portfolio returns
5. The average of the last 5% of the observation gives us the Value at Risk of the portfolio.

# Position Sizing for active trader



## 11.1 – Poker face

Last month I got an opportunity to play poker with a few good friends. I was playing poker after a gap of 6 years and I was quite excited about it. The buy in for this friendly game was Rs.1000/. For those who are not familiar with poker – it's a card game where in your skill and luck are tested in equal measure.

So, the game started, cards were dealt, and in the very first round I bet Rs.200/- and I saw it go away, just like that. In the next round, I bet another 200, and again saw it go away. At this stage I convinced myself that I could make up my losses in the 3$^{rd}$ round, and with this thought I increased the bet size to 600, only to watch it go away! So for all practical purposes, I lost Rs.1000/- in a matter of 10 minutes! In the trading world, this is equivalent to blowing up your entire trading account.

I didn't give up, after all, I'm supposed to know trading and poker draws many similarities to trading. I decided to 'recover' my initial loss and stay in the game longer. I bought in for another 1000 and started fresh. This time, I stayed on the table a bit longer – for a total of 15 minutes!

Clearly, it was not working for me. I had a better memory of me playing poker 6 years ago. Though not the best, at least, I would stay on the table till the game lasted and even win few hands. So what was happening this time around? I was confused and I kind of didn't believe that this was happening to me? How could I wipe my account twice in a matter of 25 minutes?

With these confusing thoughts on my past poker skills and my current game play, I decided to buy in again for another 1000 Rupees. This was my 3$^{rd}$ buy in. In the trading world, this is equivalent to funding your account 3$^{rd}$ time over after successfully blowing it up twice.

What advice would you give someone who has blown up his account twice in the markets? – 'get out of the markets immediately', would perhaps be the best-suited advice right? Well, I dint pay any heed to my inner voice, gambler's fallacy had taken over my rational thinking abilities and I bought in again for 1000 Rupees more.

For those of you who don't know gambler's fallacy – if you are betting on an outcome and you tend to make a long streak of losses, then at the time of quitting, your mind tells you or rather tricks you to believe that your losing streak is over and your next bet will be a winner. This is when you increase your betting size and lose a bigger chunk of money. Gamblers fallacy is one of the biggest culprits in wiping out many trading accounts clean.

Anyway, back to my poker game. This was my 3$^{rd}$ buying, I had already lost 2K and was betting with another 1K. I was confident I'd recover plus make some money and save myself some shame, but the boys on the table had other plans for me. They knew I was the sucker on the table and it was easy to allure me to make irrational bets. So they did and wiped me out clean over the next 7 minutes.

That was it, I called it quits and I got back more after losing 3k.

After the game, I thought through on what went wrong. The answer was very clear –

1. I had forgotten to recognize the odds of winning with the cards that were dealt
2. I was not 'position sizing' my bets – my bets were way too irrational and random

After a couple of weeks, I had another invite to the game. I had set a bad precedence of giving away easy money. This time around I had decided to position size my bets well.

I bought in for 1000 and started the game. Each time the cards were dealt – I accessed my odds fairly well and if I thought my odds were fair, I bet accordingly. In the trading world, this

was equivalent to following a 'trading system' backed by position sizing techniques. The result of this simple systematic approach had a great impact on my game –

1. I won few hands
2. At the peak, I must have had about 4K of winnings
3. I lasted throughout the game and had a lot of fun along the way
4. Towards the end I gave up some gains but was extremely happy with the fact that few simple techniques helped me manage my game much better

Position sizing made all the difference in this game. It always does and this is the exact reason for me to narrate this story. I do not want you to speculate in the markets without understanding your odds or without position sizing your bets. If you do, you will end up making a fool out of yourself.

Poker is played for fun but when you trade, you are essentially deploying your capital for a more serious and meaningful outcome. So please do pay attention to some of the things we will discuss over the next few chapters. I'm certain it will have a positive impact in your trading career.

At this point I have to mention this – I myself learned position sizing many years ago by reading Van Tharp's books. Van Tharp is one of the most prominent people to bring in the concept of position sizing to traders. I'd even recommend you buy some of his books to expand your knowledge on this subject.

## 11.2 – Gambler's fallacy

We briefly discussed the gambler's fallacy early on. I guess it makes sense to discuss a little more on this at the very beginning especially in the context of markets.

Take a look at this chart –

This is the chart of Nifty – Nifty hit the magical number of 10,000 on 25th July 2017. As a trader, how would you trade this?

1. Nifty is at an all-time high – 10K
2. Many market participants may book profits at this point – considering it is a psychological level
3. All time high implies no resistance points
4. Nifty has been in a great up wards trend over the past few weeks
5. Maybe Nifty would consolidate around these levels?
6. Maybe a correction of 2-3% before the rally continues?

Let us just assume that these are some valid points for now. This means a short position is justified or for that matter buying of puts. Your analysis could be as simple as this or as sophisticated as studying the time series data and modeling the same using advanced statistical or machine learning models.

Irrespective of what you do – there is no certainty in the markets. No one technique will tell you the outcome in advance. This implies that we are dealing with fairly random draws here. Of course, based on how meaningful your analysis is, your odds of winning can improve, but at the end of the day, there is no certainty and you have to acknowledge the fact that markets are indeed random.

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Now imagine this – you have done a state of the art analysis and you place your bet on Nifty only to see the stop loss trigger. You do not give up, you place another trade and to your misfortune, you are stopped out again. This cycle repeats for say the next 4 trades.

You know your analysis is bang on – but then your stop loss is continuously getting triggered. You still have money in your account to take on bets, you are still convinced that your analysis is rock solid and the markets will turn around, you still have an appetite for risk – given all these, what do you do?

1. Would you stop trading?
2. Would you risk the same amount of money again?
3. Now that you have lost 6 consecutive bets, would you consider that your odds of making money on the 7th trade is higher and therefore increase your bet size to recover your previous losses plus reap in some profits?

Which option are you likely to take? Take a minute and answer this question honestly to yourself.

Having been through this situation myself and having interacted with many traders let me tell you – most traders would take the 3rd option, the question however is – why?

Traders tend to believe that long streaks will cease when they take the 'next' trade. For instance, in this case, the trader has faced 6 consecutive losses, but at this point his conviction that the 7 trade will be a winner is very high. This is called 'Gambler's fallacy'.

In reality, when you are dealing with random draws, the odds of making a loss on the 7th trade is as high (or low) as it was when you placed your first bet. Just because you have made a series of losses, the odds of making money on the next trade does not improve.

Traders fall prey to 'Gamblers fallacy' and often end up increasing their bet sizes without understanding how the odds stack up. In fact, gamblers fallacy ruins your position sizing philosophy and therefore is the biggest culprit in wiping out trading accounts.

This works on the other side as well. Imagine, that you are fortunate enough to witness a 6 or let us say 10 consecutive wins. Whatever you bet on, the trade works out in your favor. You are on your 11th trade now, which of the following are you likely to do?

1. Considering that you made enough money, would you stop trading?
2. Would you risk the same amount again?

3. Would you increase your bet size?
4. Will you take a conservative approach, maybe protect you profits, and therefore reduce your bet size?

Chances are that you will take the 4th option. You clearly want to protect your profits and do not want to give back whatever you have earned in the markets and at the same time you would want to take a trade considering you have had a great winning streak.

This is again 'gamblers fallacy' at play. Being completely influenced by the outcome of the previous 10 trades, you are essentially reducing your position size for the 11th trade. In reality, this new trade has a same odds of winning or losing as the previous 10 bets.

Perhaps, this explains why some of the traders, even though get into profitable trading cycle end up making very little money.

The antidote for 'Gambler's Fallacy', is position sizing.

## 11.3 – Recovery trauma

In the trading world, the capital we bring on the table is the raw material. If you do not have enough money to trade with, then how will you make a profit? Hence we need to not just protect the profits that we make, but also protect the capital.

Extending this thought – if you risk too much capital on any one trade, then you stand a chance to risk your capital to an extent that you may burn your capital leaving you with very little money. Now if you are trading with very little money, then every trade that you take will appear to be too risky. The climb back to where you started will (in terms of capital) will be a Herculean task.

I have prepared a table to help you understand this fact. Assume you have a trading capital of Rs.100,000/-. Let us see how the numbers stack up with –

| Starting Capital | | 100,000 |
| --- | --- | --- |

| Drawdown | Starting Capital | Efforts |
| --- | --- | --- |
| 5% | 95,000 | 5.3% |
| 10% | 90,000 | 11.1% |
| 15% | 85,000 | 17.6% |
| 20% | 80,000 | 25% |
| 25% | 75,000 | 33% |
| 30% | 70,000 | 43% |
| 35% | 65,000 | 54% |
| 40% | 60,000 | 67% |
| 45% | 55,000 | 82% |
| 50% | 50,000 | 100% |
| 55% | 45,000 | 122% |
| 60% | 40,000 | 150% |
| 65% | 35,000 | 186% |
| 70% | 30,000 | 233% |
| 75% | 25,000 | 300% |
| 80% | 20,000 | 400% |
| 85% | 15,000 | 567% |
| 90% | 10,000 | 900% |
| 95% | 5,000 | 1900% |

You can download the excel sheet **here**.

Assume you lose 5% of your capital or Rs.5000/-. Your new starting capital is Rs.95,000/-. Now, in order to recover to Rs.5000 with a capital of 95000, you need to generate a return of 5.3%, which is 0.3% more than what you lost.

Now, instead of 5%, assume you lost 10% and your capital becomes 90000, now in order to recover 10000 or 10% of your original capital, you have to earn back 11.1%. As you can see, as the loss deepens, you will have to work really hard to bounce back to original starting capital. For example at 60% loss or original capital, you are staring at a 150% boun ce back.

Unfortunately, the 'recovery trauma' affects traders with smaller account size. Assume you come to the market with Rs.50,000/- capital. Now you would have heard of stories on how Rakesh Jhunjhunwala, grew his money from 10,000 to 15K Crores. You would want to replicate at least a small portion of this success. Honestly speaking, if you can manage to grow Rs.50,000/- to say Rs.60,000 by the end of the year, you would have done a great job. This translates to a 20% return. But this is not exciting, right? I mean earning Rs.10,000/- over 1 year when you are actively trading somehow does not seem right.

So what do you do? You tend to take bigger risks and hope to make bigger gains, and if the trade goes against you, then you are essentially falling prey to the 'recovery trauma' phenomena.

This is exactly the reason why you should never risk too much on any one trade, especially if you have a small capital. Remember, your odds of making good money in the markets is high if you can manage to stay in game for long, and to stay for a longer period, you need to have enough capital, and to have enough capital, you need to risk the right amount of money on each trade. This really boils down to working towards longer term 'consistency' in markets,  and to be consistent you need to position size your trades really well.

I'm going to close this chapter with a quote from **Larry Hite.**



I have two basic rules about winning in trading as well as in life. 1. If you don't bet, you can't win. 2. If you lose all your chips, you can't bet

Larry Hite

Over the next few chapter, we will dig deeper into position sizing techniques.

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**Key takeaways from this chapter**

1. Position sizing forms the corner stone of a trading system
2. Gamblers fallacy is a bias highly applicable to the trading world. It makes the trader believe that a long streak of a certain outcome can break
3. When there are infinite draws, the odds of making a profit or loss on the $N^{th}$ trade is similar to the odds of making the same profit or loss on the $1^{st}$ trade
4. The recovery of capital is much more difficult task than one can imagine
5. Traders with small accounts have a tendency to take larger bets, which they need to avoid

# CHAPTER 12

# Position Sizing for active traders (Part 2)

## 12.1 –Defining Equity Capital

The last chapter we laid down few key thoughts on position sizing and with that, I guess it is amply clear as to why one has to incorporate position sizing at the core of every trading strategy. Position sizing technique helps you identify how much of your equity capital has to be exposed for a given trade. In this chapter, we will take that discussion forward and explore ways to position size.

A quick recap of sorts before we proceed. What is position sizing?

Position sizing is all about answering how much capital you will expose to a particular trade given that you have 'x' amount of trading capital. One classic position sizing strategy which most people employ is the standard 5% rule. The 5% rule does not permit you to risk more than 5% of the capital on a given trade. For example, if the capital is Rs.100,000/-, then they will not risk more Rs.5000/- on any single trade.

Here 5000 is the exposure to a trade and 10000 is the equity capital. You have decided to invest 5000 a trade based on a position sizing rule or a strategy.

Needless to say, there are many different ways to position size, which by the way, also means (unfortunately) that there is no single guided technique to position size. You as a trader need to experiment and figure out what works for you. Of course, I will discuss few position sizing techniques soon.

Now, irrespective of which position sizing technique you will follow, at some point the technique will require you to estimate your equity capital. For this reason, we will address the technique of estimating equity capital first and then proceed to learn position sizing techniques.

What do I mean by equity capital?

Equity capital is the basically the amount of money you have in your trading account based on which you decide how much capital to deploy in a trade. This may seem very trivial to you at this point. But allow me to illustrate why this is a tricky task.

Assume you have Rs.500,000 capital and you work with a simple position sizing principle of exposing not more than 10% capital to a single trade. Given this, assume you take a position worth Rs.50,000/-.

Now for the next trade, how much is your equity capital?

1. Is it Rs.450,000?
2. Is it still Rs.500,000 considering the fact 50K is deployed in a trade?
3. Should it be 450,000 plus 50K ± the P&L from the trade that exists in the market?

   Given that there are numerous outcomes and possibilities, estimating equity for the trade is not really a straightforward task. Hence, getting our act right in estimating the equity capital is very important before we proceed to learn position sizing concepts.



## 12.2 – Estimating Equity Capital

At this point, I'd like to go back to good old Van Tharp and talk to you some of the techniques he uses to estimate equity capital. These are some of the better techniques compared to the many out there. Essentially there are three techniques or models as he calls them –

1. Core Equity model

2. Total Equity model

3. Reduced total equity model

The **core equity model** requires you to deduct the capital allocated to a trade from the existing capital. This way, the exposure to a trade goes on reducing as you ladder up more and more positions. Let me give you an example – assume your equity capital is Rs.50,000/- and you follow a simple 10% position sizing formula. The 10% rule implies that you do not expose or risk more than 10% of your capital to a trade. So the first trade gets an exposure of Rs.5000. The core equity is now reduced to Rs.45000. Have a look at the following table –

| Trade | Available Equity | Trade Exposure | Core Equity |
|-------|-----------------|----------------|-------------|
| 1 | 50,000 | 5,000 | 45,000 |
| 2 | 45,000 | 4,500 | 40,500 |
| 3 | 40,500 | 4,050 | 36,450 |
| 4 | 36,450 | 3,645 | 32,805 |
| 5 | 32,805 | 3,281 | 29,525 |
| 6 | 29,525 | 2,952 | 26,572 |
| 7 | 26,572 | 2,657 | 23,915 |
| 8 | 23,915 | 2,391 | 21,523 |
| 9 | 21,523 | 2,152 | 19,371 |
| 10 | 19,371 | 1,937 | 17,434 |

Download the excel sheet **here**.

So, the first trade assumes the equity available is Rs.50,000, hence 10% of the available equity is exposed first trade i.e Rs.5000/-. The core equity model requires you to deduct the capital deployed to a trade and re work on the core equity model. So, the core equity is now Rs.45000/-, which is also the available equity for the 2nd trade.

For the 2nd trade, we again deploy 10% of the equity available i.e 10% * 45000 = Rs.4500/-. We deduct this amount to calculate the new core equity, which is now Rs.40,500/-. This also is now the newly available equity for the 3rd trade.

So for the 3rd trade, the capital exposure for the trade is Rs.4050 and the new core equity is Rs.36,450/-. So on and so forth, I'm assuming you get the drift.

I consider this as a slightly conservative equity estimation model as you tend to reduce the capital allocation as the number of opportunities increases. For all you know, your 5th trade (for which the equity exposure is far lesser) may be a great winner. The other side of the argument is that the 5th trade could be the worst loser compared to the rest.

Having said that, I like this model for the sake of its simplicity. Once you commit the capital to a trade, you kind of forget about that and move on with what is available.

The **Total equity model** aggregates all the positions in the market along with its respective P&L and cash balance to estimate the equity. Let me straight away take an example to explain this –

Free cash available – Rs.50,000

Margin blocked for Trade 1 = Rs.75,000

P&L on Trade 1 = + Rs.2,000

Margin blocked for Trade 2 = Rs.115,000

P&L on Trade 2 = + Rs.7000

Margin blocked for Trade 3 = Rs.55,000

P&L on Trade 1 = – Rs.4,000

Total Equity = 50000 + 7000 + 2000 +115000+7500+55000-4000

= **Rs.300,000/-**

So, as you can see, in the total equity model, free cash along with margins blocked and the P&L per position is taken into consideration. Now, if my position sizing strategy suggests a 10% exposure to a new position, then I'd expose Rs.30,000/- on a new trade. If the free balance in my account does not permit me to take this position, then I'd not really initiate a new position. I'd wait to close one of the existing positions to take a new position.

The fact that this model considers a live position along with its P&L into account for estimating equity makes it a little risky. I'm personally not a big fan of this equity estimation model. This is somewhat like counting the chicken before they hatch.

I do like the 3rd model to estimate the equity, this one is called the '**Reduced Total Equity Model**'.

This model kind of combines the best of both the core equity model and the total equity model. It basically reduces the capital allocation to a particular trade (similar to core equity

model) and at the same time includes the P&L of the trade which is already in place (similar to total equity model). However, the P&L is only on the locked in profits.

Let me work with an example to help you understand this better. Assume I have a capital of Rs.500,000/-. Further, assume my position sizing strategy allows me to invest not more than 20% on a single trade, which is Rs.100,000/- per trade.

I'm looking at the chart of ACC and I decide to go long on ACC futures at 1800 by blocking a margin of approximately Rs.90,000/-, which is well within my position sizing limit of Rs.100,000/-.

I've now entered a position and waiting for the market to move. Meanwhile, as per the reduced total equity model, my the capital available for the 2$^{nd}$ trade is –

20%*( 500,000 – 90,000)

= Or about 20% of Rs.410,000/-

= Rs. 82,000/-

Note, because of the existing position, the exposure capital has reduced from Rs.100,000 to Rs.82,000/-. Up to this point, it works exactly like the core equity capital model.

Now, assume the stock moves, and ACC jumps by 25 points to 1850. Considering the lot size of 400, I'm now sitting on a paper profit of –

400*50

= Rs.20,000/-

I would now put in a trailing stop loss and lock in at least about 25 points out of 50 point move or in Rupee terms, I want to lock in Rs.10,000 as profits.

This means, for the long ACC position at 1800, I have to now place a stop loss at 1825 and locked in Rs.10,000/- as profits.

I will now add this locked in profits back to the total equity. Hence my total equity now stands at –

410,000 +10,000

=420,000/-

This means, my new exposure capital will be 20% of the total equity –

=20% * 420000

= **Rs.84,000/-**

As you notice, the exposure capital has now increased by an additional 2000/-.
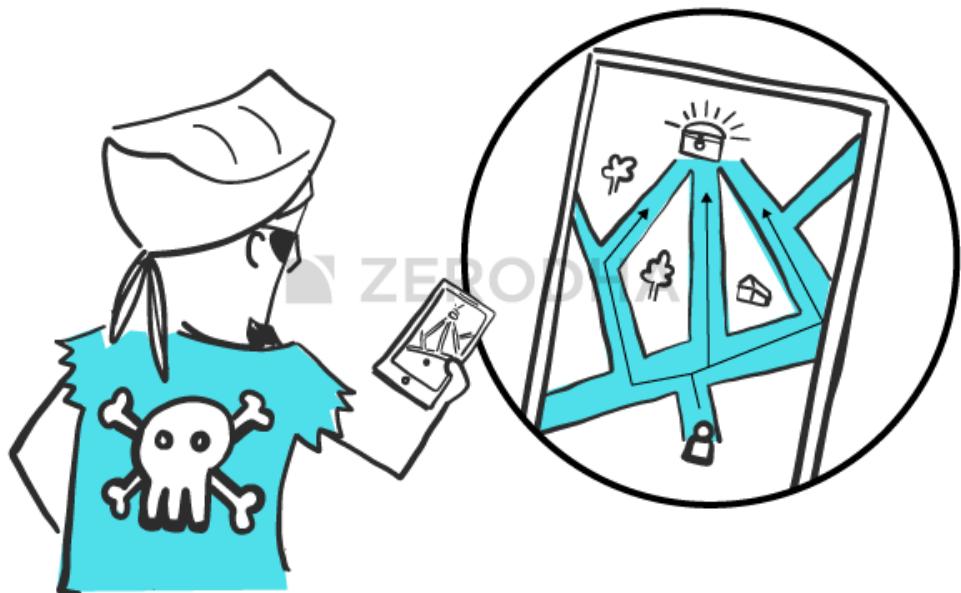
I kind of like the reduced total equity model to estimate the total capital available to position size.  If one follows tends to follow this technique, then it kind of forces you to practice basic stop loss principles, which according to me is very good.

Anyway, I'd like to close this chapter at this point. In the next chapter, we will consider one of the above-stated methods to estimate equity and look into few position sizing techniques.

**Key takeaways from this chapter**

1. Estimating equity capital is crucial for position sizing
2. Core equity model deducts the capital allocated to a trade and recalculate the capital available
3. Total Equity model requires you to add the free cash, margins blocked, and the P&L of the positions to estimate the equity capital
4. Reduced Total Equity model requires you to add the free cash to the locked in profits of an existing position

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# Position Sizing for active traders (Part 3)



## 13.1 – Choose your path

We addressed a very crucial concept in the previous chapter. We looked at how one can determine equity based on 3 different models. Each of these three models on its own merit imposes some sort of position sizing discipline, but clearly that's not enough. We still need a standalone method to position size. Given this, we will move forward to discuss some of Van Tharp's techniques on position sizing.

I'd like to talk about three core position sizing techniques at this point, they are –

1. Unit per fixed amount
2. Percentage margin
3. Percentage of volatility

Do note, these models are asset independent and time frame independent. What do I mean by this? This means that you can apply these position sizing techniques to any asset you want. It could be stocks, stock futures, commodity futures, or currency futures. Further you

can apply them across any time frame – intraday, few trading session, or even trades extending for over few months.

To understand this really well, I'd suggest you pick a trading system, it could be as basic as a moving average crossover system. Identify entry and exit rules and evaluate the returns you would generated for the given time period. Now for the same set of data, apply one of the position sizing technique (which we will shortly discuss) and evaluate the performance. I'm sure, you will observe a huge improvement not just in terms of P&L but also the stability of the system.

Just to throw some light into how complex this can get –

- Assume you have a trading system – a simple moving average cross over system
- You intend to deploy cash on this and start trading every signal that the system generates
- There are 3 models to define equity and there are at least 3 basic models to define position sizing techniques
- This means you can position size in 3 x 3 = 6 different ways to deploy cash for the same opportunity (signal)
- The P&L for each will be different

However, from my experience, I would suggest you stick one method to estimate equity and maybe 1 or at the most 2 (meaningful) techniques to position size. Anything more may not be a great, in the sense, it would induce complexity, and complex does not necessarily mean better.

So you as a trader need to assess which path to follow based on your temperament. Anyway, let's get started on the core position sizing techniques.

## 13.2 – Unit per fixed amount

Let's discuss the '**Unit per fixed amount**' model first. This is a fairly simple model. Any trader who has a slight inkling towards position sizing would have explored this model in the initial days. I like and dislike this model for the same reason – its simplicity.

The model requires you to simply state how many shares or lots (in case of futures) you will trade for a given amount. For example, assume you have Rs.200,000 in your trading account and you have the following 5 assets (futures) as your opportunity universe –

1. Nifty

2. SBI
3. HDFC
4. Tata Motors
5. Infosys

You could simply state that you would not want to trade more than 1 lot of futures per 100,000 of any asset at any given point. Given this, assume you get a signal to buy Nifty, now since there is 2L in the account, you can choose to buy one or 2 lots.

The best part about this model is that it does not complicate the decision-making process. However, there are few problems with this model.

Consider this – the trading system that you follow generates a signal to buy Nifty Futures and at the same time the system signals you to buy Tata Motors. Since you have 2L in your account, you decide to buy 1 lot each. Do note at the point of writing this article, Nifty Futures requires a margin of about 60K and Tata Motors around 72K.

Irrespective of the margin, the rule simply states, 1 lot per 1L. This means, position sizing rule is assigning an equal weight to both the contracts, ignoring the implicit 'riskiness' of the asset. To give you a perspective, Nifty Futures has an annualized volatility of around 14% and Tata Motors has an annualized volatility of over 40%. So essentially, you are exposing yourself to a higher risk at the portfolio level.

This in fact, is both good and bad at the same time. Good in the sense that it does not reject a trade based on the riskiness and bad in the sense it does not really factor in risk.

There is another angle here – think about this, consider you are following a trading system to which you apply the 1 lot per 100,000 position size rule. Assume you have a 2 lac capital. Now, further assume that the system performs really well and you are bestowed with multiple winning trades. Now, for each signal, the maximum number of lots you can buy is restricted to just 2. For you to increase another lot or 2, you really need to double your capital or wait for your profits to double up you capital. So in a sense this particular position sizing technique limits the scalability of a system. The only antidote to this is to bring in a much larger account size.

For these reasons, I kind of don't prefer the 'unit per fixed amount' position sizing technique. However, please don't take my word, I'd suggest you work around and figure out your comfort level with this technique before deciding to adopt or not adopt this as your core position sizing technique.

## 13.3 – Percentage Margin

The percentage margin is an interesting position sizing technique. I personally think this technique is far more structured than the 'unit per fixed amount', technique especially for intraday traders. The percentage margin technique requires you to position size based on the margins.

Here you essentially fix a 'X' percentage of your capital as margin amount to any particular trade. Let's work with an example to understand this better.

Assume you have a capital of Rs.500,000/-, with this you decide that you will not expose more than 20% as margin amount to a particular trade. This translates to a capital of Rs.100,000/- per trade.

Assume you spot an opportunity to trade Nifty Futures, you can easily take this position as the margins for this is roughly around 60K. However, let's say you spot an opportunity in ICICI, you will be forced to let go of this as the margin for this is close to Rs.105,000/-. This means, ICICI will be out of your trading universe until and unless you increase your capital. Obviously, one should not randomly increase the capital just to accommodate opportunities. Capital should increase as an outcome on profits accumulating in your account.

Anyway, after you initiate the position in Nifty, assume you spot an opportunity in ACC, the margin for this is 90K.

Will you take this position?

The answer to this really depends on the way you estimate equity.

If you consider the total equity model, then you will still consider your capital to be 5L, 20% of which is 1L, hence you can safely take the position in ACC.

However, if you consider the reduced total equity model, then this is how it would work (assuming 20% position sizing rule) –

Starting Capital = 5L

Margin blocked = 60K

New capital = 4.4L

Margin @ 20% = 88K

Given this, you'd fall short by (just) 2K for a 90K position, hence you would have to let go…and as you realize, equity estimation plays very crucial role here.

Lastly, assume, you spot an opportunity which requires a margin of 40K, since you have 88K, you can comfortably take up 2 lots of this position.

So on and so forth.

The percentage margin rule ensures you pay roughly the same margin to all positions. However, the volatility from each position could vary. You could end up with risky bets and therefore altering the entire risk profile of your account.

This exposure to risk is overcome by next position sizing model.

## 13.4 – Percentage Volatility

The percentage volatility rule accounts for volatility of the underlying asset. The volatility as per this technique is not really the 'standard deviation', but rather the daily expected movement in the underlying.

For example, if SBI's OHLC is 276, 279, 274, and 278, then the volatility for the day is simply the difference between low and high i.e

279 – 274

= 5

To get a sense of the generic volatility measured this way, I can look at the difference between low and high for last 'n' days and take an average. However, the only problem here would be that I would be ignoring the gap up and gap down openings. For this reason, Van Tharp suggest the use of 'Average True Range' to measure the stock's volatility.

The 'Percentage Volatility' method of position sizing requires us to define the maximum amount of volatility exposure one can assume for the given equity capital.

For example, if the equity capital is Rs.500,000/- then I could make a rule saying that I do not want to expose more than 2% of the capital to volatility.

Let's work with an example. Here is the chart of Piramal Enterprises Limited (PEL) –

The 14-day ATR is 76. This means each share of PEL contributes to a fluctuation (volatility) of Rs.76/- to my equity capital.

Now assume I spot an opportunity to trade PEL, the question is how many share should I buy considering my equity is 5L and I've capped volatility exposure as not more than 2%.

2% of 5L is 10,000/-. This means I should only so many number of shares of PEL, such that the overall volatility caused by PEL is not more than 10k.

Given this, I simply have to divide 10,000 by 76 to find out the number of shares that I can buy –

10,000/76

= 131.57 or about 131 shares.

PEL is currently trading around 2700, which means to say, your overall exposure would be –

131 * 2700

=Rs.353,700/-

I'd suggest you stick to the reduced total equity model for estimating equity here. This means, the capital available for the next trade would be –

500,000 – 353,700

=146,300

Now @ 2% volatility, the capital exposure reduced to Rs.2929/-. Clearly the capital exposure to the next trade would reduce, but the exposure to volatility would remain the same.

Here is an advice (from Van Tharp, of course) if you are inclined to follow percentage volatility technique – the do estimate the total amount of volatility you want to expose your portfolio too. If the number is say 15% then on a 5L capital this works out to Rs.75,000/-.

Think about it, if every position goes against you, then you stand to lose 75k on a capital of 5L on a single day. How does that feel? If your stomach churns, then 15% portfolio volatility maybe a bit high for you.

In the next chapter, we will explore few more concepts before we proceed to understanding 'Trading biases'.

**Key takeaways from this chapter**

1. Estimating equity plays an important part in position sizing
2. Suppose you have 3 ways to estimate equity and 4 ways to position size, then essentially you have a 4 x 3 = 12 position sizing technique
3. Unit fixed model requires you to ascertain how many shares or lots you will trade for every 'x' amount of capital in your account
4. Unit fixed model does not consider risk
5. Percentage margin method requires you to define the maximum margin amount you will expose your capital to. You ideally should club this with total reduced equity model
6. Percentage volatility measures volatility in term or ATR.
7. Percentage volatility equal weights 'volatility' exposure to each position

# CHAPTER 14

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# Kelly's Criterion

## 14.1 – Percentage Risk

Last chapter we looked at three important position sizing techniques, all of them were unique in their own merit. The three techniques were –

- Unit per fixed amount
- Percentage Margin
- Percentage Volatility

All three methods work differently and when combined with a certain equity estimation technique, they produce totally different results. Given this, it is really up to you to figure out the marriage of which position sizing technique with which equity estimation technique works best for you.

Before I proceed, I thought it is important to discuss another practical position sizing technique, called the 'Percentage Risk', method. I do know quite a few traders who use this and I myself find this quite simple and intuitive technique to use.

The percentage risk method, relies upon your own assessment of 'loss' that you are willing to bear for a given trade. This, as you may know is also called the 'Stop loss' for the trade. The stop loss for a trade is the price at which you decide to close the trade and take a hit. The percentage risk technique controls the position size as a function of risk defined by stop loss.

Let me take the example of a stock futures and explain how this works, in fact, I think this is a good trade setup –



Here is an intraday chart of Tata Motors, the frequency is 15 mins (14th Sept 2017, around 11:30 AM).

Let me explain why this is a trade worth considering –

Tata Motors is at 393.65, which happens to be a price action zone, considering it tested the same level, twice in the past. So this makes 393.65, a support price for Tata Motors (on an intraday basis). Both the times in the past, the price declined of Tata Motors declined when the stock tested 393.65. Given this, there is a possibility that the price could again test 393.65 and react to bounce back to the price from which it started to decline i.e 400.

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Also, do notice the low volume retracement between 400 to 393.65 – I've discussed why I like trades like these in the Technical Analysis module. If you've not read that module, maybe you should

Considering these factors, a trader could be inclined to go long on Tata Motors Futures at 393.65.

What if the trade heads the other direction? What is the stop loss?

I notice some sort of support at 390/-, hence I'd be happy to set this as stop loss for the trade.

Nothing complicated, as you can see this is a very straightforward setup.

So the trade would be –

Stock: Tata Motors Limited

Trade: Long

Trade Price: 393.65

Target Price: At least 400

Target value 6.35

Stop loss Price: 390

Stop loss value: 3.65

Reward to Risk: 1.7 (which is great for an intraday trade)

Lot size: 1500

Margin Required: 73.5K

Now assume I have a capital of Rs.500,000/-, how many lots of Tata Motors can I buy considering the margin per lot is Rs.73,500/-?

Technically speaking one can buy up to 6.8 or 6 lots –

500000/73500

=6.8

However the question is – would you expose your entire capital to this one trade alone? Not a smart thing to do, if you were to ask me, because if the trade goes wrong, you would be losing Rs.32,850/- (3.65 * 1500 * 6) on this trade.

In other words, you would lose –

32850/500000

=6.57% of your capital on one trade.

However great a trade set up is, it is not a smart thing to expose so much capital to risk. As a thumb rule, professional traders do not risk more than 1 to 3% of their capital on any single trade, and this rule forms the core of the 'Percentage risk' position sizing technique.

Given this, let us define the **maximum risk per trade** as a percentage of overall capital – maybe 1.5% for now. This means on this trade, the maximum loss I'm willing to bear is

1.5% * 500000

Rs.7,500/-

In other words, I don't intend to lose more than Rs.7,500/- on any single trade. This is the maximum loss threshold.

We know the stop loss for this trade is 390, from an entry price of 393.65, the stop loss in absolute Rupee terms is –

393.65 – 390

= 3.65

The loss per lot is –

3.65 * 1500

= 5475

In the event the stop loss is triggered I would be taking a hit of Rs.5475 per lot.

Now to identify the number of lots I could take for the risk I'm willing to bear, I simply have to divide the maximum threshold by the loss per trade.

= 7500/5475

= 1.36

Therefore, on this trade I can go ahead and buy up to 1 lot, which will cost me Rs.73,500/- as margin deposits.

For the next trade, it is prudent (or rather conservative in a positive way) to reduce the money blocked from the overall capital and re-work the maximum loss threshold. Let's do that and identify the new max loss threshold –

500000 – 73500

= 426,500

1.5% * 426500

**= 6397.5**

Given this, for the next trade, I will work out the stop loss, multiply that with the lot size and divide the max risk i.e 6397.5 by loss threshold to identify how many lots I can transact in.

So on and so forth!

By the way, curious to know how the trade panned out? Here you go –

I like trades like these, when the price does not even approach close to the stop loss J. As I had pointed out earlier, I did have a great amount of conviction on this trade. This leads me to the next topic – how do I position size when my conviction on a particular trade is high? What in such situations I want to expose a slightly higher capital?

Well, say hello to Kelly's Criterion!

## 14.2 – Kelly's Criterion

Kelly' Criterion has an interesting background. It was proposed by John Kelly in the 50's who at that point was working for AT&T's Bell Laboratories. He in fact, suggested the Kelly's Criterion to help the telecom company with long distance telephone noise issues. However, the same theory was adopted by professional gamblers to identify the optimal bet size. This soon found its way to the stock markets as well, and there are many professional traders and investors who use Kelly's Criterion for bet sizing. Perhaps, this is one of those very few tools that both traders and investors commonly use.

I still don't know how the transition from Telecom to stock markets happened – I'm a Telecom Engineer by qualification (although I know nothing about Telecommunications now) and I've been involved in Stock markets for over 13+ years….but I just can't wrap my head around how Kelly's Criterion made its transition across these two different worlds J

Anyway, the Kelly's Criterion essentially helps us estimate the optimal bet size (or the fraction of our trading capital) considering –

- We have a certain information on the bet we are about to take
- We have an edge taking that particular bet

Let's jump straight to Kelly's Criterion with an example. The Kelly's Criterion is an equation, the output of which is a percentage, also known as a the Kelly's percent. The equation is as below –

**Kelly % = W – [(1-W)/R]**

Where,

W = Winning probability

R = Win/Loss ratio.

- The winning probability is defined as the total number of winning trades divided over the total number of trades
- The win/loss ratio is the average gain of winning trades divided over average loss of the negative trades.

To understand this better, let's take up an example. Assume I have a trading system which has produced the following results, for sake of simplicity, let's assume this is a trading system to trade just one stock, Tata Motors.

| SI No | Signal Date | Result | P&L (in INR) |
|-------|-------------|--------|--------------|
| 01 | 3rd Sept | Win | + 5,325 |
| 02 | 4th Sept | Win | +2,312 |
| 03 | 5th Sept | Win | +4,891 |
| 04 | 6th Sept | Loss | – 6,897 |
| 05 | 11th Sept | Win | +1,763 |
| 06 | 12th Sept | Loss | -3,231 |
| 07 | 13th Sept | Loss | -989 |
| 08 | 14th Sept | Loss | -1,980 |
| 09 | 15th Sept | Win | +8,675 |
| 10 | 18th Sept | Win | +4,231 |

Given the above data –

W = Total Number of winners / Total number of trades

= 6/10

=0.6

R = Average Gain / Average Loss

Average gain = Average of [5325, 2312, 4891, 1763, 8675, 4231]

= 4,532

Average loss = Average of [6897, 231, 989, 1980]

=3,274

R = 4532 / 3274

= 1.384

Do note, a number greater than 1 is always desirable as it indicates that your average gains are higher than your average loss.

Lets plug these numbers back to the Kelly's Criterion equation –

**Kelly % = W – [(1-W)/R]**

= 0.6 – [(1-0.6)/1.384]

=0.6 – [0.4/1.384]

= 0.31 or **31%.**

As per the original school of thought – Kelly's percentage is a direct representation of how much capital one should expose for a trade. For example, for the 11th trade on Tata Motors, Kelly's Criterion suggests a capital exposure of 31%.

But I think this can be a little tricky, imagine a trading system with great accuracy – the Kelly;s Percentage can turn out to be 70%, suggesting a capital exposure of 70% to the next trade. Not a very smart thing to do if you ask me. However, you may ask why not? After all a system with 70% accuracy is a great, so why not maximize the bet?

This is because, there is still a 30% chance to lose 70% of your capital!

Given this, here is a simple modification to Kelly's criterion. Let us go back to the percentage risk position sizing technique we discussed earlier in the chapter.

We defined the percentage risk as a technique wherein the exposure to a trade is defined as 1.5% (or any percentage) of the capital. Given Kelly's criterion, we can modify the exposure as 'up to 5%' (or any percentage you deem suitable).

What does this mean? This means for a given trade, I would not expose more than 5% of the capital. This also means that capital exposed could range from as low as 0.1% to all the way up to 5%. So how do I decide?

We can use Kelly's percentage here. For example, if the Kelly's percentage is 30%, then I'd expose, 30% of 5% or in other words, I'd expose 1.5%. If the Kelly's percentage is 70%, then I'd expose 70% of 5% or say 3.5% of the capital on the trade.

So higher the Kelly's percentage, higher is the capital exposed and vice versa.

For a more Mathematical explanation on Kelly's Criterion, I'd suggest you **watch this video**, if not for anything, watch from the 10th minute onward.

With this, I'd like to close the discussion on position sizing, hopefully the last 4 chapters has given you a fair understanding of the importance of position sizing and techniques to position size your bets.

Onwards to 'Trading and Investing Biases'.


**Key takeaways from this chapter**

1. Percentage Risk is an easy and intuitive position sizing technique
2. One has to define the maximum amount of risk one as a percentage of capital, dividing this over the stop-loss gives us a sense of how much capital one should expose to a trade
3. Kelly's Criterion suggests how much capital one can expose for a given trade
4. One can combine Kelly's Criterion with percentage risk for optimal results

# CHAPTER 15

# Trading Biases

## 15.1 – Mind games

If you are a part of any WhatsApp group related to stock markets, then chances are that you may have watched this **video** –

If you are in no mood to watch it, then let me give you a quick summary – This is a show where people call in during the show and ask the show host questions related to stock markets. This is a video clip of one such caller asking the host of the show, the procedure to convert 20,000 shares of MRF LTD from paper to digital form. The shares were bought by his grandfather back in the 90's and were kept in the paper form – 'physical certificates', as they are called.

After informing the caller the procedure to convert the shares from the physical form to DEMAT form, the show host casually informs him the value of his shares in today's terms.

The price of MRF on a per share basis was roughly Rs.64,000/-. Considering the fact that he has 20,000 shares, the overall value works out to –

20,000 * 64,000= 1,280,000,000

Or about Rs.128 Crores.

Can you imagine that – **ONE TWENTY-EIGHT Crore!**

I was flabbergasted when I first saw this video.

The first thought that occurred to my mind was – how can someone have the vision to buy MRF 25 years ago? How is he motivating himself to still stay invested? How could he resist the temptation to not sell the stock? Especially after watching the stock grow multiple times over his initial investment?

A common investor according to me would probably sell his investment if he saw his investment return say – 50%, maybe 100%…or at most 200%. But this guy has held his stock across years, watching it grow at least 20 times or 2000%.

How did this happen?

Think about this – if we can understand what exactly is happening here, maybe it will throw out a bunch of insights which will help us create similar wealth right?

When I thought through this again (and watched the video again) – I kind of figured what was going on here. Here are my observations –

- His grandfather had bought the shares of MRF back in days, has not paid much attention to it since the purchase
- One fine day he realized that he has few shares of MRF lying in the attic
- He must have mentioned this to his grandson (the caller)
- The grandson has now decided to convert them to DEMAT
- I'm assuming that he would probably sell the shares as soon as it gets them converted

I find this situation extremely interesting, there is a lot happening here and one can draw few conclusions here –

1. It is likely that the grandfather has forgotten about his investment, and spent his time somewhere else
   - *This is a valid conclusion as otherwise; he would have taken efforts to convert shares to DEMAT long ago*
2. Because he had forgotten, he has not paid much attention to the price appreciation over the years

What can we infer from this?

One straightforward inference that you would agree I suppose – granddad had made a ton of money by simply forgetting the fact that he owns shares of MRF.

Now for a moment imagine – what if he had not forgotten about his investments? What if he had access to a broker or a friend who would call him every day to tell him the stock price of MRF?

Do you think he would have held on to his shares for these many years? Don't you think there is a high probability of him selling out his investment – at say a return of 100%, 200% or even 500%?

In other words – because he forgot and did not pay attention to his investment, he held on to his investment over the years and reaped its benefit.

Now, had he deiced to track the stock price and update himself with the latest developments – what do you think would have happened? He would analyze the data – when people analyze data – they don't just analyze the facts, they try and be smart about it by adding their own imagination. These imaginations originate from our own interpretation of an ideal world. We often refer to this as 'biases'.

Biases, in the trading and investing world, is the only thing standing between you and a profitable P&L.

This objective of this chapter and the next is to discuss some of these common biases and help you overcome these biases.

## 15.2 – Illusion of Control

Let us start with one of the most common biases traders and investors tend to have. Have a look at the chart below, a typical chart you'd find on any technical analyst's desk. There are quite a few things happening here in this chart –

1. Candlestick chart for price action
2. Bollinger band to track volatility
3. Fibonacci retracement to identify retracements
4. Pivot points for support and resistance
5. Volume chart
6. ATR
7. Stochastic indicator

I'm certain, at least 8 out of every 10 technical traders would have a similar setup while analysing charts. Clearly, for someone not familiar with charts or technical analysis this chart would look quite intimidating. After all, there are so many things happening here.



Each element on this chart gives out a unique insight to the trader. Along with these so-called insights, the chart does something else to the trader at the subconscious level.

Because of the complexity of the chart, and the fact that not many people can relate to it – it somehow makes the trader believe that he is dealing with a complex subject – and he is in total control over the stock by virtue of all the 'important insights' he seems to have derived.

This is often called the 'illusion of control' – one of the biggest trading biases for a technical trader. Traders who are heavily influenced by the illusion of control often make statements like 'This stock is not going to go above 500' or sometimes they make super confident statements like 'Go ahead and buy puts', you question them why, and they will be quick to say 'Boss, I'm telling you just buy Puts'.

Why do they do this?

Well, traders have this tendency to get attracted to complex things, it just feels very nice to be looking at complex charts and making sense out of it. This is like fighting fire with fire – markets are so complex, the default notion is to fight this complex beast with complex analysis. Further, the fact that only you can make sense of it and others cannot give you that additional kick.

This physiological behavior can be attributed to the 'Illusion of control'.

Remember, no matter how many indicators you load or how many numbers you crunch, there is no way you can control all the outcomes. End of the day, there are several different outcomes possible for every possible situation in the market. You cannot control them all.

The only way to overcome this behavior is to stay focused on results and statistics. If you are dealing with a trading strategy, then you got to know the odds of the next trade being profitable. When you start looking at market opportunities this way, you will start being truthful to yourself (and others around you) and will always remain humble. If not for anything, you not get carried away by noise.

From all my market experience I can tell you one thing with conviction – the best analysis is done when things are kept simple. Complex does not necessarily mean 'better'. Hence, you as a trader need to be completely aware of this and work towards building a data-driven approach and not get swayed by inputs that don't really matter.

## 15.3 – Recency Bias

Here is another bias that plagues traders. I find this quite interesting – no matter how many years of experience you have, at some point, you will fall prey to it. Let me illustrate with a recent example.

If you have been tracking 'Café Coffee Day Enterprises' (CCD), then you'd know what is really happening with the company and stock price. For the uninitiated – the company has been under the radar of 'Income Tax Department' for tax evasion and hoarding large amounts of income. Couple of days ago, Economic Times carried out the story in great detail, here is what the headlines said –

## Coffee Day Enterprises slips 10% as I-T raids on CCD find Rs 650 cr concealed income

ETMarkets.com | Sep 25, 2017, 11.45 AM IST

I've always maintained one stance when it comes to making long-term investments – if the company's corporate governance is questionable, then no matter how attractive the investment appears, one has to avoid. History has taught us many times that such investments will eventually go down the drain. Given this investment stance and the recent events in CCD, I'd be hesitant in making a long-term investment in CCD.

But what if you already have an investment and this news rolls out? Well, assuming there is truth in the news, the first thing I'd do would be to get out, no matter how much money I'd be making or losing at that point.

A good family friend had made an investment in CCD, he called me **a couple of days after** the news rolled out asking me for my advice. Do note, the news by the time he called me was already 2-3 days old. Things had calmed down (but the fact that the income was concealed, still remains). When he asked me for my advice – I asked him to get out. He quickly pulled the chart of CCD and asked me to take a look –



As you can see, after the steep fall, the latest green candle suggests that there was some buying in the stock. Maybe, there were few traders/investors trying to bottom fish.

Now, if the idea is to get out because of corporate governance issue – you have to. There are no two ways about it. However, this friend of mine suggested, 'Maybe I'll hold for few days before selling, I could get a better price'.

I just left it at that and didn't really try convincing him to get rid of the sock.

But why do you think this friend of mine wanted to hang on to the stock? Does the latest green candle override the fact that there was concealed income at CCD? Or does it give a clean chit to the company's corporate governance?

I don't think so.

Instead, what it does is – it induces a bias called the 'Recency bias'.

'Recency bias', gets you carried away with the latest information/event by making you turn a blind eye to the past events or facts. This is exactly what is happening to my friend – the latest green candle is making him turn bullish and he is convincing himself that there is more up move left. Well, there could be an up move – but that still does not override corporate governance and turns the stock to an investable grade stock.

Recency bias distorts your sense of judgment. It makes you weigh the recent event far higher than what you probably should.

The only way to overcome recency bias is by taking cognizance of the wider picture. You should be in a position to see things from an overall perspective and not really a microscopic view.

**Key takeaways from this chapter**

1. Markets are complex, but the means to analyze markets need not be complex
2. Traders often complicate their charts, subconsciously it makes them think they are invincible, gives them a sense of control
3. Illusion of control makes you spend many hours trying to derive data, which is otherwise pointless
4. More data does not necessarily mean quality of information
5. Recency bias makes you turn a blind eye to the past events (which could have more impact on markets)
6. Having a sense of the overall picture helps you prevent yourself from falling prey to recency bias

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# Trading Biases (Part 2)



## 16.1 – Anchoring Bias

I've spent close to about 13 years participating in the stock markets. I've spent these years in various capacities – as a trader, investor, broker, money manager, analyst etc. I've had my fair share of happiness and regrets in the markets and I've learned a lot (still continue to learn) during these years. I've realized that happiness and regret may not always be a linked to the outcome of a trade that you've taken up – you feel happy when you make a profit and regret when the trade results in a loss. These feelings can also manifest out of trades that you've not taken up. Let me tell you one of my biggest regrets in the stock markets till date.

I the recent years, August / Sept 2013 was one of the greatest times to build a long-term portfolio from scratch. Stocks of great business were available at throwaway valuations. I was fortunate enough to be aware of this situation in the market and I was really busy structuring my equity portfolio. I had a tough time selecting stocks to include in my portfolio. Tough time in the sense that there were too many opportunities to choose from. In fact, this is what a bear market does to you – it spoils you for choices.

I included few stocks in the portfolio (which I still continue to hold) and I let go of many stocks including MRF, Bajaj Finserv, etc. The decision to let go of these stocks was based on the fact that I perceived investing in other stocks more attractive. Stocks like MRF and Bajaj Finserve have performed phenomenally well, but then I don't regret my decision.

However, the decision to not invest in Sundaram Clayton Limited pains my heart – I consider this as one of the biggest regrets.
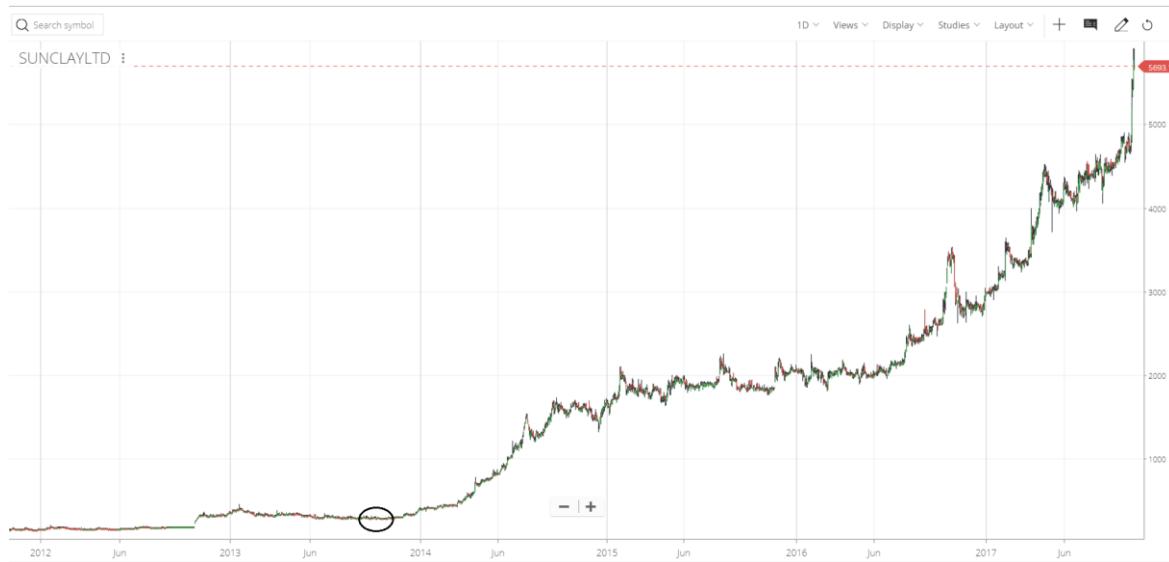
Take a look at this chart –



I did my usual stock research and was convinced that the stock was a great buy. I've circled the area around which I wanted to buy – roughly around 270 per stock. Given that it was a bear market, I was kind of rigid on the price to buy – 270 or lower.

The stock price moved slightly higher to about 280, but I did not budge. I waited. The stock price moved to 290, I waited. A couple of days later, the stock shot to 310 and I remember convincing myself – the stock will retrace back to 270 considering that it was a bear market. After all, I was in no mood to pay a 15% 'premium' on a price that I perceived as 'the best price'.

As you may have guessed, 270 never occurred and I never got to buy this stock, and here is what really happened to the stock later on –

I've circled the 270 price mark again for your reference, which is where my so-called 'price conflict' occurred – all in my mind!

I probably missed out one of the greatest investment opportunity in my life, and all thanks to the games my mind played with me. More formally, what really prevented me from buying Sundaram Clayton can be attributable to a notorious trading bias called 'The Anchoring Bias'.

I was looking up on Wikipedia for 'Anchoring Bias', and I discovered a new term for the same – it is also called 'Focalism'. Anchoring bias belongs to a group of biases grouped under 'Cognitive Biases'. Cognitive bias is a systematic error in our thinking that affects the way human beings make their decisions or judgments. Anchoring Bias leads the list of cognitive biases.

Under the influence of Anchoring Bias, we tend to get fixated to the first level of information we get. For example, in my very own case, the first price I saw on the terminal was 270 (for Sundaram Clayton), and I was fixed to that price. Here 270, formed a price anchor.

Think about your own trading situations – how many times you may have missed placing that buy order or a stop loss order because the price that you perceived as 'right' never occurred, only to later see the stock perform exactly the way you thought it would. After all, in most of these situations, the price difference between what we perceived as right and the one available in the markets would be marginal – few Rupees probably, but then our minds just do not permit us to go ahead.

Like any other biases, there is no real cure for anchoring bias. The only real cure is to be aware of it and adopt critical thinking in your approach to markets.

## 16.2 – Functional Fixedness

This is yet another cognitive biases – although you will not read much about this particular bias in the trading world. However, I think it kind of has its impact on traders, especially the ones who trade derivatives.

Let me give you a generic explanation of 'functional fixedness' bias and then relate this to the trading world.

There is juice shop near my office which I frequent for a glass of fresh juice. On one of those visits, I asked for my regular orange juice, but the guy at the juice shop was busy fixing the mixer jar. The handle of the jar was loose and had to be fixed. The guy was busy trying to find a screwdriver to tighten the mixer's handle. Unable to find one, he was kind of clueless on how to proceed.

At the same time, his colleague walked in and learned about the issue. He simply picked up a spoon which was lying around, used the other end of the spoon (which basically has a flat side) as a makeshift screwdriver and tightened the jar. Problem solved, juice was served.

This is functional fixedness at its best. Functional Fixedness is a cognitive bias that limits a person to using an object only in the way it is traditionally used. We assign tasks to objects and we live with that rigidity all our lives. For example – we have all grown up with the notion that we only need to look for a screwdriver to tighten screws, without which one cannot. However, a simple spoon can do the same job! One has to start thinking out of the box to solve problems in unconventional ways.

There are few ways in which Functional Fixedness limits our way of thinking when it comes trading. Let me start with a classic example.

Assume you have Rs.100,000/- in your trading account. You have identified a great trading opportunity in Nifty and you expect to hold onto the trade for the next 2 or 3 days.  Since you intend to hold this trade overnight, you have to opt for a 'NRML', product type.  The typical margin blocked for this trade would be about Rs.65,000/-.

So you take the trade around 3:20 PM and carry the position forward. End of the day 65K would be blocked as margin and 45K would be your available balance, which can be utilized toward another trade the next day.

The next day market opens, Nifty starts moving in the direction that you expect it to move. You are happy with the way things are going.

Now, assume that you spot a great intraday opportunity, TCS stock futures, which requires you to pay an MIS margin of 60K. What will you do? The available margin is 45K, you'd fall short of 15K right? Therefore, you cannot take the TCS intraday trade.

Now, this is where the functional fixedness is playing the culprit. We consider the NRML (margins blocked for overnight positions) as 'margins blocked', and we invariably forget about this capital until we square off the position.

With a little bit of 'out of the box', thinking (and some efforts) we can, in fact, continue to hold the overnight position plus take up the intraday opportunity.

Here is how it would work –

1.  At the start of the day, you have available margin of 45K, short of 15K to take up the intraday trade
2.  Convert the NRML Nifty position to MIS. When you do this, from the 65k that was blocked, nearly 39K would be freed up – as MIS for Nifty is about 26K
3.  You now have 45K + 39K or 84K free cash for the day
4.  With 84K, you can easily place an MIS order, blocking 60K. You will still have 14k as available margin
5.  End of the day, square off the MIS stock futures trade – remember this was an intraday trade
6.  Your available margin goes up to 84K
7.  Convert back the MIS Nifty trade to NRML and carry forward the position

The snapshot below shows you how you can do this on Kite –

| INFY | | NET QTY. | AVG. PRICE | P&L ✕ |
|------|--|----------|------------|-------|
| MIS / NSE | | 1 | 932 | 0 |

| LAST CLOSE | | LTP | | DAY'S P&L | | |
|------------|--|-----|--|-----------|--|--|
| 0 | | 932 | | 0 | | |

| BUY QTY. | PRICE | VALUE | SELL QTY. | PRICE | VALUE |
|----------|-------|-------|-----------|-------|-------|
| 1 | 932 | 932 | — | — | — |

🗑 ADD    🗑 EXIT    ↻ CONVERT    ▣

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## 16.3 – Confirmation Bias

Have a look at the Tata Motor's below



I've marked few important points on this chart –

1. The stock is around 430 today
2. 430 seems to be a price action zone considering the past price reactions
3. Sometime in early August, the price cracked through 430 and declined to 370
4. The stock price stabilized around 370, quite evident with the double/triple bottom formation
5. Since 370, the price has consistently trended up, all the way back to 430, which is where the current stock price is

Considering the above, guess the stock is all primed up for an up move – don't you think so?

Also, keeping that analysis in the back of our mind how would you view this piece of news which made the headlines earlier today –

# Tata Motors Starts Electric Bus Pilot-Runs In Guwahati

Tata Motors has completed trials for electric bus in Shimla and Chandigarh where it ran for almost 165 km and 143 km on a single charge, respectively.

Chances are that you will views this news piece as a trigger for Tata Motors to edge higher and therefore support your logic of buying the stock. However, in reality, the fundamental news may not really be a great trigger to drive the stock price higher. But then, at a subconscious level, you start looking for pieces of information that support your view. In other words, when you form a trading opinion, no matter what happens, you only look and assimilate information that supports your view. Your brain somehow does not allow you to pay attention to information that does not support your original contention.

This is called the 'Confirmation Bias'.

Critical reasoning is the key to overcome the confirmation bias. You got to ask yourself – so what?

## 16.4 – Attribution Bias

This one is funny.

How many times have you had a winning trade and ended up feeling proud of your analysis? Perhaps you bought an option and it gained 100% on the premium or maybe you bought a stock and saw it appreciate multifold.

Every time you make a profit – it is somehow because of your smart trading logic, and therefore you give yourself a pat on your back. But what about the times you've made a loss? How do you deal with it?

Coming from a stockbroking industry, let me tell you one thing – when people make a loss, they invariably attribute this as broker's fault and not really their own. Traders find all sorts of reasons to blame the broker – broker's system failed, charts not loading, orders are slow, and what not.

Everything thing is attributable to someone else's mistake (mainly the broker) and not really the subpar analysis in the first place!

This is called the 'Attribution Bias' and people succumb to it owing to acknowledge the fact that they are wrong. One way to overcome the attribution bias is to maintain a trading journal and make entries which reason outs why you've entered into a trade and why you decided to close the trade. These journal entries over time give you a great insight into your own trading behavior.

## 16.5 – And it's a wrap!

The list of these biases gets endless. Naturally, covering all of them would be hard. However, here is what I'll do – I'll keep this chapter open and I will continue to add more biases as and

when I discover them myself

With this chapter, I'd like to close this module on Risk and Trading Psychology. As usual, I hope you enjoyed reading this module, as much as I enjoyed writing it for you all.

Keep those comments coming!

**Key takeaway from this chapter**

1. Anchoring Bias can be quite notorious – tricks the trader/investor to anchor them to the first piece of information
2. Anchoring Bias may lead you to miss great opportunities
3. Functional Fixedness fixes your opinion on the utility of the tools, restricts your imagination
4. One can overcome functional fixedness by practicing 'out of the box' thinking approach
5. Confirmation bias makes you seek information (or tricks you to assimilate information) which can support your original hypothesis
6. In a typical trading world, traders attribute losses to problems in the outside works and not really because of subpar analysis
7. Attribution Bias can be overcome by maintaining a trading journal